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GEOLOGICAL AND NATURAL HISTORY SURVEY AND MUSEUM

OF CANADA.

REPORTS AND MAPS

OF

INVESTIGATIONS AND SURVEYS.

1882-83-84.

To the Honorable

Sir David Macpherson,

Minister of the Interior.

Sir.—I have the honor to submit herewith the Annual Reports of the Geological and Natural History Survey and Museum of Canada.

It will be observed that the reports and the maps embrace a part only of the work of several years up to 31st of December, 1884.

I have the honor to be,

Sir,

Your obedient servant,

ALFRED R. C. SELWYN.

Ottawa, 1st. January, 1885.

160 J

J. B. Tyrrell

GEOLOGICAL AND NATURAL HISTORY SURVEY AND MUSEUM
OF CANADA.

ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., Director.

REPORT OF PROGRESS

1882-83-84.

PUBLISHED BY AUTHORITY.

MONTREAL:
DAWSON BROTHERS.

1885.

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II.

B.

III.

ERRATA.

Page 22. *Side note, for* calcereous *read* calcareous.
" 13, *line* 15 *from bottom, for* their, *read* the.
" 32, *lines* 4 *and* 5 *from top, for* These latter are, however, of Lower Silurian age, *read* These latter are probably of Huronian age.
" 40, *line* 18 *from top, for* Untenun (?) *read* Untenum.

C.

—

IV.

REPORT ON THE REGION IN THE VICINITY OF BOW AND BELLY RIVERS, NORTH WEST TERRITORY, BY GEORGE M. DAWSON.

(C.)

DESCRIPTIVE GEOLOGY.

(C.)

PAGES

GENERAL GEOLOGY.

USEFUL MINERALS.

GLACIATION AND SUPERFICIAL DEPOSITS.

ERRATA.

Page 17, *line* 20 *from top, for* south-western, *read* south-eastern.
" 33, *tine* 15 *from top, for* band-land, *read* bad-land.
" 35, *line* 7 *from top, for* proposition, *read* proportion.
" 47, *line* 10 *from top, for* Baculites ovatus, var., *read* Baculites asper?
" 53, *line* 12 *from bottom, for* Corbula pyriformis, *read* Corbula n. sp. like C. pyriformis.
" 57, *line* 25 *from bottom, for* indicated, *read* indurated.
" 58, *line* 12 *from bottom, for* Bulimus, *read* Bulinus.
" 61, *side note, for* their, *read* thin.
" 62, *line* 9 *from bottom, for* Cpyriformis *read* Corbula n. sp. like C. pyriformis.

Note.—The lists of fossil molluscs given in this report are to be regarded as provisional only. These fossils will form the subject of a subsequent report by Mr. J. F. Whiteaves.

CC.

—

V.

REPORT ON PART OF THE BASIN OF THE ATHABASCA RIVER, NORTH WEST TERRITORY, BY ROBERT BELL.

ERRATA.

Page 6, *lines* 15 *and* 28 *from top, for* Isle, *read* Ile.
" 6, *lines* 5 *and* 6, *for* sixteen, *read* eight.
" 27, *line* 18 *from top, for* as up, *read* up as.
" 27, *lines* 5 *and* 17 *from bottom, for* Isle, *read* Ile.

Note.—The unconformability shewn in the wood-cut on page 19 c.c., is apparently only an instance of the false bedding so common in these sandstones.—A. R. C. S.

D.

—

VI.

REPORT OF GEOLOGICAL OBSERVATIONS IN THE SAGUENAY REGION.—J. C. K. LAFLAMME.

ERRATA.

Page 10, *line* 3 *from bottom, for* 270 *read* 275.

DD.

—

VII.

OBSERVATIONS ON LABRADOR COAST, HUDSON'S STRAIT AND BAY, BY ROBERT BELL.

(**DD.**)

PAGES

E.

VIII.

REPORT ON EXPLORATIONS AND SURVEYS IN THE INTERIOR OF GASPÉ PENINSULA AND PRINCE EDWARD ISLAND, BY R. W. ELLS, 1883.

(E.)

Prince Edward Island.

Gaspé Peninsula.

F. Devonian.

E. Silurian.

ERRATA.

In title add and Prince Edward Island.

Page 11 E, *for* Permo-Carboniferous H. G., *read* Permo-Carboniferous and Triassic G4, and H.

In Foot note page 18 E *add* 4 M. M.

F.

—

IX.

REPORT ON EXPLORATIONS AND SURVEYS IN THE INTERIOR OF GASPÉ PENINSULA, BY A. P. LOW, 1883.

G.

X.

REPORT OF EXPLORATIONS AND SURVEYS IN PORTIONS OF YORK AND CARLETON COUNTIES, NEW BRUNSWICK, BY L. W. BAILEY.

ERRATA.

Page 9, 11 *lines from bottom, for* Joy's, *read* Ivy's.
" 25, 13 *lines from bottom, for* chloride, *read* chlorite.
" 29, 18 *lines from top, omit* have.
" 30, 2 *lines from bottom, for* quartz-porphyric, *read* quartz-porphyry.

G G.

REPORT ON THE SURFACE GEOLOGY OF WESTERN NEW BRUNSWICK, WITH SPECIAL REFERENCE TO THE AREA INCLUDED IN YORK AND CARLETON COUNTIES, BY R. CHALMERS.

H.

XII.

REPORT ON THE GEOLOGY OF NORTHERN CAPE BRETON, BY HUGH FLETCHER.

Topographical Features.

ERRATA.

Page 4, 9 *lines from bottom, for* S. E. Burchell, *read* J. E. Burchell.
" 8, *last line for* below, *read* above.
" 12, 19 *lines from top, for* brooks, *read* brook.
" 17, *last side-note, for* Warre, *read* Warren.
" 18, 19 *lines from bottom, for* legdes, *read* ledges.
" 20, 21, 22, side-notes out of place.
" 25, 5*th side-note from top, for* Northwest, *read* Northeast.
" 29, 3rd, 4th, 5th and 6th side notes out of place. *Second part of foot note on this page should come in as foot note to end of first paragraph* p. 32.
" 30, 1*st line, for* schist, *read* schists.
" 31, 2*nd line from top, for* brooks, *read* brook.
" 31, 2*nd side-note, for* similating, *read* simulating.
" 33, last four side-notes out of place.
" 34, *foot note, for* page 174, *read* p. 14.

Page 38, 2 *lines from top, for* east, *read* south.
" 39, 18 *lines from top, for* quartz, felspathic, *read* quartzo-felspathic.
" 39, 13 *lines from bottom, for* beds, *read* bed is.
" 40, 20 *lines from bottom, for* McLennan, *read* McLellan.
" 40, 4 *lines from bottom, for* Angu's, *read* Angus.
" 41, 10 *lines from top, for* Doyles', *read* Doyle's.
" 63, 22 *lines from bottom, for* passed, *read* passes.
" 80, 21 lines from top, for *Vitis Idæa*, read *Vaccinium Vitis Idæa*.
" 91, 15 *lines from bottom, for* page 5, *read* page 8.

On several pages commas and stops are wanting or misplaced, and there are a few other small typographical errors. See pages 29, 30, 31, 33, 37, 39, 41, 44, 45, 50, 51.

J.

XIII.

REPORT ON APATITE DEPOSITS, OTTAWA COUNTY, QUEBEC, BY J. FRASER TORRANCE.

ERRATUM.

Side Note, page 32—*for* phosphates *read* graphite.

K.

—

XIV.

REPORT ON THE GOLD MINES OF THE LAKE OF THE WOODS, BY EUGENE COSTE, M.E.

ERRATA.

Page 6, *line* 12 *from bottom, for* Is the large *read* In the large.
" 9, " 8 *from top,* " Quarter *read* Greater.
" 9, " 14 " " Eighteen *read* Ten.
" 19, " 15 *from bottom,* " At the Thompson Mines *read* And the Thompson Mines.

L.

—

XV.

REPORT OF OBSERVATIONS IN 1883 ON MINES AND MINERALS IN ONTARIO, QUEBEC, AND NOVA SCOTIA. BY CHAS. W. WILLMOTT.

ERRATA.

Page 3,	*line* 6 *from bottom,*	*for*	Bennett *read* Brumell.
" 6,	" 7 "	"	Where there is *read* Were there.
" 8,	" 7 "	"	Fresh *read* First.
" 8,	" 8 "	"	Polished *read* foliated.
" 9,	" 4 *from top,*	"	" " "
" 9,	" 12 "	"	Into *read* With.
" 10,	" 13 *from bottom,*	"	Had penetrated them *read* been penetrated.
" 14,	" 19 *from top*	"	Picrotite *read* Picrolite.

M.

—

XVI.

ANALYSES OF COALS AND LIGNITES OF THE NORTH-WEST TERRITORY, BY G. C. HOFFMANN.

MM.

XVII.

CHEMICAL CONTRIBUTIONS TO THE GEOLOGY OF CANADA FROM THE LABORATORY OF THE SURVEY, BY G. C. HOFFMANN.

(MM.)

PLATES, MAPS AND SECTIONS IN THIS REPORT AND ACCOMPANYING IT.

IN REPORT.

ACCOMPANYING REPORT.

SUMMARY REPORT

OF THE

OPERATIONS OF THE GEOLOGICAL CORPS,

TO 31st DECEMBER, 1883,

AND

OBSERVATIONS ON THE WORK OF 1884.

Explorations and surveys have been carried on during the summer by a larger number of parties than any previous season. Occasionally they acted in concert, but for the most part, independently of each other. Their investigations have embraced geography, geology, mining, botany and zoology, in all of which much valuable and interesting material has been collected. When studied and arranged, the details will be given in the annual Report of Progress, and the value of the information will, I trust, prove commensurate with the increased expenditure that has been incurred. In the meantime, the following abstract reports of the work performed have been furnished by the officers in charge of the several parties, and are given in geographical sequence from the west. It may be observed that a large portion of the first six months of the year, now reported on, viz.: 1st January to 31st December, 1883, was occupied in the preparation of the reports just issued, forming a volume of 250 pages, R. 8vo, with 9 maps and 12 illustrations giving details of most of the work, up to December, 1882.

Nature of investigations.

My own work during the past summer from the 5th of July to the 1st November, consisted in a further examination of the northern shores of Lake Superior, from Port Arthur to the Pic River, including a visit to the Slate Islands, &c., also an examination of the Rabbit Mountain silver mine. The Jack Fish Lake, now called Huronian Mine, was also visited, and I have much pleasure in being able to say

Work of the Director.

that I consider it the most promising mining venture I have yet seen in this region. The lode is well defined and can be traced for a considerable distance to the south-west with an equally promising character, though yet undeveloped. On the 18th of August I proceeded to Rat Portage, where a few days were spent in company with Mr. E. Coste, examining the relations of the Huronian and Laurentian systems. Proceeding thence to Brandon, my attention was directed to an examination of the region south to the Turtle Mountains, including the Brandon Hills and the Souris River, from its junction with the Assiniboine upwards to Plum Creek, the main object being to ascertain the probability of the existence of beds of coal and the occurrence in the Turtle Mountain district of the lignite coal-bearing Tertiary rocks of the Upper Souris River, Roche Percée, &c. The evidence obtained clearly shows that there is every likelihood of workable seams being found here, as on the south flank of the mountain, at the head of Willow Creek, in Dakota, a seam has already been found shewing from 3 to 5 feet of lignite of fair average quality. This seam was visited and examined, and subsequently in range 20, 21 and 22, Township 2, a number of outcrops of strata quite similar to those associated with the coal south of the boundary were found. I was unable to verify the reports that have appeared, from time to time, in the local papers of seams of coal having been discovered in the sinking of wells in the townships on the north side of the mountain, but it would be very desirable to make some further investigations by boring to a moderate depth on the outcrops referred to. This could be done at a cost of about $5.00 per foot.

Returning to Brandon on the 24th of September, I proceeded west to Calgary and thence, *via* Morley and Padmore to the Cascade (Devil's Lake) River, at the base of Cascade Mountain, where the newly discovered seams of anthracite are exposed. The samples of these coals brought down are now being analyzed, and the result, with such further details as have been ascertained respecting the seams, will be given in the annual report to be prepared during the winter.* Cost of season's explorations $1,302.25.

BRITISH COLUMBIA AND NORTH-WEST TERRITORY.

Mr. Bowman's work in British Columbia.

In the southern interior portion of British Columbia, Mr. A. Bowman's work covered a large number of outlying areas, between the 40th and 52nd parallels of latitude. The work of the past summer, together with that of the summer of 1882, briefly noticed in the last report, has been directed to the accumulation of additional precise geographical and geological details, and these are now sufficient to jus-

* See Report M. of present volume.

tify the publication of a new edition of the map of this region, which was prepared by Dr. Dawson and published in the report for 1877-8. Additional interest now attaches to this area, as it is traversed throughout by the line of the Canadian Pacific railway, and its economic importance is therefore likely soon to be realized. The area to be covered by the map is about 30,000 square miles, lying between the 118th and 120th degrees of longitude and the 49th and 52nd degrees of latitude. The main points have been fixed from a series of carefully selected stations, by a system of transit and latitude observations, and these are connected and the intervening country delineated by careful track surveys, of which over fifty sheets are now ready for reduction.

Fossils were collected and geological sections examined on the Chilliwhack River, Harrison Lake and along the Fraser at several points, showing the position of the Cretaceous rocks in the axis of the coast ranges and on the Tulameen, South Similkameen and Tranquille Rivers, in proximity to noteworthy gold mining developments: also on the Ma-mit Lake plateau, Adams Lake and elsewhere. Cost of exploration including salary to 30th November, $2,187.53.

Dr. G. M. Dawson, assisted by Mr. J. B. Tyrrell, B. A., has been occupied during the past summer in the exploration of a portion of the North-West Territory, in the districts of Assiniboia and Alberta and in the Rocky Mountain range, partly on the eastern and partly on the western, or British Columbia slope.

Dr. Dawson's Work in the North-West Territories.

The month of June was entirely devoted to work on the plains, where a number of outlying points were visited for the purpose of completing the information for a map of the coal fields of the southern portion of Alberta. Mr. Weston accompanied Dr. Dawson during this part of the work, devoting himself principally to the collection of fossils and illustrative rock specimens. A large portion of these were afterwards unfortunately lost by the burning of the steamer "Glenfinlas," on which they were shipped from Port Arthur.

The months of July, August, September, and the early part of October, were spent in the Rocky Mountains, between the parallels of 49° and 51° 30′. The Crow Nest, North and South Kootanie, and the Kicking Horse and Bow River passes were explored geologically and geographically with considerable care. These passes afford an interesting series of sections, running in each case completely across the Rocky Mountain range. The great valley bordering the range on the west, in which the upper portions of the Columbia and Kootanie Rivers flow in opposite directions was examined in a preliminary manner for a length of about 200 miles. Some time was also spent in exploring the head waters of the North Fork of the Old Man River, and the Devil's Head valley north of the Bow.

Though the continued dense smoke produced by forest fires interfered much with the work, a preliminary knowledge of the geological and geographical structure of this part of the range, much in advance of that previously available, has been gained. If work can be continued in the same region next year, it should be possible to fill the gaps still remaining and construct a sufficiently accurate map of the whole district.

In connection with the work in this part of the Rocky Mountains, the existence has been proved of large tracts of coal-bearing Cretaceous rocks in the very heart of the range, of which the anthracite region of Cascade River is a special development.

In addition to the geological and necessarily concurrent geographical work, and the collection of fossils and rock specimens, a large collection of plants—chiefly due to the exertions of Mr. Tyrrell—has been made, together with other miscellaneous zoological collections of an interesting character. Over 100 excellent photographs, illustrating the character of the country traversed, were also obtained. Meteorological observations were kept up as regularly as possible, and over sixty points were fixed in latitude by observations. Cost of season's explorations $2,663.60.

Work of Mr. R. G. McConnell in the North-West Territory.

Mr. R. G. McConnell's field work extended over the country included between Medicine Hat and the eastern end of the Cypress Hills, the South Saskatchewan and the 49th parallel. The southern part of this area afforded a sufficient number of sections to enable the junctions of the various formations to be traced out with a tolerable degree of accuracy, but in the northern portion, their separation, owing to the thickness of the drift covering, was a matter of much greater difficulty, and even of some uncertainty.

In addition to the geological work proper, all the principal topographical features of the country examined were carefully mapped. About 1,800 miles of measurement, principally with the odometer, and also about 250 miles of river traverse, with estimated distances, was accomplished.

The most important fact brought to light during the summer's work was the existence of Tertiary beds in the Cypress Hills region, of later age than any which have yet been found in the North-West. These beds contain well-preserved mammalian remains, of which a number of specimens were collected. They are also underlain by a lignite seam throughout the whole extent of the Cypress Hills, which in some places shows five feet of fair fuel.

Horses stolen.

On the night of the 20th August, at Fish Creek, four horses were stolen from Mr. McConnell, which interfered to some extent with the progress of his work. Every effort has been made to recover them, but hitherto without success. Cost of season's exploration $1,924.47.

District of Keewatin (East of Lake Winnipeg).

A general knowledge of the geology of the whole country between Lake Superior and the Red River valley has been obtained by explorations made in different years, from 1869 to 1881. Owing to the discovery of the precious metals at the Lake of the Woods, it seemed desirable to have an area of the so-called Huronian rocks carefully worked out as a type of this system, as it occurs in the west. Dr. Bell was therefore instructed to commence a more minute examination than had heretofore been made, of the southern part of the district of Keewatin, including an actual survey of the shores and islands of the Lake of the Woods and of Shoal Lake, for the purpose of showing accurately the arrangement and distribution of the sub-divisions in that region, of the system referred to. Dr. Bell's work, Lake of the Woods, &c.

In pursuance of these instructions, Dr. Bell left Ottawa on the 2nd of July, and the next day he was joined at Toronto by Messrs. A. C. Lawson and J. W. Tyrrell, as assistants. Supplies, boats and men were secured on the way up, and the party reached Rat Portage on the 16th of July. Dr. Bell had made a general geological examination of the Lake of the Woods, Whitefish Bay and Shoal Lake in 1872, 1873 and 1881, and during the past season his own time was devoted principally to new work in the country lying to the northward of the line of the Canadian Pacific railway. The following is his report of the season's work:—

"While arrangements were being completed for our systematic survey of the Lake of the Woods, I visited the mining district of Big Stone Bay. Then having provided Messrs. Lawson and Tyrrell with everything requisite for carrying on the detailed survey of the lake, and seeing them well started with the work (Mr. Lawson taking the geological and Mr. Tyrrell the topographical), I went to Wabigoon, the starting point of my explorations to the northward. A track survey was first made of the route from Little Wabigoon Lake to Minnietakie Lake, thence the route leading to Lonely Lake was followed, of which a survey had been made in 1872. From Lonely Lake a similar survey was now made of the route and the lakes connected with it, *via* the English, Mattawa and Red Lake Rivers to Red Lake, the distances being checked by numerous observations for latitude.

"A very careful track survey was next made of Red Lake itself, as its shores proved to be of great geological interest. The whole lake (which is of considerable size) lies within a wide belt of Huronian rocks, among which several of the rarer varieties are well developed, and they were found to contain some interesting minerals. The narrow belt of Huronian rocks which, in 1872, we conjectured would pass a few miles to the northward of the junction of the English and Mattawa Rivers, was actually found in the position and with the strike it was then supposed to have.

"Returning to Lonely Lake, a track survey of this large sheet of water was made from one extremity to the other, including its numerous islands and deep bays. A long, narrow arm was discovered from its eastern part to a point on the Sturgeon Lake River below Minnietakie Lake. This arm was surveyed in a similar manner, in returning to Little Wabigoon Lake.

Examination of gold mines by Mr. Coste.

"During my absence on these surveys, Mr. E. Coste, of the Ecole Nationale Superièure des Mines (Paris), whom you had sent up to join my party, arrived at Rat Portage, and, agreeably to your instructions, proceeded to examine the various locations on the Lake of the Woods at which mining for gold had commenced. He collected a considerable number of specimens to illustrate the veins and their associated rocks. Upwards of forty samples of the ores from amongst these are submitted for assay.† On my return to Rat Portage, some of the mining locations which I had not previously examined were visited, and the geological and topographical work which was being prosecuted by Messrs. Lawson and Tyrrell was inspected and tested. In arranging the programme of work for the remainder of the season, at this time, I found it most advantageous in order to expedite matters, to hand my outfit at Wabigoon to Mr. Coste, with instructions to proceed thence to Rainy Lake, by way of the Manitou Lake and River. He was also to examine the large north-west bay of Rainy Lake, Rainy River and part of the Lake of the Woods. In addition to these examinations, if time permitted after his arrival at Rainy Lake, he was to examine the Seine arm of this lake, as far as Sturgeon Falls.

Survey of Winnipeg River.

"During the latter part of the season, in further pursuance of your instructions to descend the Winnipeg River and to re-examine the Huronian rocks of the southern shores of Lake Winnipeg and Big Island, where gold was reported to have been discovered, I made a track-survey simultaneously with the geological examination of the whole length of the Winnipeg River. Although you had made a preliminary reconnaisance of the lower part in 1872, and I had explored the upper part during the same year, a considerable intervening portion of it had, however, never been visited by any member of the survey. In making this survey, the distances were checked

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† See Report M.M. present volume.

by observations for latitude. The rocks were found to consist throughout of Laurentian gneiss with limited areas of granite and Huronian schists.

"On Lake Winnipeg, I was prevented from reaching Big Island by stormy weather, but the east shore of the lake was carefully mapped, from the mouth of the Black River to that of the Red River.

Work of Messrs. Lawson and Tyrrell.

"Before leaving Rat Portage, I had instructed Messrs. Lawson and Tyrrell, on finishing the work on the Lake of the Woods and Shoal Lake to proceed separately to make track-surveys of several canoe routes leading eastward and north-eastward of the former lake, and also certain traverses by land. Mr. Lawson was also to visit Shebaskong Bay and other places in the southern division of this lake. By thus dividing the party into four sections, each vieing with the others which could accomplish the most, a large extent of ground was rapidly covered, for I found on my return from Rat Portage that the other three sections had completed nearly the whole of the work prescribed, and had all arrived at the place of rendezvous on the same day.

"Only half a day was then spent in packing up our outfit, specimens, &c., and attending to business matters at Rat Portage, which we had made our headquarters for the season, and we left for the east on the 10th October, with the exception of Mr. Coste, who went westward, intending to proceed to Ottawa by way of Winnipeg and Chicago. The men were paid off at Sault Ste. Marie, and Mr. Tyrrell at Owen Sound. Mr. Lawson was continued at field work for a short time in the country to the northward of the head of Lake Ontario, in compliance with your desire to ascertain a few additional facts in order to complete for publication, my work of 1859-62, in the western peninsula of the province of Ontario.

"In conclusion, it may be stated that the results of the season's operations are to confirm the general mapping in 1873, of the distribution of the Laurentian and Huronian rocks of the above districts, and to add a large amount of accurate geological and topographical details to those which had been ascertained up to 1881, as shown upon the map accompanying my report of that year.

"In addition to the geological and topographical work, which has been briefly referred to, information was collected, as usual, in regard to such matters as the soil, climate, forests, fisheries, zoology and botany of the different districts examined. Photographs of places of interest were taken and numerous observations were made for the variation of the compass. Our collections consist principally of those of rocks, ores and mineral species; those of zoological and botanical specimens being necessarily limited, on account of the expedition with which we carried on the main objects which we had in view. The

Collections and photographs.

zoological collections consisted principally of the mollusks, and the botanical, of the ferns of the region, of which seventeen species were found. Cost of season's exploration including salaries of Messrs. Coste, Tyrell, Lawson and Cochrane to 30th October, $3,660.00.

QUEBEC.

Work of Mr. Ells, Quebec.

During the first half of May, Mr. R. W. Ells, accompanied by Mr. H. M. Ami, visited and examined certain localities along the Vermont boundary from Lake Champlain to Memphremagog, for the purpose of collecting further palæontological evidence on certain doubtful points, in relation to the horizon of some of the formations included in the Quebec group, in the vicinity of Highgate, Swanton. and Philipsburgh, and also to compare the crystalline rocks further east, in St. Armand, Sutton, and Brome townships, with those of the Shickshock Mountains in Gaspé. On the 6th of June Mr. Ells proceeded to the Bay of Chaleurs, accompanied by Mr. A. C. Barlow and N. I. Giroux as assistants, to continue and extend the work of previous seasons in that region and complete, if possible, the surveys of the heads of the various rivers which were partly surveyed by Sir W. Logan and Mr. Murray in 1844. The starting point for the work now contemplated was, therefore, about fifteen miles inland, at the forks of the Bonaventure River.

Mr. Ells reports on the work as follows :—

" After repeated delays from violent rains and heavy freshets, we reached the forks of the Bonaventure River, fifty-three miles from the mouth, where Mr. Murray had been stopped by the immense timber jams. We, however, cut portage roads past the worst, and cleared out the others, and thus succeeded in completing the survey of the main branch to the lake at its head or nearly to the waters of the Magdalen River. This gave us a section almost across the entire peninsula. We then returned to the forks and tried to ascend the other branches, but the water in them was so low and they were so badly jammed in all directions, that we found a micrometer survey, in canoes, impossible, and, therefore, returned to the mouth of the river. We thence ascended the Cascapedia to the forks previously surveyed by Sir W. E. Logan, and surveyed the Salmon Branch, or the direct branch, from Lake Cascapedia, in the Shickshock range. This is a very difficult stream to ascend, having a fall of 840 feet in 22 miles. It was measured to within four miles of the lake at its head, beyond the Serpentine Mountains, where our work in this direction was stopped by tremendous rains and lack of supplies, as well as by the difficult nature of the river. The limit of the Devonian and Silurian formations, and of the serpentine and their contact with the hornblendic and chloritic rocks, were fixed in this direction. Returning thence to the forks, we ascended the Lake Branch, which was struck by Sir Wm. Logan in his traverse from the Chat River, and surveyed the lake and the inlet for several miles, as far as was practicable on account of the low state of the water and the presence of timber jams. We then surveyed the western branch or Miner's Brook for twenty-seven miles to the head waters of the Casupscull River and the vicinity of Lake Matanne. From a point on the Miner's Brook, five miles from its mouth, a portage of two miles and a half leads to the great elbow of the Chat River. All these streams take their rise in great alder swamps, and we found a large plateau occupied by Devonian strata, having a breadth of ten to fifteen miles, and extending almost the entire distance from the vicinity of Matapedia Lake to the extremity of the Gaspé peninsula, embracing an area of some 1,500 square miles, having a fine agricultural soil, good timber, and well suited for settlement, unless summer frosts may prevail. We had none of any account while we were in that vicinity, up to the 15th of August, though on the upper waters of the Bonaventure severe frosts were common about the 15th of July. This plateau or table-land has an elevation by aneriod of about 650 feet above sea.

"Having completed, as far as practicable, our surveys on the heads of the Cascapedia, we went, on the 15th August, to Gaspé, for the purpose of completing the survey of the upper part of the York River. We, however, found the upper part of this river to be impassable for canoes on account of the low state of the water, and we could only ascend a distance of twenty-five miles, and were therefore obliged to return without completing our survey. Thence I proceeded to the Grand Pabos, and measured that stream by pacing for about fifteen miles in order to determine the northern limit of a Cambro-Silurian basin which had a considerable development before unsuspected. By the time this survey was completed the water in the various streams had become so low that further expeditions in canoes became impossible, and a few days were spent in collecting fossils from various points along the north side of the Bay of Chaleurs. My assistant, Mr. A. E. Barlow, had, in the meantime, made large and valuable collections in the vicinity of Percé and Gaspé.

"The latter part of the season was devoted to the examination of the geology of Prince Edward Island, with a view to ascertain more definitely the relations of the so-called Permo-Carboniferous to the Triassic, aud also to determine the limits and probable value of the gold-bearing strata lately discovered at Cape Wolf. The greater part of the island was traversed and the shore examined from Cape North along the south and east coast to Orwell Bay. Samples of the so-called gold ore were collected, and have been assayed in the survey labora- Prince Edward Island.

tory, with the showing of a very small percentage of gold, (.044 ounces to the ton.) The assays held by the company at Charlottetown show from $15 to $20 per ton. Similar rock to that assayed can be found all along the coast as far as examined, from Cape North to Cape Traverse, and the prospects for successful mining are apparently as good at one point as the other.

"The work of the past season, together with that of 1882, has now been plotted and is being embodied in the map sheets, the continuation of those already published of New Brunswick and southern Gaspé. Of these, nine quarter sheets, covering 13,500 square miles, are in preparation, the greater part of which will soon be ready for the engraver."

Returned to Ottawa, October 6th.

The amount expended during the season, including the trip to Highgate and Magog, was $2,095, of which $100 was spent in the trip with Mr. Ami. Of the balance $450 was spent in salaries of assistants, to November 1st; $617 for canoe men, and the balance for travelling and incidental expenses.

Work of Mr. Low, Gaspé Peninsula.

In pursuance of instructions to continue the exploration of the Gaspé Peninsula, Mr. Low, accompanied by Messrs. Porter and Hamilton, as assistants, left Montreal on the 25th of May and proceeded to Quebec, remaining there three days making copies of Crown Land plans.

Leaving Quebec he arrived at Matanne on the 3rd of June, and was employed collecting fossils in the rocks of that locality until the 6th. Ste. Anne des Monts was reached on the 7th. Being unable to proceed up the river on account of the freshet, a base line, a mile and a quarter long, was accurately measured along the coast, and from it the positions of three peaks, in the Shickshock range, were determined. On the 20th of June he proceeded up the river to the forks, distant thirty-two miles.

Here the work of the season commenced. A survey of the south branch was made as far up as the lake at its head. And having returned to the forks on July 4th, where a store camp had been established, the summit of Mount Albert, one of the highest peaks, was reached next day. Here a base line about four miles long was measured, from which the positions of 160 peaks were fixed.

While Messrs. Hamilton and Porter were engaged running this base line, and collecting some rare alpine plants, Mr. Low made some paced surveys down the brooks which rise in the neighborhood. These afforded good sections of the pre-Cambrian rocks on the flanks of the mountain. After much delay, caused by rain and fog, the work on Mount Albert was finished, and the dépôt at the Forks again reached on the 20th of July. Leaving his assistant to make surveys of several brooks on the north side of the river, Mr. Low descended to

Ste. Anne to obtain a fresh supply of provisions and also to compare his barometer with that of Mr. Vibert, of Ste. Anne, who kindly kept readings all summer, thus facilitating the determination of the heights of the mountains ascended during the season.

Having returned to the Forks on the 26th of July, the summit of Table Top Mountain, about ten miles distant, was reached next day, and two days were spent there examining the rocks. A micrometer survey was then made of the west branch of the Magdalen River, from the lake at its head, as far as the Forks, a distance of about twenty miles.

While this survey was being made, Mr. Hamilton remained on the mountain and triangulated about twenty-five additional peaks.

After these surveys were completed, the Forks of the Ste. Anne were again reached, and from there, descending the river, offset surveys were made up the larger tributary brooks on both sides.

On one of these brooks, Mr. Low had the misfortune to strain his knee and was obliged to return to Ste. Anne, leaving Messrs. Porter and Hamilton to finish the work. Having completed this, they reached the mouth of the river on the 19th of August, and, as their services were no longer required, they returned by steamer to Montreal on the 22nd, taking with them all the specimens collected during the summer. The next week was spent making a rough survey of the Cape Chatte River and examining the rocks found along it. On account of the low state of the water, the river could only be ascended thirty miles.

On the 30th of August, a traverse from Ste. Anne to New Richmond, by way of the Ste. Anne and Little Cascapedia Rivers, was commenced. This occupied eighteen days, and was rendered very difficult on account of the number of timber jams met with in the upper part of the Little Cascapedia. A quantity of good land was observed on this river, about twenty-five miles from its mouth, which would make fine farming land if early frosts do not interfere.

Much valuable timber was also observed along the river, although not of very large size, and composed chiefly of white spruce, balsam, fir, white and yellow birch, poplar, cedar and a few pine. Timber.

Arriving at New Richmond, Mr. Low proceeded to Dalhousie, where he was joined by Mr. A. E. Barlow. After spending several days here, collecting specimens, he proceeded to Lake Matapedia, where careful examinations of the rocks on the east side were made. These examinations, and a few surveys in the neighborhood of Rimouski, finished the field work, and Ottawa was reached on the 8th of October.

The work was much delayed by rain during June and July, few days passing without rain during some of the twenty-four hours, and on three occasions delays of a week were caused by the freshets in the rivers.

Expenses of the season amounted to $1,398.

Examination of apatite mines by Mr. Torrance.

It being considered important to obtain more definite and detailed information in connection with the distribution and mode of occurrence and association of the valuable apatite deposits north of the Ottawa, in the townships of Hull, Wakefield, Templeton, etc., and also regarding the location, extent and character of the various worked mines and openings on these deposits, on the 17th of May Mr. Fraser Torrance was requested to commence this work.

From his preliminary report, he appears to have encountered unexpected difficulties and delays, to such an extent, indeed, that very little progress seems to have been made in the actual survey and mapping of the region. A number of mines were visited and located and specimens collected, and Mr. Torrance concludes his report with the following romarks :—

" The season's work does not seem to have thrown any fresh light on the question of the origin and character of these peculiar deposits. Nowhere on the Lièvre River did I see a single deposit that I would venture to pronounce, undoubtedly, a true fissure vein. But it is equally true that these deposits were not observed anywhere presenting the usual appearance of beds. In fact, no two pits in the whole region examined present the same phenomena. The deposits seem to be highly irregular seggregations from the country rock, which is usually a pyroxenic gneiss."

Mr. Torrance was assisted by Messrs. W. H. Howard and W. J. Torrance, and was in the field from the 4th of June to the 10th of October. He has since visited the mines of Messrs. Wilson and Moore, in Hull Township, and the Union Mines on High Rock, on the Lièvre River. A detailed report is being prepared.*

Work by the Rev. Professor Laflamme.

The Rev. Professor Laflamme, of Quebec University, was so good as to continue, for the Survey, at my request, certain investigations he had himself commenced the previous season, in the valley of the Saguenay River and Lake St. John, in connection with the distribution of the Archean and Palæozoic rocks in that region. He has thus added considerably to our knowledge, especially in regard to the Cambro-Silurian formations which there overlie the Laurentian gneisses, and are, he states, in some places strongly impregnated with petroleum. Professor Laflamme has furnished a detailed report, which will appear in the annual volume now in preparation.†

* Report J. this volume.

† Report D. this volume.

The only other exploration last year, in the province of Quebec, was undertaken at the urgent request of residents in the vicinity of Three Rivers, where inflammable gas had been observed issuing from the ground and from springs. This occurrence was locally supposed to indicate extensive sources of petroleum, and a shaft was sunk with a view of testing the correctness of this idea. The site selected was where, in 1879, the calcareous pipe of an extinct spring, now in the Museum of the Survey, had been discovered. Lot 20, St. Alexis, parish of St. Maurice, county of Champlain, seven miles north of Three Rivers. The work was superintended by Mr. L. M. A. Genest, of Three Rivers, and consisted in sinking a shaft which, after passing through 48 feet of the ordinary clays and sands, &c., of the boulder drift that covers a large portion of the region, struck the solid Trenton limestone formation, which, as is well known, underlies the whole of the country along the north shore of the St. Lawrence, from Montreal to Quebec. It is highly improbable that any practically valuable result would be obtained by further sinking in this formation, notwithstanding the not infrequent local impregnation with petroleum of some of the strata of the Trenton formation, a fact long since noticed and described by Sir W. E. Logan,* as were also† the springs emitting the inflammable carburetted hydrogen gas, which has recently attracted the attention of the residents of Three Rivers. Investigation of gas well at Three Rivers.

NEW BRUNSWICK.

In New Brunswick the work has been continued, during the past season, under the supervision of Professor Bailey. His own work in the field extended from the 1st of July to the 1st of October, and that of his assistants, Messrs. McInnes and Chalmers, from the same date to the 31st of October. The attention of Professor Bailey and Mr. McInnes was directed chiefly to observations required for the ¼-sheet map, No. 1, N.W., embracing portions of the counties of York and Carleton, commenced in 1879 by Professor Bailey and Mr. Broad, and further advanced by the latter in 1880 and 1881. This map is now ready for the engraver. It covers an area of 216 square miles, co-terminous with that embraced in the ¼-sheets already published. The details of the season's work will be given in the report now being prepared,‡ including that of Mr. Robert Chalmers, whose attention was directed to the surface geology and physical features of the region embracing the valley of the St. John River, from Fredericton to Edmunston, in the county of Madawaska ; also, the valley of the Work of Professor Bailey and assistants in New Brunswick.

* Geology of Canada, 1863, p. 521.
† Ibid, chapter xviii.
‡ Reports G. and G. G. this volume.

Becaguimic, Shiktehawk, Tobique and other eastern tributaries of the St. John, and westward from the latter to the Maine frontier. Mr. Chalmers paid particular attention to the nature of the soils in the districts examined, in relation to their forest growth and suitability for settlement. The cost of the season's explorations was $1,394.96, including salaries of Professor Bailey and Mr. Chalmers.

NOVA SCOTIA.

Mr. Fletcher's work in Eastern Nova Scotia.

In Nova Scotia the work was continued by Mr. Hugh Fletcher. He left Ottawa on the 5th of June, 1883, and spent several days re-examining the Chimney Corner, Broad Cove and Port Hood coal fields, in order to obtain, if possible, a more definite idea of their geological relations by the facts developed in the mining and exploration recently done at these places. At Chimney Corner, Mr. Thomas Evans has re-opened the old workings and extracted a considerable quantity of coal, which he has shipped to Prince Edward Island and elsewhere. No regular mining has been done at Broad Cove, although it was at one time hoped that this mine was about to be re-opened by an American company. Several new openings have, however, been made by Mr. James Wilson, of Broad Cove, on the 7 and 14-feet seams. The want of harbours and of a railway retards mining as well as other branches of industry on the western shores of Cape Breton.

Between June 18th and October 17th, a minute survey and examination was made of the district lying between Country Harbour River and Cape Canso. In its eastern part this district is a wilderness of rocks, interrupted only by a few clumps of second growth spruce and hardwood, and by small clearings made with great labor around the coves and inlets. It is dotted with lakes full of trout, and is underlaid for the most part by grey granite.

From the valleys of Isaac's Harbour, Salmon, and other rivers further west, large quantities of *ship* and *ton* timber have been obtained, but here also the greater part of the country is unsettled, and the soil rocky and poor. On the Cape Canso peninsula westward to Tor Bay and Guysborough, there are no roads worthy of the name, except that from Guysborough to Canso, and another constructed by the direct Cable Company from Guysborough to Tor Bay. The settlements are mostly around the harbors and inlets of the coast, and are occupied by fishermen, who travel chiefly by boats. The shore is deeply indented, especially on the south, and guarded by numerous rocks, reefs and islands; inland it is nowhere high, and the brooks are consequently sluggish and interrupted by lakes and "stillwaters."

The prevailing grey granite comes boldly to the shore in the neighborhood of Cape Canso, but generally the shore of Chedabucto Bay is occupied by more or less slaty rocks, separated from the granite by a narrow belt, sometimes of gneiss, sometimes of staurolite rock. The granite also extends brokenly to the westward. From a short distance east of Isaac's Harbour, the gold-bearing rocks extend westward along the shore, although interrupted in many places by the granite. Within this district lie the gold fields of Isaac's Harbour and Stormont. At the former, the Gallagher Company is vigourously working a vein or "lead" which has produced a large quantity of gold. To the north of the granite, lie the metamorphic and igneous Devonian rocks, which have already been described as occupying the greater part of Madame Island and the country between Chedabucto Bay and the Strait of Canso. The southern boundary of these formations extends from the mouth of Salmon River towards Melrose, the river forming the boundary for several miles, and their unconformable contact with the Carboniferous, is to he seen at Guysborough Harbour.

The surveys in Guysborough county referred to above have been plotted and are now being reduced; and a map of this area will be ready for publication next spring. The maps of the counties of Richmond, Victoria and Inverness are already in the hands of the engraver and will soon, it is hoped, be ready for publication. These maps cover an area of about 4,000 square miles.

Area of maps preparing for publication.

Mr. Fletcher was assisted during the whole season by Messrs. John McMillan and Rodolphe Faribault, and during part of it by Messrs. J. A. Robert, W. T. McLeod and D. McKinnon. Mr. McMillan was engaged till the end of November collecting specimens of the copper, iron and manganese ores of Cape Breton county for the Museum; and Mr. Faribault, during the same period, was tracing railway and other plans in Halifax, for which every facility was afforded him through the courtesy of Mr. Austen, of the Crown Lands Office and Mr. E. Gilpin, Inspector of Mines.

PALÆONTOLOGY AND NATURAL HISTORY.

Palæontological publications.

In this section, Mr. Whiteaves has written the letter press and superintended the illustrations of volume three, part one, of the "Palæozoic Fossils" of Canada. Six out of the eight lithographic plates required have been printed off; the manuscript was given to the printer in December (1883), and the report will probably be issued in February, 1884. When complete, this report will consist of about fifty pages octavo of text, with eight lithographic plates and a few wood cuts, and will contain descriptions of new, imperfectly characterized or previously unrecorded species of fossils from the Guelph formation of Western Ontario. Its preparation has necessitated a previous examination and study, not only of the large collections of fossils from this formation in the museum of the Survey, which have accumulated since 1865, including some five or six hundred specimens recently obtained from Mr. Townsend, of Durham, Ont., but also of the series in the Redpath Museum at Montreal, and of specimens loaned by the trustees of the Elora School Museum, and by the authorities of Queen's College, Kingston.

Mr. Whiteaves also reports that about one-third of the text of the third and concluding portion of the first volume of Canadian "Mesozoic Fossils" has been written, and that the volume will probably be completed early in the spring. The drawings required for its illustration are nearly all mad , and four of the lithographic plates have been printed off.

The extensive series of invertebrata from the Laramie and Cretaceous rocks of the Bow and Belly River districts, collected by Dr. G.M. Dawson, in 1881, and by R. G. McConnell, in 1882, has been subjected to a preliminary examination, and the whole of the specimens from the Hamilton formation of the Devonian system of Ontario, in the possession of the Survey, including the rare specimens recently presented by the Revs. Hector Currie and J. M. Goodwillie, have been studied critically, and most of the species, new to that formation, have been identified. For about four months of the present year, as in 1882, the director of the Survey has been occupied in field explorations, and during his absence from Ottawa on each of these occasions the position of acting director has devolved upon Mr. Whiteaves. The remainder of Mr. Whiteaves' time has been devoted to the direction and supervision of the work in this section of the museum.

Mr. Foord prepared a report entitled, "Contributions to the Micropalæontology of the Cambro-silurian Rocks of Canada," which has been published during the year. It embodies the results of his recent studies on some of the Monticuliporidæ and corals of these rocks, and consists of twenty-two pages of text octavo, illustrated by seven lithographic plates. He applied for and obtained leave of absence for four months, dating from the 1st of June, and at the expiration of that term, resigned the appointment he held on the staff of the Survey.

Work of Mr. Weston.

From January 1st to May 20th, Mr. T. C. Weston was occupied in making and mounting some 300 microscopical sections of rocks and fossils, in mending and preparing for exhibition in the museum, a number of fossil bones collected by Dr. G. M. Dawson and Mr. R. G. McConnell in the North-West, and in making arrangements for his own field work. The months of June, July and August were spent in the North-West. The principal localities visited were the Cypress Hills, Milk River Ridge, Old Man River, Waterton River and Lake, Pincher and Mill Creeks, Scabby Butte, the South Saskatchewan River, &c., &c.

Hand specimens of most of the typical rocks of these localities, and samples of many of the clays and silts, as well as about 1,600 fossils, were collected. These were carefully packed in twelve boxes and shipped when favorable opportunities occurred. Three of these boxes, however (which contained a very important collection of fossils, rocks, skulls, &c., from the Cypress Hills and Milk River district) were, unfortunately, lost on the steamship "Glenfinlas." The following is approximately the number of specimens of fossils and rocks collected, exclusive of those which were lost:—

60	Fossil plants from Mill Creek.
7	" " " South Saskatchewan.
56	" " " Scabby Butte.
15	" wood " " "
80	" shells, &c., from St. Mary River.
229	" " " " Old Man River.
329	" " " " Pincher Creek.
156	" " " " South Saskatchewan.
60	" " " " Old Man River.
983	Fossils.
78	Rock specimens from various localities.

On the 17th of September, Mr. Weston visited the South Joggins coal field and made an interesting collection of its fossil plants. The rest of his time has been spent in labelling the specimens collected during the summer, and in museum work.

Considerable progress has been made in the classification of the fossils in the museum. The whole of the species from the Trenton, Utica, Galena, Arisaig, Lower Helderberg and Oriskany formations have been re-arranged and labelled by Mr. H. M. Ami, under the supervision of Mr. Whiteaves. The nomenclature of all the fossils from these formations has been revised, and new labels for each species have been printed. The post pliocene fossils of the provinces of Quebec and British Columbia have also been re-arranged and labelled. The fossils of the Hudson River and Guelph formations have been re-grouped, and the manuscripts of the labels required for them have been prepared and sent to the printer. The fossil plants from the upper Cretaceous rocks of Pine River Forks, B. C., and Vancouver Island, and from the Tertiary deposits of Quesnel, the Similkameen River, and other localities in British Columbia, described by Principal Dawson in the first volume of the "Transactions of the Royal Society of Canada," have been placed on exhibition in their proper places in the museum.

Classification of palæontological collections.

Several collections of fossils received during the year from various formations and localities have been examined by Mr. Ami, and the species determined as far as practicable. Early in the summer, Mr. Ami visited St. Armands and Phillipsburg, Q., also the vicinity of Highgate Springs and Swanton, near the boundary line in Vermont, and made collections of fossils at each of these localities. Later in the season he collected fossils at Thedford, Bartlett's Mills and Ravenswood, O., in the Hamilton formation (Devonian), at Kettle Point, Lake Huron, in the supposed equivalents of the Gennessee slates, at Guelph, Elora, and Durham, O., in the Guelph formation (Silurian), and at Whitby, in the Utica formation (Cambro-Silurian). Three collections of fossils have been made and sent to private collectors in Canada, in return for valuable specimens presented by them, and a full record of all additions to the Museum has been kept. Some five or six hundred specimens of Mesozoic and Palæozoic fossils have been collected by Dr. G. M. Dawson and his assistants at several localities between Maple Creek, Alberta district, and the Rocky Mountains, also in the mountains themselves, from the boundary line northward to the Kicking Horse Pass. A series of mammalian bones of unusual interest, including jaws of a large species, apparently nearly allied to *Brontotherium*, has been obtained by R. G. McConnell. Twelve boxes of Palæozoic fossils from various places in the Gaspé peninsula have been received from R. W. Ells and his assistants, and Professor Macoun has collected a number of fossils and a few recent mollusca from the island of Anticosti.

The number of donations to this branch of the Museum during the year has been unusually large and important, as may be seen by the following list:—

Her Royal Highness the Princess Louise.

Presentations to the Museum, Biological section.

Fine example of the *black variety* of the common wolf (*Canis lupus*, L.), from Port Simpson, B.C.

Specimen of the porcupine fish (*Paradiodon hystrix*, L.), from Bermuda.

A horned toad (*Phrynosoma cornutum*), from Sherman, Texas.

An embryo shark.

Specimen of the black-lipped conch shell (*Cassis tuberosa*), L.) of exceptionally large size, from the West Indies.

Pancake coral (*Mycedium fragile*, Dana), from Bermuda.

His Excellency the Marquis of Lorne.

Pair of rough-legged buzzards (*Archibuteo lagopus*).

Flying squirrel (*Sciuropterus volucella*, L.), from the Rideau Hall grounds.

Indian dress from the North-West Territory.

A number of sharks' teeth, etc., from the Miocene phosphatic deposits of South Carolina.

Specimen of fossil rootlets (*Stigmaria ficoides,* Bgt.), from the "underclays" of the coal measures in Nova Scotia.

COLONEL BERNARD, OTTAWA.

Specimen of coralline limestone, seven keratose sponges, six crabs, one dark colored variety of the black-lipped conch shell (*Cassis tuberosa*), L.), seeds of *Eriodendron*, etc., and a number of small shells. All from the Bahamas.

COLONEL C. C. GRANT, HAMILTON.

Sixty specimens of Silurian fossils from the Clinton and Niagara formations at Hamilton, Ont.

A. J. HILL, ESQ., C.E., BRITISH COLUMBIA.

Six specimens of wood, showing the burrows of the ship-worm (*Xylotrya*) of the Pacific coast.

Numerous alcoholic preparations of mollusca and asteriadæ from British Columbia.

F. N. GISBORNE, ESQ., F.R.S.C., OTTAWA.

One (dry) specimen of *Astrophyton agassizii*, Simpson, from the Gulf of St. Lawrence.

S. CASTLEMAN, ESQ.

Stone gouge and stone adze, from Casselman, O.

W. R. BILLINGS, ESQ., OTTAWA.

Two specimens of *Receptaculites occidentalis,* Salter; one *Astylospongia parvula,* and thirteen specimens of sponges, from the Trenton limestone of Ottawa, O.

W. H. MCINTYRE, ESQ.

One specimen of the great white egret (*Herodias egretta,* Gray).

REV. HECTOR CURRIE, B.A., THETFORD, O.

Specimens of blastoids and crinoids from the Hamilton formation of western Ontario.

REV. J. M. GOODWILLIE, M.A., NEWMARKET, O.

Sixteen fossils from the Hudson River formation of Weston, O.

W. R. SMITH, ESQ., BELLEVILLE.

Eight species of fossils from the Trenton limestone at Belleville, O., retained out of a series of thirty-two species sent for examination.

J. S. Brough, Esq.

One specimen of *Trimerella acuminata*, Billings, from the Guelph formation of Elora, O.

BOTANY.

Respecting the work in this section, Professor Macoun reports as follows:—

Botanical investigations by Professor Macoun.

"During my studies last winter, it became apparent that a very superficial knowledge of the flora of Nova Scotia, Prince Edward Island and Anticosti had been obtained by local botanists and other collectors. It was therefore considered desirable to examine as much as possible of these areas during the summer. I am happy to state that the results are far in advance of our most sanguine expectations, and much more correct views can now be arrived at in regard to the geographical distribution of many species. Along the outer coasts of Nova Scotia and on the islands in the Gulf, there are remnants of a flora more closely related to that of Greenland and Europe than has been hitherto suspected.

"I left Ottawa on the 6th of June, and reached Truro, in Nova Scotia, on the 9th. A week spent there enabled me to make a very complete examination of the flora of the vicinity, both cryptogamic and otherwise.

"Six hundred and forty-nine species were noted, and specimens were collected of all that were fit. On the 16th I proceeded to Halifax, where, in the space of four days, numerous discoveries and large collections were made. Between the 21st and 30th of June, Yarmouth, Digby, Annapolis, Kingston, Kentville, Cape Blomidon and Windsor were visited. On the 3rd of July I was at Bedford, on the 4th at Truro, and on the 5th and 6th at Pictou. Between the 7th and 23rd of July I visited the Straits of Canso, Sidney, Louisburg, Baddeck and Whycocomagh. In all of these localities, discoveries and large collections were made. Leaving Nova Scotia on the 24th of July, I proceeded to Quebec, hoping to obtain a passage to Anticosti by the "Napoleon III.," but did not succeed in doing so, and therefore returned to Gaspé Basin, and there hired a schooner to take me to Anticosti. We reached the Island on the 9th of August, landing at Salt Lake, and commenced collecting the same day. Hitherto, only 211 species of flowering plants had been recorded from Anticosti. These were all found in less than two days. South-West Point was next examined; Jupiter River was ascended for twenty miles, and Gunn, St. Mary and Becsie Rivers were visited. We were detained by head winds for five days at the latter, which was ascended to a lake about six miles inland. At all these points collections were made, including

Anticosti Island.

fossils and recent shells from some of them. The unfavorable weather continuing, I started on foot for Ellis Bay, and the following day reached English Bay, at the extreme western end of the island, having walked thirty-seven miles in the teeth of a north-west gale. On the 12th of September, I left English Bay and returned *via* Gaspé Basin and Quebec to Ottawa. About two weeks were then spent collecting fungi around Ottawa, and ten days in the county of Northumberland, where over one hundred species, not seen around Ottawa, were collected. This work is preparatory to the publication of a complete standard catalogue of Canadian fungi in which, as far as practicable, the edible and poisonous species will be noted."

During the year the first part of the catalogue of Canadian plants, Polypetalae referred to in my last report was published in a volume of 192 pp. R. 8vo.. Part II., Gamopetalæ is now being prepared and will be ready for publication in the spring. Catalogue of Canadian plants.

In June last I was authorized to purchase for the museum, Professor Macoun's private collection, consisting of 1,745 genera and 7,000 species of Canadian and United States plants.

Chemical, Mineral and Lithological Sections.

The work carried out in the chemical laboratory during the past year has been almost solely confined to the examination and analysis of such minerals, &c., &c., as were deemed likely to prove of economic value. Work in the laboratory.

It included :—

1. Analysis of an extensive series of coals and lignites from the North-West Territory.
2. Analysis of iron and copper ores.
3. Gold and silver assays.
4. Qualitative analysis of waters—mineral and otherwise—and numerous miscellaneous examinations.

Upwards of 200 mineral specimens have been received—brought or sent—for identification and information in regard to their possible economic value. Apart from the time devoted to personal interviews in this connection, it further entailed the writing of some seventy letters, which, in a great many cases, partook of the nature of reports.

Besides assistance rendered in the laboratory, Mr. J. D. Adams has devoted a portion of his time to lithological investigations; he was also engaged during the summer in field work, having spent about two months and a-half in examining the area of anorthosite rocks, about Lakes St. John and Kenogami and the discharges of the Saguenay. Lithological investigations by Mr. Adams.

The Assistant Curator of the mineralogical section of the museum, Mr. C. W. Willmott, was engaged during the earlier portion of the year in sorting, arranging and cataloguing the contents of a large number of boxes of minerals, thereby rendering the same readily accessible for making up collections for educational institutions. Ten such collections were arranged, catalogued and distributed during the past year, comprising in all some 1,000 specimens of rocks and minerals.

Visits to mining locations.

During the summer months he visited a number of localities in the provinces of Quebec, Ontario and Nova Scotia, for the purpsse of collecting minerals and acquiring such information in regard to mines and mineral localities as opportunity might afford. The collections made embrace abont ninety species, some of which were not previously represented in the museum, and others advantageously replacing inferior specimens. Since his return, he has been engaged in unpacking and sorting these specimens, also in numbering and assisting to arrange the museum collection. He has, throughout, been ably assisted by Mr. H. G. Brumell.

Mr. K. L. Broadbent has been unremittingly engaged in labelling the various specimens in this section of the museum. He has applied himself to the work with great assiduity and success, and, as a consequence, what may be regarded as most satisfactory progress has been made in this direction.

Presentations to the Museum.

Presentations as follows have been made, to the Mineralogical section of the Museum during the year 1883 :—

Messrs. Haldane & Sons, Aylmer, apatite.

Messrs. McIntyre & Co.—Native silver.

J. Robertson, Ottawa—Crystals of pyrite.

The Marquis of Lorne—Disseminated graphite, and agate pebbles.

J. G. Miller, Ottawa—Stalagmite and Stalactite from the Island of Mona, West Indies.

Isaac Moore, Ottawa—Crystals of Apatite and pyroxene.

Captain Deville, Ottawa—Selenite and clay iron stone.

W. F. Ferrier, Montreal—Willemite, tincite and franklinite.

H. K. Lea, Ottawa—Asbestos and titanite.

W. Sheppard, Aylmer—Stibnite, galena, auriferous quartz, 2 sp. specular iron ore on mica.

T. C. Keefer, Ottawa—Sphalerite, argentite with native silver.

C. T. Moseley, Sydney, C. B.—Pyrolusite.

Fenwick & Sclater, Montreal—Asbestos mill-board and asbestos packing.

C. Jennison, Beaver Brook, Colchester Co., N.S.—Gypsum.

C. & M. E. Iron Co., Salmon River Lakes, Guysborough Co., N. S.—Micaceous iron ore.

G. Cameron, Roman Valley, Guysborough Co., N. S.—Micaceous iron ore.

Wylie & Hall, Carleton Place, O.—Magnetite.

LIBRARY.

During the year ending 31st December, 1883, the number of the publications of the Survey which have been distributed is 671; of these 636 were in English and 35 in French. 375 were sent to institutions and persons in Canada, the remainder, 296, to scientific and literary societies in the United States and other parts of the world. In return for these, 411 publications were received, including books, transactions. memoirs, periodicals, pamphlets and maps.

Forty scientific magazines and periodicals have been subscribed for, a list of which will be found in the Annual Report.

Forty-eight volumes have been added to the Library by purchase.

During the year 406 volumes have been bound.

VISITORS.

It is gratifying to report that the popularity of the Museum appears to be increasing. In 1882 there were 9,549 visitors. During the same period in 1883, viz., from the 1st January to the 31st December, there have been 11,093 names recorded in the register,

Insufficient accommodation.

The want of more accommodation, referred to in my report for 1881 and 1882, I regret to say, still exists, and in a constantly augmenting degree, no steps having been taken to carry out the suggestions which were then made respecting it. An outlay of from $10,000 to $15,000 would probably suffice to make, in the present building, all the space which would be required for some years to come. Better light would be secured, and the external appearance of the building greatly improved.

STAFF, APPROPRIATION AND EXPENDITURE.

The strength of the staff at present employed is forty-eight, viz.: professional, thirty-four; ordinary, 14.

Changes in the staff.

The following changes have occurred during the year. Mr. Broad resigned on the 9th May, and Mr. R. G. McConnell was promoted to the vacancy, Mr. J. B. Tyrrell filling Mr. McConnell's place. Mr. Arthur H. Foord, Artist and Assistant Palæontologist, resigned on the 20th August, after three months leave of absence.

The following were appointed from the 1st of July:—

Mr. Henry M. Ami, 2nd Assistant Palæontologist, Mr. Rodolphe Faribault, Surveyor and Explorer: and Mr. Henry P. Brumell, as Museum Assistant.

Appropriation.

The appropriation for the fiscal year ended 30th June, 1883, was $60,000, against which the whole expenditure for the Geological and Natural History Survey and for the maintenance of the Museum is charged, including salaries and wages of all employés.

The expenditure may be summarized under the divisions named, as follows :—

Pay-list, salaries, and wages	$32,682.86
Exploration and survey, including travelling charges, purchase of horses and equipment	13,941.60
Printing and lithography	2,440.16
Purchase of specimens	2,888.22
Purchase of books and instruments	1,963.04
Chemical and laboratory apparatus	275.64
Stationery	455.72
Fuel	604.95
Incidental and other expenses, including Museum and Office fittings, &c	2,585.29
	$57,837.48

Correspondence.

The correspondence of the Branch shows 2,031 letters sent, and 1,845 received.

OTTAWA, 31*st December*, 1883.

The foregoing summary report was published in January, 1884, as Part III. of the annual report of the Department of the Interior. The detailed reports of some of the investigations referred to in it will be found in the present volume, while before giving the conclusions of others more extended survey and further study are required. Thus in reference to the Lake of the Woods region, Mr. Lawson writes : "The work of one season has proved quite inadequate to enable me to report coherently upon so important a series of rocks as the Huronian of the Lake of the Woods, and the topography of the region is still incomplete." It is proposed, therefore, to devote another season in the field to the completion of the topography and geology of the area under investigation which lies within the limits of longitude 94° 2′ and 95° 38′ west, and latitude 49° 9′ and 49° 50′ north, an area of about 3,456 square miles. In the meantime the economic mineral developments of the region have been carefully examined by Mr. E. Coste, M.E., and his report on these accompanies the present volume. In it he refers to the evident connection between the presence of areas of massive granitic rocks and the occurrence of the auriferous quartz veins in the

Huronian. It, therefore, becomes important to determine the distribution and extent of these granite areas. Mr. Lawson's further work will effect this, and his map, when published, will be a useful guide to the prospecter in searching for metalliferous veins. Further investigation will also be required before reporting in reference to the distribution, structure, lithology, and relations of the anorthosite rocks in the region of the Saguenay and Lake St. John to which Mr. Adams' attention has been devoted for a short time during the summers of 1883 and 1884. It has been already ascertained that they occupy a much larger extent of country than was hitherto supposed. They extend more than a hundred miles to the northward on the Peribonka River, and they have been observed also on the Bersimis River, 156 miles to the eastward, where they are associated with large deposits of magnetic iron ore which may yet prove to be of great economic importance. This series of rocks is also referred to in Report D. of the present volume, where Professor Laflamme points out their probable northern extension, since determined by Mr. Adams.

Natural history publications.

Of the publications referred to in the natural history section, there have been published Part I., Vol. 3, Palæozoic Fossils of Canada, by Mr. Whiteaves, also Part II., Gamopetalæ. of the List of Canadian Plants, by Professor Macoun, containing 202 pp., R. 8vo., giving names and distribution of 908 species. Dr. G. M. Dawson, in conjunction with Dr. Tolmie, of British Columbia, has prepared a vocabulary of the Languages of the West Coast Indian tribes, forming a volume of 131 pages, R. 8vo., with a colored map of the geographical distribution. This has also been published during the past year, 1884. Dr. Tolmie has also made some valuable additions to the collections in the Museum of West Coast Indian implements and relics.

Summary for 1884.

The general work of the season of 1884 is summarized in the recently published report of the Department of the Interior and does not need to be now further referred to.

Report of Select Committee on Geological Surveys.

Attention, however, may be called to the Report of the Select Committee of the House of Commons on Geological Surveys, published during the year, and on the subject of delay in the publication of results to which it refers, a recent letter on the Dominion Geological Survey, addressed to the editor of "The Week," by Major Powell, U. S.A., the accomplished and able director and organizer of the largest geological survey in the world, may perhaps be usefully quoted, for the information of persons unacquainted with the methods and requirements of scientific surveys and investigations, and as explaining any, to them, apparently unnecessary delay in publication.

DOMINION GEOLOGICAL SURVEY.

To the Editor of the Week:

Letter from Major Powell.

Sir,—I have in reading your valuable paper fallen upon the article headed "Geological Surveys" in the number for December 11th, 1883. There are two criticisms in the article which seem not to be quite fair. The geologists engaged in the survey of the Dominion have to attack problems of the greatest complexity under difficulties of the greatest magnitude. Some of these difficulties are far greater than they are in the United States. In a very large portion of the Dominion the geological structure of the country—that is, the systematic arrangement of its indurated formations—is deeply masked by overlying drift, and every well-informed geologist fully appreciates that the gentlemen engaged in the survey of the Dominion have to use the utmost care and proceed with great diligence and great caution before pronouncing upon or publishing conclusions respecting that structure. It would be very unwise to urge speedy publication to such an extent as to bring about premature publication, and thus give to the world incomplete and erroneous ideas of the geology of that vast area.

Those who are engaged in geologic and geographic researches are placed under peculiar conditions. Most scientific men carry on their researches in the laboratory, the museum and the library. Geologists, however, travel in the field, and must necessarily traverse the whole region under investigation. While thus engaged in performing their proper functions as geologists, if they are broad men, with such an appreciation and knowledge of the whole realm of science as make them worthy of being intrusted with geologic work, they necessarily discover many facts and are able to make many observations relating to other departments of knowledge than geology itself. It has thus happened that throughout the world geologists have come to be students of physical geography and ethnology; and to a large extent the geologists of the world constitute the chief authority in physical geography and ethnology. It would therefore be a reproach to the geologists of the Dominion were they to neglect such opportunities as arise for the collection of ethnological data. It must be remembered that in doing this work very little additional expense is incurred, and that the same amount of ethnologic research could not be prosecuted by any other agency to the same economic advantage. I therefore beg of the editor of The Week, and of its readers, not to consider the small amount of ethnologic work done by the Geological Survey of the Dominion to be improper or valueless, but those officers should in fact be commended for the broad views they take in respect to the prosecution of many lines of research. The ethnologic materials which have been collected and published by the members of the Survey of the Dominion as a part of their natural history work are of interest and value to scholars in America and Europe alike, and it would be wisdom to strengthen this work. The savage races of all that part of the continent are rapidly changing their institutions, languages and other characteristics, and if they are to be studied and their history become a part of the history of the world the work of collecting the data must be begun at once, and be pushed with vigour.—

I am, with respect, your obedient servant,

J. W. Powell.

U. S. Geological Survey, Washington.

I submit that in reference to the subject, referred to by Major Powell and other matters, that the report shews that the Committee must have been laboring under misapprehension.

Evidences of misapprehension on the part of the Committee.

Among the evidences of this may be pointed out, the omission when complaining of delay in cataloguing the Museum and Library,—of allusion to the fact that, in the interval, the whole establishment was dismantled in Montreal and transported to Ottawa, where it had to be entirely re-organized and re-arranged, necessitating a complete re-cataloguing of the whole.

The Committee admit that the tabulated statement, page 9, of Reports, published and unpublished, " is not complete or accurate." It is therefore, I submit, misleading. If not in the form of a report, the work done, or the result of it, if in the hands of the Director, has been briefly stated in every case in the published records of the survey. I am at a loss to understand who the " thirty highly-trained " scientists are, referred to on page 6: Certainly no such number were ever employed at one time on the survey. Whether the derogatory allusions to myself, professionally, are justified by facts, or not, I must leave others to decide, only remarking that I have at least done the best that unremitting attention, forty years experience, and a deep interest in the progress, success and public usefulness of the work have enabled me to accomplish during the fourteen years I have now had the honor of directing the Canadian Survey. While the constantly augmented fund placed at my disposal, during that period, by Parliament, has induced me to believe that my endeavours were satisfactory to the Government, and that the results were generally appreciated by the public.

Publications issued by the Geological Survey.

During that time I have superintended the publication of, and contributed to, 12 volumes of reports, containing upwards of 4,600 pages, Royal 8 vo., with numerous maps and illustrations. Large and important collections of Canadian economic minerals have been collected and prepared for two International Exhibitions—Philadelphia in 1876, and Paris in 1878, with full descriptive catalogues on each occasion, in which statistical information relating to all the worked mines in the Dominion was given. That for Philadelphia containing 152 pages, 8 vo., and that for Paris, 134 pages, small 8vo., the latter published in French only. Notwithstanding the extra work entailed by these Exhibitions, and by the removal of the Museum to Ottawa in 1880-82, the publication of the regular Annual Report of the Survey has never been interrupted, although the amount of work accomplished has necessarily been diminished, especially during the removal of the Museum.

It has also been stated that, apart from the Museum, the only benefit which the public derives from the expenditure on the survey is in the published reports.

Other work of the Geological corps.

There is, however, a very large amount of other valuable work done by the survey which is not shown, either by the annual volume of reports or by the museum. As a part of this work may be named: the large distribution of educational collections: the professional advice and information given to practical miners,—including assays, analyses, examinations and reports,—and also the large amount of purely geographical work effected by the survey, regarding which latter one of the members of the late Committee is reported in *Hansard*, 1880, to have spoken as follows:—

Extract from Hansard 1880.

"The Geological Survey has shown what may be accomplished by small parties. By its means a knowledge of vast areas has been obtained at a very moderate outlay, and although such surveys as its very efficient and industrious officers make are not sufficiently precise for the location of a railway, nor intended to be so, they nevertheless give a fair idea of the topography of a country and are invaluable in the selection of highways."

Recently a geologically colored sketch map of the whole Dominion has been published, accompanied by a descriptive sketch of its physical geography and geology, from Cape Breton to Vancouver Island. Reports on botany, palæontology and ethnology have also been prepared and published, none of which appear in the annual volume.

Papers, also the result of survey work, have been prepared for the Royal Society, and these are published in its transactions. It will thus be seen that the last annual volume, dated 1880-81-82, does not "profess to give the useful work of the survey for two years," neither do any of the ten volumes which have preceded it.

ALFRED R. C. SELWYN,
Director.

OTTAWA, 1st Jan., 1885.

ADDITIONS TO THE LIBRARY.

FROM JANUARY 1st to DECEMBER 31st, 1883.

BY PRESENTATION.

CANADA.

J. W. Dawson :—

On the Cretaceous and Tertiary Floras of British Columbia and the North-west Territory, 1883.

Lecture Notes on Geology, and outline of Geology of Canada, 1880.

On the Result of Recent Explorations of Erect Trees containing Animal Remains in the Coal Formation of Nova Scotia, 1882.

Address delivered at Minneapolis, August, 1883. Two copies.

Chas. Gibb :—

Ornamental and Timber Trees, not natives of the Province of Quebec, 1882.

Capt. E. Deville :—

Examples of Astronomical and Geodetic Calculations, 1878.

Department of Agriculture, Ottawa :—

Report of a Select Standing Committee on Immigration and Colonization, 1883.

Archives' Report, 1882, by Douglas Brymner.

The Third Volume of the Census of 1881 and its Critics, by J. C. Taché, 1881.

Public Works Department, Ottawa :—

General Report from 1867 to 1882. Maps.

Department Marine and Fisheries, Ottawa :—

Annual Report, 1877. Supplementary Nos. 2–4.

List of Vessels on the Registry books of the Dominion of Canada.

Report of the Commissioner, 1878.

Report of the Chairmen of the Boards of Steamboat Inspection and Examiners of Masters and Mates, 1878–81.

Montreal, Toronto and Pictou Harbour Commissioners' Report for 1874–6.

List of Lights on the Coasts, Rivers and Lakes of the Dominion for 1876-'77 and '81.

Reports of the Meteorological, Magnetic and other observatories for the Dominion of Canada, 1874-77, 1879-80-81.

Post-Office Department, Ottawa :—

Official Postal Guide, Canada, 1883.

Department of Interior, Ottawa :—

Manual of Survey of Dominion Lands, 1871, by J. S. Dennis.
Manual shewing the System of Survey of the Dominion Lands, 1883, by Captain Deville.

Department of Railways and Canals, Ottawa :—

Report, 1882.

Commissioner of Railways, Prov. Quebec :—

Report, with map of Canada, 1881-2.

Commissioner of Agriculture and Public Works, Quebec :—

Report, 1881.

Crown Lands Department, Quebec :—

Commissioners' Report, 1880.

Terres de la Couronne, Prov. de Quebec :

Cartes accompagnant la Rapport du Commissioner, 1881.

Halifax Fisheries Commission :—

Record of the proceedings, 1877.
Chart of the Gulf of St. Lawrence, 1877.

Inspector of Mines, Nova Scotia :—

Report, 1882-83.

E. B. BORRON :—

Report. Stipendiary Magistrate on part of Hudson's Bay, 1882-83.

Legislative Library, Halifax :—

Commissioners and Librarian's Annual Report, 1880.

Province of Manitoba :—

Municipalities Act, Judicial Districts Act and Administration of Justice Amendments Act of Province of Manitoba, 1883.

Department of Agriculture, Manitoba :—

Crop Bulletin, No. 4, 1883.
Report of the Department of Agriculture and Statistics, 1882.
Prize List, Prov. Exhibition, 1883.

Historical and Scientific Society, Winnipeg :

Annual Report, 1882-83.

Department of Agriculture, British Columbia :—

British Columbia—Its Climate and Resources, with information for Emigrants, 1883.

McGill University :—

Report No. 2 on the Peter Redpath Museum, 1883.

Prospectus Ottawa Iron and Steel Manufacturing Company, 1874.

T. S. HUNT:

Decay of Building-stone of City of New York, 1883.
Decay of Rocks Geologically considered, 1883.

J. S. DENNIS:

Navigation of Hudson's Bay, 1878.

The Resources of British Columbia. Vol. I., No. 8. 1883.
VENNOR'S Weather Bulletin, 1883.
Annuaire du Seminaire de Chicoutimi (Saguenay), No. 6, 1882-3.

W. B. DAWSON:—

Topographical Survey of Gold fields of Nova Scotia.

HY. MONTGOMERY, Toronto:—

A Blastoid found in the Devonian Rocks of Ontario, 1883.

Ottawa Field Naturalists' Club :—

Transactions No. 4. Vol. I. 1882-3.

Natural History Society, New Brunswick :—

Bulletin No. 2, 1883.

King's College, Nova Scotia :—

Calendar 1883-4.

The Sanitary Journal, Vol. V., Nos. 9, 10.

ENGLAND.

Royal Geographical Society, London :—

Journal, Vols. 1–29, 44-5, 49, and two Vols. of Index for first ten vols. and third ten vols.

Proceedings, Vols. 1–2, complete.
" 3, Nos. 10–12.
" 5, " 1, 4, 5, 7. New series.
" 6, " 5.
" 7, " 1, 3, 5.
" 8, " 2–4.
" 9, " 1–2.
" 12, " 2.
" 13, " 5.
" 14, " 4, 5, 7, 9.
" 15, " 2.
" 16, " 2–5.
" 17, " Complete.
" 18, " Complete.

Geological Society, London :—

Quarterly Journal, Vol. 39, pts. 1–3.
President's Address, Annual Meeting, 1883.

Manchester Geological Society :—

Transactions, Vol. 17, pts. 3–9, 1883-4.

Plymouth Institution and Devon and Cornwall Natural History Society :—
Annual Report and Transactions, Vol. 8, part 2.

The Midland Naturalist :—
Vol. 6, No. 68.

Royal Colonial Institute :—
Report of the Council, 1883.

Iron and Steel Institute :—
Index to the Proceedings, 1869–81.

Literary and Philosophical Society, Liverpool :—
Proceedings, No 6.

Manufacturers' Gazette :—
Vol. 4, No. 2.

Royal Society of Cornwall :—
Transactions, Vol. 10, part 5, 1883.

Borough of Birmingham :—
General and Detailed Statement, 1882, with estimates.

H. S. Snell :—
An account of Experiments to test the accuracy of registering Anemometers.

Boyle & Son :—
Warming and Cooling the Fresh Air supply to Buildings.

W. T. Stanley :—
Mathematical and Drawing Instruments, with Hints upon Drawing and Colouring, 1878.

Sir Joseph Fayrer :—
Rainfall and Climate of India, 1880.

R. Etheridge and P. H. Carpenter :—
Further Remarks on the Morphology of the Blastoidea, with descriptions of a new British Carboniferous Genus and some new Devonian species from Spain. 1882.

Alfred R. C. Selwyn :—
Compendium of Geography and Travel, North America, 1883. Hayden and Selwyn.

SCOTLAND.

Institution of Engineers and Shipbuilders, Glasgow :—
Transactions, 1882-83.

Royal Physical Society, Edinburgh :—
Proceedings, 1881-82.

Botanical Society, Edinburgh :—
Transactions and Proceedings, Vol. 14.

Geological Society, Glasgow :—
Transactions, Vol. 7, part 1, 1883 (2 copies).

UNITED STATES.

Boston Society of Natural History :—
Proceedings, Vols. 21, 22.
Memoirs, Vol. 3, Nos. 6–7.

American Geographical Society :—
Bulletin, Nos. 2, 3, 4, 1882.
" " 1, 2, 4, 5, 1883.

Peabody Museum of American Archæology and Ethnology :—
Reports, Vol. 1–3.

Johns-Hopkins University :—
Circular, Vol. 2, No. 25.

American Academy of Arts and Sciences, Boston :—
Proceedings (N.S.), Vol. 10, 1883.

Geological Survey of Wisconsin :—
Geology of Wisconsin, Vols. 1–4.

Engineer's Club, Philadelphia :—
Proceedings, Vol. 3, Nos. 3–4.
List of Members, 1882.

Academy of Natural Sciences of Philadelphia :—
Proceedings, Part 3, 1882.

American Philosophical Society :—
Proceedings, Vol. 20.
Transactions (N.S.), Vols. 3–5.

American Institution of Mining Engineers :—
Transactions, Vol. 10.

American Museum of Natural History :—
Report 14th, 1883.

Long Island Historical Society :—
Proceedings, 1883.

Indianapolis :—
Catalogue of Public Library, 1883.

The Cornell University :—
Register, 1882–83.

New York State Survey :—
Report, 1881.
" 1882, with maps 1–6.

Ohio Mechanics' Institute :—
Proceedings, Vol. 1, No. 4.
" " 2, Nos. 2–3, 1883.

CHAS. F. WHEELER & E. F. SMITH :—
Catalogue of the Phænogamous and Vascular Cryptogamous Plants of Michigan, 1881.

Geological Survey, Ohio :—
Reports, Vols. 3–4.

Essex Institute :
Bulletin, Vol. 14, Nos. 7–12

Harvard College :
Bulletin of the Museum of Comparative Zoology, Vol. 10, Nos. 2–6.
" " " " " " 11, " 1–2.
" " " " " (Geol. Ser.) Vol. 1, Nos. 9–10.
Memoirs, Vol. 8, No. 2.
" " 9, " 2.

Boston Society of Natural History :—
Proceedings, Vol. 21, Pt. 4.
" " 22, Pts. 1–2, 1883.
Memoirs, " 3, Pt. 6, 1883.

Astor Library :—
34th Report, 1882.

New York State Library :—
Reports 62nd, 63rd, 64th, 1880–82.

E. W. Claypole :—
On the Kingsmill White Sandstone.
Note on a large Fish-plate from the upper Chemung(?) beds of Northern Pennsylvania.

Zoological Society, Philadelphia :—
11th Annual Report, 1883.

Minnesota :—
Natural History Survey, 10th Annual Report, 1881.

Davenport :—
Academy of Natural Sciences :
Proceedings. Vol. 3, Pt. 3, 1879–81.

Michigan :—
Report of Commissioner of Minerals. Statistics, 1882.

Henry G. Hanks, *State Mineralogist of California* :—
2nd Annual Report, 1882.

J. D. Whitney, *State Geologist of California* :—
Geology, Vol. 2. The Coast Ranges, 1882.

United States Fish Commission :—
Reports, 1871–79.
Bulletin, 1881.

Charles R. Barnes and Editors of Bot. Gazette :—
Catalogue of the Phænogamous and Vascular Cryptogamous Plants of Indiana, 1881.

J. S. Newberry :—
Physical Conditions under which Coal was formed, 1883.
Origin of the Carbonaceous Matter in Bituminous Shales.
Hypothetical High Tides as agents of Geological change, 1882.

SAMUEL H. SCUDDER:—

Extract from Proceedings of the Boston Society of Natural History: Explanation of a specimen of Scolopendrella.
The Pine Moth of Nantucket, *Retinia frustrana*, 1883.
Fossil White Ant of Colorado, 1883.

H. C. LEWIS:—

The Great Ice Age in Pennsylvania, 1883.
The Great Terminal Moraine across Pennsylvania.

W. H. HARKNESS:—

Footprints found at the Carson State Prison.

JOS. LE CONTE:—

On certain remarkable Tracks found in the Rocks of Carson Quarry.

R. E. C. STEARNS:—

On the History and Distribution of the Fresh-water Mussel and the identity of certain alleged species.

C. A. M. TABER:—

How the great prevailing Winds and Ocean Currents are produced, and how they affect the Temperature and Dimensions of Land and Seas, 1882.

G. G. BROADHEAD:—

Carboniferous Rocks of Eastern Kansas.

THOS. W. SYMONDS:

Report on an examination of the upper Columbia River and the Territory in its vicinity, 1882.

A. A. JULIEN:—

The Dunyte-Beds of North Carolina, 1882.
The Decay of the Building-stones of the City of New York, 1883.
The Genesis of the Crystalline Ores, 1882.
Volcanic Tuffs of Challis, Idaho, and other Western localities, 1882.

W. D. CROSBY:—

Origin of Continents, 1883.
On the Elevated Coral Reefs of Cuba, 1882.
On the Classification and Origin of Jointed Structures, 1882.

ERNEST INGERSOLL:—

Oyster Industry. 1881.

A. S. PACKARD:—

On the Homologies of the Crustacean Limb. 1882.
The Crustacean Nebalia and its Fossil Allies representing the order Phyllocarida. The Palæozoic Allies of Nebalia.

SAMUEL HAUGHTON:—

New views of Mr. Geo. H. Darwin's theory of the Evolution of the Earth-Moon system considered as to its bearing on the question of the Duration of Geological Time. 1882.

Persifor Frazer :—

Cleopatra's Needle : Mineralogical and Chemical Examination of the Rock of the Obelisk, 1883.

Thèses présentées a la Faculté des Sciences de Lille Université de France pour obtenir le grade de Docteur des Sciences Naturelles, 1882.

The Iron Ores of the Middle James River in Amherst and Nelson Counties, Virginia, 1883.

James D. Dana :—

Geological Relations of the Limestone Belts of Worcester Cy., New York, 1881.

M. E. Wadsworth :—

Meteorites. 1883.

The Argillite Conglomerate of the Boston Basin. 1883.

James Hall and R. P. Whitfield :—

Description of a new species of Fossil from the vicinity of Louisville, Kentucky, and the Falls of the Ohio, from the Collections of Dr. James Knapp.

St. Mary's Falls Ship Canal :—

Annual Report of Superintendent and Collector, 1878.

A. Welch :—

An Illustrated Catalogue of the Lambertville Iron Works.

W. J. McGee and R. Ellsworth :—

On the Löss and associated Deposits of DesMoines, 1882.

List of a Collection of Minerals belonging to the estate of C. B. Hayden, including a collection of Shells from Virginia Marl-beds and other places, 1883.

Vermont :—

Catalogue of the University of Vermont and State Agricultural College, 1882–3.

Young & Son *Philadelphia*:—

Manual and Price List Engineering and Mathematical Instruments.

Ward's Natural Science Bulletin.

Discussion on Trolus's Paper on Chemical Methods of Analyzing Rail Steel, 1881.

J. W. Queen & Co., *Philadelphia* :—

Priced and Illustrated Catalogue.

Abridged Catalogue of Optical Instruments, &c.

U. S. Coast and Geodetic Survey :—

Report, 1880–81.

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REPORT

ON THE

GEOLOGY OF THE COUNTRY

NEAR THE

FORTY-NINTH PARALLEL OF NORTH LATITUDE

WEST OF THE ROCKY MOUNTAINS.

FROM OBSERVATIONS MADE 1859-1861.

BY

H. BAUERMAN, F.G.S.

GEOLOGIST TO THE NORTH AMERICAN BOUNDARY COMMISSION.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL.
DAWSON BROTHERS.
1884.

NOTE.

The Geological Survey is indebted to Mr. H. Bauerman for the privilege of publishing his report on the geology of the country near the 49th parallel west of the Rocky Mountains. This report, though prepared by Mr. Bauerman in connection with the Boundary Commission Expedition of 1859-1861, has never been printed, which accounts for the fact that no reference has been made to it in the reports of the Geological Survey on British Columbia, the first of which appears in the Report of Progress for 1871-72. The western portion of the country in the vicinity of the 49th parallel, described by Mr. Bauerman, is included in the area of the map accompanying my report of 1877, and while some pages of Mr. Bauerman's report, such as those describing the travelled route from Hope to Vermilion Forks and the valley of the Similkameen, refer to lines examined by me and described in 1877, it has been thought best, on account of the priority of his observations, to print Mr. Bauerman's report in its entirety. Even in this western portion of the country, however, Mr. Bauerman gained access, by means of trails cut by the Commission, to many points in the immediate vicinity of the boundary-line, which have since been practically inaccessible; and if his report had been available at the time of the publication of the map above referred to, it would have enabled the geological boundaries along its southern edge to have been drawn with considerably greater accuracy.

The report is here printed almost exactly as prepared by Mr. Bauerman, though, with his permission, a few alterations and corrections in names of places, distances, etc., have been made. The bearing of the more recent systematic observations on the geology are indicated, where it appears desirable, in foot-notes. In reproducing Mr. Bauerman's sections, his originals have been exactly followed in the outlines and accompanying notes, but the colouring has been changed so as to conform to that adopted on the adjacent maps already published by the Geological Survey. This change also enables the Cretaceous and Tertiary age of parts of the series,—points rendered evident by the subsequent examination of the country to the north of the 49th parallel—to be brought out clearly. In addition to the study of Mr. Bauerman's report, it may be added, that the writer has had the opportunity of examining his original suite of specimens, now in the museum of the Geological Society of London, which has facilitated the exact correlation of the rocks referred to by him with those described in the reports of the Geological Survey.

GEORGE M. DAWSON.

REPORT

ON THE

GEOLOGY OF THE COUNTRY

NEAR THE

FORTY-NINTH PARALLEL OF NORTH LATITUDE

WEST OF THE ROCKY MOUNTAINS.

The country immediately adjacent to the 49th parallel of north latitude, on the western side of the continent of America, which forms the subject of the present communication, is in the first place remarkable for its excessively rugged profile, as with the exception of a belt of terraced plains bordering the sea and extending for a short distance inland. it presents a continuous succession of steep mountain ridges, which are furrowed by the deep, narrow and tortuous valleys of the Fraser and Columbia Rivers and their tributaries; the former flowing from east to west, while the latter usually follow a general north and south course. Principal orographic features.

The most important among the mountain ranges, orographically considered, are two in number. First, the main chain of the Rocky Mountains which forms the eastern terminus of that portion of the boundary-line which the commission was instructed to define, and divides the Pacific waters from those of Hudson's Bay and the Gulf of Mexico. Second, a western chain containing a few snowy summits, which occasionally rise to a height of about 9,000 feet above the sea level. This is situated on the northerly prolongation of the Cascade Mountains of Oregon, and divides the waters of the Fraser River, and in part, of the streams flowing into the Gulf of Georgia from those discharging into the Pacific in much lower latitudes through the basin of the Columbia River.

The streams of the western slope of the Cascade Mountains are mostly small, consisting of one principal tributary of Fraser River, the Rivers.

Similkameen. Chilukweyuk, and some unimportant brooks which empty themselves into Semiahmoo Bay. On the eastern face, the tributaries of the Columbia are of more importance. The first of these which is encountered after crossing the chain, is the South Similkameen, which originates in three small lakes fed by the melting of the snow on the Hozamen Mountains, at a height of nearly 5,000 feet above the sea level, and flows in an easterly and northeasterly direction for forty-two miles, when it joins the Tulameen, a stream of about the same size, which rises in latitude 50°, a little to the eastward of Fort Hope. The united waters of these two streams form the main Similkameen, which takes a southeasterly direction, receiving one principal affluent, the Ashtnoulou, in its passage, and joins the Okanagan, after a course of about sixty-two miles, at a point about three miles south of the lower

Okanagan. end of Osoyoos Lake. The Okanagan is one of the most considerable of the northern tributaries of the Columbia. It rises in latitude 50° 25′, and flows through several long and comparatively narrow lakes, the largest of which is about sixty-nine miles in length. At the crossing of the 49th parallel the waters of Osoyoos Lake are 757 feet* above the sea level. This is the lowest ground found in the basin of the Columbia within British territory.

Kettle River. To the eastward of the Okanagan three great tributaries discharge into the main stream of the Columbia on or near to the boundary-line, one of them coming from the west, the other two from the east. The first of these is the Newhoialpitku or Kettle River, which rises in latitude 49° 40′, near the Okanagan, and has a total length of one hundred and five miles. For a considerable distance it follows a very tortuous course, crossing the boundary-line three times; but for the last twenty miles it flows nearly due south, and joins the Columbia

Pend D'Oreille and Kootanie. about two miles above Fort Colville. The two streams coming from the eastward are the Pend D'Oreille or Flathead River or Clark's Fork of the Columbia, of which the mouth is nearly opposite to Fort Shepherd and close to the boundary-line; the other is the Kootanie or Flatbow River, which falls into the Columbia about twenty-three miles further north. The courses of these two rivers form irregular serpentine curves, the longer portions being generally parallel in direction to the main chain of the Rocky Mountains, while, in the shorter ones, the passage through the numerous parallel ridges is generally effected by a continued succession of small falls and rapids. That portion of the boundary-line which lies between the Columbia at Fort Shepherd and the western crossing of the Kootanie River, a distance of about fifty miles, is the most inaccessible part of the whole. There is no practicable route

*880 feet by more recent barometric observations.

available between these points other than the circuitous one *via* Fort Colville and the Spokan Valley, a distance of 220 miles. The total length of the course of the Pend D'Oreille River is about 370 miles, that of the Kootanie about 350 miles.

As the whole of the country is more or less thickly wooded, the most noticeable of the physical features, next to the shape of the ground and the direction of the water-courses, is the character of the forest growth. On the western plateau and seaward face of the Cascade Range, as well as in the valley of the Skagit—a small river which flows through the heart of that chain—the forest is composed principally of the Douglas spruce (*Abies Douglasii*), several large species of pines and the western cedar (*Thuja gigantea*), all very densely packed together, with a thick undergrowth of willows and vine-maple. There is no open grass land in this section of the country other than the marshy alluvial plains bordering Sumass Lake, which are subject to annual overflow from the flood-waters of Fraser River. In the valley of the Similkameen, the characteristic tree is the large red-barked yellow pine (*Pinus ponderosa*), which flourishes up to about 4,000 feet above the sea level. At lower levels it is usually found in scattered groups of three or four trees on a dry gravelly soil, which supports a growth of coarse bunch-grass. On the Okanagan, at Osoyoos Lake, large timber-trees are almost entirely absent. The ground is sandy and covered with alkaline efflorescences, with a growth of small cactus, sage and other plants characteristic of the lava-covered desert of the Columbia, further to the south. On the hills lying to the eastward of Osoyoos Lake, the larch, (*Larix occidentalis*) is first seen in quantity, and it is found abundantly from this point eastward, in the Kettle and Columbia valleys, associated with *Abies Douglasii* and *Pinus ponderosa*, grouped in small clusters as noted above. The last mentioned species is found as far eastward as the head of Tobacco River, beyond the eastern crossing of the Kootanie, where it is seen for the last time at about 4,000 feet above the sea level. It attains its western limit at about the same altitude on the eastern face of the hills above Similkameen River on the road to Fort Hope. The thickest forest on the line is found between the Columbia and the western crossing of the Kootanie River, in the district already noticed for its inaccessible character. Most of the hills that rise to a greater height than 4,000 feet above the sea level, are distinguished by particular species of conifers, which are not as a rule found in the lower grounds. In the Ashtnoulou and Rocky Mountains, the upper limit at which forest trees are found is about 6,500 to 7,000 feet, a belt of stunted larches being usually present between these levels.

Wooded character of country.

Limits of forest growth.

In addition to the two great mountain ranges which shut in the basin

Mountain ranges.

of the Columbia, there are others of minor importance within that area; and it will here be convenient to refer to the whole of them by name, in order from west to east.

Cascade Range. First, the Cascade Range, which, as has already been stated, is the northerly extension of that bearing the same name in Oregon, and is divided into two principal parts by the Skagit River. The western portion contains the highest summits, and may be called the Chilukweyuk chain, after the name of the principal stream to which it gives rise. The eastern part may be conveniently distinguished as the Hozamen chain, that being the Indian name for its most prominent peaks. Ashtnoulou Mountain. Next in order come the Okanagan or Ashtnoulou Mountains, which first diverge from the eastern face of the main Cascade Range near the Yakima Pass, in Lat. 47°, but are about fifty miles distant from it on the boundary-line. They reach a height of nearly 8,000 feet on the line, but do not appear to rise to any great height or to be easily distinguished north of the Similkameen River. The mountains between the Okanagan and Columbia Rivers do not appear to form Eastern ranges. parts of any of the great north and south systems of lower latitudes; and the same may be said of those lying between the Columbia and Pend D'Oreille Rivers, as in both cases they abut southward against the high table-land of the Spokan. The latter chain is, however, situated nearly on the northerly prolongation of the Blue Mountains of Oregon. These ridges, in spite of their low elevation, not exceeding 6,000 feet at the highest points, are very inaccessible. They possess no practicable passes leading to the eastward, and the whole traffic of the district is deflected by them through the Spokan Valley. Between the western and eastern crossings of the Kootanie River, the mountains rise in places to a height of nearly 8,000 feet, but like those last mentioned they are without any good east and west valleys. The range bordering the eastern side of that river is a very important one. It is parallel to the main chain of the Rocky Mountains, and contains several large, bare and snowy peaks, in the district south of the second Kootanie Crossing; further to the north it is called, on Blackiston's map, Galton's range. It divides the Kootanie waters Rocky Mountains. from those of the Flathead River. The last and most easterly of the ranges is the main chain of the Rocky Mountains, which divides the Columbia waters from those of the Saskatchewan, and is accompanied by a smaller parallel ridge which does not extend north of the eastern entry of the South Kootanie Pass, and encloses the basin of Chief Mountain or Waterton Lake. The smaller ridge contains the peak known as the Chief's Mountain, and forms another important watershed, namely of the Saskatchewan and Missouri Rivers.

The following rough list of the principal differences of level on the line gives a fair idea of the more considerable undulations of the ground* :— List of elevations.

1.	Cascades, Chilukweyuk or western range, (highest)	8,700 feet
2.	Skagit Valley	1,600 "
3.	Cascades, Hozamen or eastern chain, (highest)	7,500 "
4.	Sources of Similkameen River, (about)	4,800 "
5.	Ashtnoulou or Okanagan Mountains (highest)	7,500 "
6.	Okanagan Valley, Osoyoos Lake	750 "
7.	Kettle River Mountains (highest)	5,000 "
8.	Columbia Valley, Fort Shepherd	1,400 "
9.	Pend D'Oreille Mountains (highest)	6,500 "
10.	Kootanie River, western crossing	1,700 "
11.	Mountains east of Yakh River (highest)	8,400 "
12.	Flathead Valley at the Boundary Crossing	4,000 "
13.	Rocky Mountains, highest peaks near line	10,000 to 12,000 "
14.	Watershed at eastern end of Boundary Line	7,446 "

With the exception of a few of the highest points in the Cascade and Rocky Mountain chains the mass of the mountains come within the thickly wooded region. Very little snow remains on any of the peaks after the middle of July. There are, however, a few small glaciers in the Chilukweyuk and Skagit mountains. In the former they are seen on slopes having a northerly exposure down to within about 4,500 feet of the sea level. On the Skagit side the lower limit is about 5,000 feet. In the Rocky Mountains the glaciers do not come below the level of 7,000 feet and are if possible more insignificant than those of the Cascades. Snow patches.

The country the physical features of which have been noticed in the preceding paragraphs, presents, with the exception of drift and superficial deposits, and a few patches of Tertiary and Cretaceous sandstones, a succession of unfossiliferous, slaty and crystalline rocks, most of the former being more or less metamorphosed. Besides these two small masses of fossiliferous limestone of Carboniferous or Devonian age are seen in the Kootanie and Upper Flathead valleys. General character of rocks.

The probable order of succession among the slaty and other rocks, is shown in the two accompanying diagram sections. They have been constructed by the combination of observations made on the lines of travel in the vicinity of the 49th parallel. The difference of distance between the various points measured on an east and west line is employed instead of the actual road distances, as the latter are in many cases nearly parrallel to the apparent strike of the rocks, and would General sections.

* Mr. Bauermann writes that these, with other elevations in the report, having been obtained barometrically, and without comparative readings elsewhere, must be regarded as approximate only.

therefore, if employed, render it necessary to represent the beds as unduly flattened. The dips projected are somewhat steeper than those acually seen, in order to correct the thickness for the five-fold vertical amplification of the scale. The longer section follows the Hudson's Bay Company's brigade-trail from the Fraser River at Fort Hope to the South Kootanie Pass of the Rocky Mountains, while the shorter one includes that portion of the boundary-line which lies between the sea coast and the Similkameen River, where it joins the former.

Description of shorter section.

At the western end of the shorter section the sandstones of Cretaceous age, which contain coal at Nanaimo, are seen in the cliffs of Galiano Island, which, like the majority of the adjacent islands off the coast of Vancouver Island, presents a steep mural face on the western side, while on the eastern shore there is a thinly wooded plain sloping down to the water at an angle of about 10° or 12° in the direction of the dip of the beds. On the mainland, these sandstones are hidden by drift clay, which is seen in vertical cliff-sections at Point Roberts rising to a height of about one hundred and fifty feet, accompanied by large transported boulders of granite, syenite and other crystalline rocks. A similar boulder-drift is seen at various points along the shores of the Straits of Fuca. The clay is somewhat calcareous and of a light blue colour when freshly exposed, but generally bleaches under the action of the atmosphere. The sections are often of considerable height, forming cliffs which when seen at a little distance, bear a certain resemblance in form and colour to the chalk headlands of the English Channel.

Point Roberts and Sumass.

To the eastward of Point Roberts, the country lying between Semiamoo and the Sumass Mountain is covered with a thick forest, growing on coarse drift gravels which rest on blue boulder-clay. The ground, for the whole distance of thirty-five miles between these points, is for the most part flat and swampy. The gravels are arranged in broad, flat terraces, the clay below being exposed only in the beds of the streams. The Cretaceous rocks of Nanaimo are probably present beneath the drift covering. The evidence in support of this view is, however, but small, the only known section being a patch of quartzose sandstone which is exposed in the bed of a brook about a mile north of New Westminster on the Fraser River. Further to the north, on the shores of Burrard Inlet, similar coal-bearing sandstones have been found, some of the beds containing dicotyledonous leaves.*

Sumass Mountain.

After leaving the coast plateau, the first of the metamorphic rocks are seen in the curious isolated mountain that lies on the western side of Sumass Lake. This is made up of dark green sandstones, in which

*These are of Tertiary age.

almost all the sedimentary characters have been effaced, the apparent dips being very contradictory and rarely persistent in the same direction for more than a few yards. These rocks have been altered by greenstone dykes which are exposed on the sides of the hill in great numbers. The same kind of altered rock forms the western side of the ridge dividing Sumass from Schweltza Lake, where a few bands of hard siliceous black slate are associated with the dark-green sandstones; the intrusive rocks being also represented by numerous dykes of syenitic greenstone. The cliff sections on the western shore of Schweltza Lake present a series of hard white sandstones with alternations of blanched clay-slates and white felspathic conglomerates, the whole dipping north-north-west at a very high inclination (from 70° to 85°). On the opposite or eastern shore of the lake, regularly stratified rocks are seen for the first time. They are thinly laminated, black, sandy-shales and sandstones, and are exposed in very large quantities, showing sections from 1,500 to 3,000 feet in vertical height. The dips are very regular in a south-south-easterly direction at slopes of 30° to 40°. The same series of black shaly beds is continuously exposed in the cliffs of the Chilukweyuk Valley for about twenty miles to the eastward of Schweltza Lake. In the higher parts they are associated with beds of a bluish-grey limestone, which presents a less perfectly laminated character, being like the limestones in the metamorphic rocks of Vancouver Island, somewhat concretionary in structure. They dip with great regularity to the eastward at slopes between 30° and 10°. There does not appear to be any passage between the lower part of the series at Schweltza Lake, and the highly metamorphic and uptilted rocks on the western shore, though they are only about half a mile apart. The latter are probably unconformable and inferior in position to the former. No fossils have been found after a search in three of the most likely-looking spots among the finer grained portions of the black shales at Schweltza and the Chilukweyuk Valley. Patches of carbonaceous matter and minute gypsum crystals are very commonly present, and the joints of the harder beds are generally covered with a powdrey incrustation of allophane or some allied hydrated silicate.*

Schweltza Lake

Chilukweyuk Valley.

The Chilukweyuk, in the valley of which sections of the slates are seen, is the most rapid of all the streams in the country. It flows out of a lake about five miles long and a mile broad, situated in the western range of the Cascades, and after falling through a height of 2,000 feet in about thirty miles, joins the Fraser River near the head of the tidal waters. Near the lower or northern end of the lake, the slaty rocks

Chilukweyuk River.

* It is probable, from fossils since obtained on the Chilukweyuk, that a part at least of these rocks are of Cretaceous age.

are interrupted by a great mass of syenite, the contact between the two being marked by a hard laminated black and white quartzose slate, of somewhat gneissic character.

Chilukweyuk Lake.

The syenite of Chilukweyuk Lake forms a belt of between four and five miles in breadth, measured from west to east. It is remarkable for its hardness and regularity in mineral composition, being a finely crystalline mixture of white and pink felspar, with a small quantity of quartz and well-formed crystals of hornblende, of a somewhat slender columnar type. Crystals of black mica are seldom seen. In some places the syenite is divided by a system of joints, which are arranged so as to produce a kind of imitative stratification, having a regular northwesterly dip of about 45°; but no well-defined lamination or foliation is anywhere visible. It is from this mass, or others of similar composition, that the principal part of the erratic blocks which are found scattered over the coasts of the mainland and the southern portion of Vancouver Island have been derived. The Chilukweyuk syenite is, in this latitude, the nearest point to the coast presenting a supply of the requisite material*.

Chilukweyuk Mountain.

The highest granite peak in the mountains surrounding Chilukweyuk Lake is on the western shore. It rises to a height of 6,570 feet above the sea level, the summit presenting a nearly vertical cliff-face of abont 1,200 feet in total height. In this cliff two thin black dykes are seen penetrating the syenite. From fragments picked up at the foot of the slope they appear to be dark quartzo-felspathic porphyries or elvans containing large white felspar crystals, and similar in character to the elvan dykes found in the gneiss of the lower part of the Columbia Valley.

Watershed ridge west of Skagit.

After crossing the syenite, the next rock encountered to the eastward is near the latitude-station of the Chuckchehum. It is a hard, highly micaceous and quartzose gneiss, showing irregular wavy laminations, which have their principal inclination toward the east. On the top of the dividing ridge between the Chilukweyuk and Skagit waters, a kind of outlying mass of slaty rocks is seen above the gneiss. These rocks are chiefly earthy clay-slates with conglomerates of gneiss, sandstone and slate pebbles; and purple slates, containing epidote and calcite.† The structure of this outlier is not well seen, for at the top of the ridge and for some distance on each side, the rocks are hidden by a thick talus of rubbish, in addition to which the height (4,700) is insuffi-

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* (Note by Mr. Bauerman) In 1858 syenitic boulders were visible in extraordinary numbers in and near the town of Victoria. Since that time they have been largely drawn upon for a supply of building material owing to the great ease with which they can be blown to pieces, and the absence of any other suitable building stone in the immediate vicinity.

†These doubtless represent an outlyer of the Lower Cretaceous rocks, which commonly occur in similar positions in parts of this region further to the north.

cient to clear the dense forest. The latter inconvenience has, however, been in part obviated by bush fires, which have burnt off the whole of the trees for about two miles, exposing a fine section of the mountains on the opposite side of the pass, on which there are three small glaciers on northerly slopes, all very much furrowed and broken. Immediately to the south of this point the mountains rise to great heights, and the largest observed glacier, estimated at about a mile in length, descends from them, giving rise to a stream along the valley of which the descent to the Skagit is effected. The gneiss is continuously exposed nearly down to the river, where it is concealed by the gravels of the valley.

The Skagit, on the boundary-line is a small stream, only fifty yards wide. It rises about fifteen miles east of Fort Hope and flows through a narrow opening between the highest summits. Its course is at first south, then eastward, and it falls into the northern part of Puget Sound. **Skagit River.**

The ford on the trail is about 1,650 feet above the sea level. The mountains on the west side of the river rise to a height of nearly 9,000 feet. Their sides show seven small glaciers, the lowest being about 6,000 feet above the sea level. The river flat is about two miles in width and is covered by a thick growth of timber, principally cedars of large size, with an undergrowth of willows. After crossing the river-flat, which shows a few low terraces, the trail rises up the side of a steep hill covered with thick small brush and burnt timber for more than 4,000 feet, when it reaches the watershed and follows the tops of the ridges on the north side of a steep-sided ravine in which the Similkameen River rises. On the opposite or southern side are several bold mountains of black slate. In the hollows between them are three small glaciers which are remarkable for the brilliant blue colour of their ice. The lower extremity of one of these glaciers is wasted into a hollow or cavern. Immediately above the crest of the ridge at their head of the pass, are two very remarkable peaks of black slate, which rise precipitately to a height of about 1,800 feet above the watershed. They are called by the Indians "Hozamen" which name has been adopted for the pass and the ridge of which they are the culminating points. The rocks of this district are principally black slates ranging in texture from soft earthy shales to the hardest lydian stone. In the Skagit Valley the exposed sections show north-westward dips at angles varying between 75° and 60°, the lower angles prevailing as the trail rises above the river. On the watershed they have turned over and incline at an angle of 60° towards the north-east, a direction of dip which is persistent for some distance along the pass, after which the beds are bent into smaller and more irregular curves. About the middle of the pass the slates are pierced by dykes of a compact rock, which appear as if interstratified, but their true nature is seen in cross **Mountains east of Skagit Valley.**

section, which shows them splitting and ramifying across the laminations among the older rocks. At this point a few black and irregular impressions somewhat resembling plant stems were found in a bed of sandstone. They are probably pseudomorphs after staurolite or andalusite crystals. The contortion seen to the east of this point is accompanied with (as far as can be seen) a general westerly inclination. As far as the mouth of Roche River, cherty or hornstone-like metamorphic beds, probably originally sandstones, and conglomerates of a green colour are seen.* The same rocks are continuously exposed in the valley of the South Similkameen, with a southerly dip, up to within five miles of the Peseyten river junction, where they are succeeded by a small mass of grey syenite which preserves its massive character for a mile and then becomes gneissic. The gneiss is flanked by soft talcose and micaceous slates at the junction of the two streams. The mouth of Roche River is 3,458 feet, and that of the Peseyten 3,060 feet above the sea level. The valley between these points is filled with thick masses of gravel containing a large quantity of pebbles of the green conglomerates. They are cut through in many places by the river, forming nearly vertical cliffs from fifty to eighty feet in height.

South Similkameen Valley.

Mountains east of Similkameen

After receiving the Peseyten the valley of the South Similkameen takes a nearly northerly course, but in order to continue along the boundary-line the trail turns to the eastward, crossing a steep hill 6,330 feet in total height above the sea level, known to us as Ptarmigan Hill. This summit is the culminating point of the ground lying between the Peseyten, South Similkameen, Ashtnoulou and main Similkameen. It is made up of stratified masses of blue trachytic porphyries, with a few brecciated beds of a similar mineral composition, dipping north-north-west at a slope of 50°. †

Ashtnoulou Valley.

The junction of the porphyries with the talcose micaceous slate of Peseyten is not seen, the nearest dips, however, indicate considerable unconformity. The western side of the hill is very swampy and covered with burnt and fallen timber. On the eastern side it is covered by a coating of a remarkably fine gravel, and a forest of small dead pine sticks which conceals all the rocks on the descent to the Ashtnoulou River which is struck at a point 3,550 feet above the sea level. In the Ashtnoulou Valley, green, red and grey quartz-porphyries are seen in large quantities. They are well stratified, having a west-north-west dip of 50° which nearly corresponds in direction and inclination to that of the porphyries of Ptarmigan Hill. They are underlaid by beds

* The rocks east of the Skagit, above described, form the southern extension of a considerable area of Lower Cretaceous. See Report of Progress, 1877-1878, p. 105. B.

† This is the western edge of a basin of Tertiary volcanic rocks, which are more fully described in the succeeding paragraph.

of a very coarse conglomerate, the largest of the included masses being granitic. Several of the smaller pebbles are crusted with a thin coating of chalcedony resembling dried gum. The same kind of incrustation is seen on the pebbles in the gravels of the lower Columbia Valley at Fort Vancouver.

Ashtnoulou granite mass.

The conglomerate last mentioned rests upon the western edge of the Ashtnoulou granite, a mass which is exposed along the boundary-line for a breadth of fourteen miles and forms in this latitude the whole of the mountains called in a preceding paragraph the Ashtnoulou or Okanagan chain. In a northerly direction it is seen in undiminished magnitude in the main Similkameen Valley; and to the south it is exposed almost continuously on the western side of the Okanagan Valley, down to the junction of that river with the Columbia, a distance of about sixty miles. Unlike the syenite of Chilukweyuk Lake, the Ashtnoulou granite is of an exceedingly variable composition. Near the mouth of the Ashtnoulou it contains red and white felspar, quartz, black mica and hornblende. The micaceous portions are the softest and offer least resistance to the action of the atmosphere. In the valley leading up to the latitude-station, many masses of mica-slate and other metamorphic rocks are seen. The largest one is of a dark green hornblende-slate with nearly vertical laminations, into which the granite sends off many small veins. In some of the veins the hornblende present appears to be derived from the altered rock, as the crystals of that mineral are developed in dense masses near the wall of the vein, which is filled with a granular mixture of red felspar and hyaline quartz. In the mountains immediately above the Ashtnoulou latitude-station, which rise to a height of about 7,500 feet above the sea level, the granite changes into a mixture of quartz and felspar. The quartz occurs principally in large black or white crystals, some of them measuring three inches across the basal plane. The felspar is usually found in dull cleavable masses of a dirty pink colour, and more rarely in small, well-developed red crystals. A compact variety of the same quartzo-felspathic substance is found filling small veins in the rotten reddish-grey syenite which surrounds the coarsely crystalline mass noticed above. From the top of the Ashtnoulou Mountains the granite is seen to the eastward forming low and occasionally flat-topped hills, which terminate in a tremendous cliff-face between 4,000 and 5,000 feet in vertical height on the western side of the Similkameen Valley, opposite to Hayne's House.* The flat-topped form of the intermediate hills is produced by a set of nearly horizontal divisional planes, which render the granite liable to scale off in flaggy masses when

* Now abandoned, the custom house being situated further west at Osoyoos Lake.

exposed to the action of the atmosphere. A few "tors" and projecting blocks are also seen, but they are mostly small and insignificant.

The shorter section terminates at the Similkameen River by a junction with the longer; the western portion of the latter showing a similar class of rocks which are exposed on the brigade trail—in part the new waggon road—from Fort Hope by the Similkameen. It is constructed in a similar manner to the first.

Description of longer section.

The town of Fort Hope, where the long section commences, is situated on a small gravel flat about one hundred and forty feet above the sea level, at the southern end of the great gorge made by the Fraser River in its passage through the mountains. The cliffs at the back of the town are composed of gneiss and mica-slate of very finely laminated character and usually syenitic. The probable dip of lamination is about 50° in a northerly direction. There are many small granite veins intruded nearly in the planes of lamination. About two miles out, on the waggon road, a grey felspathic granite is seen in large masses. This rock resembles the Chilukweyuk syenite in colour and hardness, but it is associated with another variety which is often largely crystalline from the presence of coarse plates of mica. The granite is seen sending off small veins from its eastern edge into a mass of black clay-slate, altering the latter for a short distance into a dark bluish-grey quartz rock. A line joining the syenite of Chilukweyuk Lake to the granite of Fort Hope, would if prolonged in the same direction pass through the granitic and gneissic rocks exposed in the gorge of the Fraser River between Fort Hope and Fort Yale. The distance between these points is about fourteen miles in a nearly north and south line. From Fort Yale to Chilukweyuk Lake is about thirty-five miles.

Rocks east of Fort Hope.

Intrusive granite.

About twenty miles from Fort Hope, another mass of syenitic granite is seen, and between it and the former one the black metamorphic slates are disposed in a flat anticlinal arch, the dips near the western granite being towards the south-west, while near the 17th mile post on the waggon road, their direction is between south-east and east-north-east. The eastern granite is a nearly compact white syenite, which is rendered porphyritic by a few small hornblende crystals. There is a thick bed of limestone in the slate which is altered at the contact into a kind of laminated black and white quartz rock, and a little further away from the junction into a mixture of carbonate of lime with white radiating masses of tremolite or actinolite. After leaving the syenite, which forms a boss of about one mile in width, a great thickness of dark green slaty rocks is seen arranged in a synclinal fold* in the mountains to the

Basin of Cretaceous rocks.

* This is the eastern edge of the Lower Cretaceous area previously alluded to. The route here followed is that described in the Report of Progress to which reference has already been made.

eastward of the Skagit River. The dips of these beds appear to increase in steepness towards the centre of the synclinal, the highest inclination being about 70°. The uppermost bed is a conglomerate made up of green and black slate and quartz pebbles, all well rounded. On the eastern side of the axis the dip is to the north-west, the inclinations being somewhat less than those of the western side, and continually diminishing until we reach a small swampy flat about 4,400 feet above the sea level, situated nearly midway between the Skagit and Similkameen valleys, where the slates are underlaid by a finely crystalline syenitic gneiss, which does not appear to be associated with any granite veins, or to show any other symptoms of the vicinity of a granite mass.* The eastern face of the slope on the descent to the Similkameen is covered, nearly to the top, by a smooth coating of gravel, chiefly made up of porphyritic fragments, which entirely conceals the rock beneath except where a few dykes of felspathic porphyry and some hypersthenic greenstones form small projecting ridges. This gravel covering continues nearly down to the level of the South Similkameen River, where there are exposed beds of a dark green altered rock, with a few thin interstratifications of a blue argillaceous limestone, the whole having a southeasterly dip. These green beds are very compact, showing no granular texture. They contain a few hornblende crystals. It is probable that the hypersthenic greenstone seen higher up on the hill may be a more completely metamorphosed condition of the same rock.

Gneissic and crystalline rocks.

The Similkameen River is formed by the junction of two smaller streams, the South Similkameen and the Tulameen. The junction takes place near the point where the brigade-trail reaches the valley and is locally known as the Vermilion Fork. Near this place sections of unaltered sandstone, containing the remains of land plants, are seen in both of the tributary valleys, and will be noticed in a subsequent paragraph. About a mile below the junction, vesicular green and grey felspathic rocks are seen in the main valley, dipping at 60° to the north-north-east. Some of the beds are rudely columnar, and large masses of quartzose and red felspathic porphyries, also apparently stratified, are associated with them. This series of beds is probably the representative of the quartz-porphyries and other trappean rocks seen in the Ashtnoulou Valley, and on the top of Ptarmigan Hill, and it occupies a similar position with reference to the granite which comes to the surface further to the eastward.† The latter rock is penetrated by several red felspar-porphyry dykes near its western edge.

Rocks of Similkameen River.

A considerable extent of the main Similkameen Valley is occupied by the northerly prolongation of the Ashtnoulou granite, as the river cuts

Granitic area.

* This junction is a faulted one. See Report of Progress 1877-78, p. 63 B.

† These rocks and the sandstones above referred to are now known to be Tertiary.

obliquely across it. The total length of the exposed section is about nineteen miles, which distance is divided into two unequal portions of fourteen miles and two miles, the intermediate space of three miles being filled by a small and disturbed synclinal of slaty rocks.* The larger or western mass of granite is of a hard and finely crystaline character, containing both mica and hornblende with white and red felspar. The smaller mass is also syenitic, and both are penetrated by numerous felspar-porphyry dykes. The trough of black slaty rocks occurring between the two granite masses differs from the included fragments seen in the Ashtnoulou district, the disturbance being chiefly mechanical, with but a slight amount of mineral alteration. It consists chiefly of black pyritous slate, with some thin bands of blue limestone at the eastern side. These limestones have been considerably affected by the granite at their contact with the smaller mass. The junction is marked by a semi-crystalline quartz-rock containing crystals of tremolite and mica. Further away from the intruded mass the limestone is converted into a mass of crystals of carbonate of lime. This is for the most part pale in colour, but still shows irregular streaks and patches of its original tint. Associated with it are thin radiated masses of actinolite and a few brown lime garnets. The coarsely crystaline portions of the limestone are very slightly coherent. From the readiness with which the constituent crystals of calcite are cleaved, they are very readily acted on by the weather, and run down into a kind of coarse sand, forming a talus which lies at a much lower angle than those of the harder rocks surrounding it. In addition to the chemical changes, there appears to have been a considerable amount of mechanical disturbance, as the lower beds of the limestone are much broken up and recemented into a kind of breccia by carbonate of lime and brown iron ore, the former mineral sometimes occurring in large crystals in the cavities between the fragments. The dip of the limestone beds at the eastern contact is 34° in a direction of N. 30° W.; but the slates above them are turned up at a much higher angle, and toward the middle of the trough they appear to be folded back upon themselves, the contortions being rendered very apparent by several thin bands of white quartz-rock interstratified among the hard black slates. The latter are often much stained with iron rust from the decomposition of the contained pyritic nodules. From the fact of the occurrence of the greatest amount of metamorphism with the smallest amount of inclination at the eastern edge, it may be that the principal disturbing force has been exerted by the granite on that side, the beds being compressed and driven back upon the portion lying to the westward. Porphyritic dykes are also

Trough of metamorphic rocks.

* See Report of Progress, 1877-1878, p. 84 B.

seen in the black slates, one of them, a fine-grained greenstone, occurring in the middle of the synclinal, and probably filling a fault, as the slate is broken up into a coarse breccia cemented by thin quartzose strings along the planes of contact.

Similkameen Valley east of granite mass.

That portion of the Similkameen Valley which lies between the eastern edge of the granite (a point six miles west of the mouth of the Ashtnoulou River) and Hayne's house near the boundary crossing, is filled with great masses of slaty rocks which are mostly very siliceous, comprising black lydian-stone and hornstone of various colours, usually red or purple with green and white bands in less quantity. The dips, as far as they can be trusted, show a south-easterly inclination, but this is accompanied by a considerable amount of contortion as seen in the small transverse gullies. There are also in places two systems of strongly developed divisional planes which make more prominent features than the supposed original bedding. A few fragmentary patches of limestone are seen high up in the hillside near the lower end of the valley, and from their similarity in position with those seen in the Chilukweyuk Valley, they may be taken as marking the upper part of the slaty series.* Near Hayne's house the granite of the Ashtnoulou mountains crosses the river, and appears under the form of a fine-grained white syenite full of small strings of epidote. Fibrous serpentine of a bright green hue has also been found in the mountains near this place.

Osoyoos Lake and vicinity.

In the hills lying between the Similkameen and Osoyoos Lake, in the Okanagan Valley, the sections show the black siliceous slates lying in a trough of contortion, on beds of gneissic mica-slate, the latter occupying the high ground in the centre of the hills. On the western shore of the lake are seen thick beds of a coarse granitic conglomerate with a dip of 70° in a direction E. 25° S.; about a quarter of a mile back they have been sharply folded over, and lie at nearly as high an inclination in a westerly direction. A thin band of extremely hard felspathic porphyry is intruded in these beds near the boundary crossing. On the same side of the lake a bed of sandstone is found which is stained bright green for a short distance. This is produced by carbonate of copper resulting from the decomposition of a minute quantity of copper pyrites scattered through the rocks. No defined copper lode could be found in the immediate neighbourhood. In the Similkameen Valley, below the boundary crossing and nearly down to its confluence with the Okanagan, black and green slaty rocks are exposed continuously. They are contorted in a similar manner to

* The rocks above described are supposed to belong to the Câche Creek series of the provisional classification of 1871.

those seen on the hill trail, but no gneissic rocks come to the surface.

Larch Tree Hill

On the eastern side of Osoyoos Lake, which is about two miles wide, there is a total change in the nature of the rocks, a very coarsely laminated gneiss, full of large crystals of felspar, prevailing. The dip of the lamination is north-west about 25°. About a mile further to the eastward, at a point about a thousand feet above the lake, it changes to 15° in an easterly direction.* The summit of the ridge dividing the Okanagan from the Newhoialpitku or Kettle river is known as "Larch Tree Hill" from its being the first point on the line at which *Larix occidentalis* is seen in quantity. It is about 3,900 feet above the sea level. The slope for nearly the whole distance from Osoyoos is covered with fine gravels and blown sand. On the eastern side, on the descent to Rock Creek, the black slates with a few thin bands of quartzose conglomerate are occasionally exposed, but over the greater part of the ground they are hidden, only a few hard porphyry dykes projecting through the superficial deposits. At Rock Creek the Colville trail first strikes the Newhoialpitku, which river, as has already been stated, follows a very tortuous course, crossing the boundary-line three times, and finally falling into the Columbia about two miles to the north of Fort Colville. This area is remarkable for the extreme character of the metamorphism of the rocks, as well as for the great profusion of intruded porphyritic dykes, greenstones, syenites and elvans which are found penetrating the slaty and gneissic rocks indifferently throughout this entire portion of the valley. In the narrow gorge of Rock Creek the black slates are exposed in steep cliffs with a southwesterly dip. Further to the eastward, they are associated with some thin shaly and irregular bands of limestone, which are seen dipping first about 5° to the north-north-west and about four miles further on 4° in an easterly direction. Opposite to the town, of Rock Creek,† large masses of a very finely crystalline greenstone in an obscurely stratified condition, are found. They are somewhat like the interstratified greenstone seen in the Rocky Mountains, but bear very little resemblance to the rocks of a similar character in their immediate vicinity. About eight miles east of Rock Creek, a hard darkgreen quartzose conglomerate in a highly metamorphosed condition is accompanied by a bed of imperfectly columnar greenstone. The position of these beds is above the slates of Rock Creek. The comparative position of the rocks in this district is, however, very obscure, as the sections rarely give good dips, from the prevalence of

Rock Creek.

Highly metamorphic rocks.

* These rocks resemble some of those on the Shuswap Lakes, and are probably Archæan.

† A mining camp, long since abandoned.

irregular joints and secondary divisional planes masking the true lines of stratification. In the case of the greenstones of Rock Creek the evidence appears to be about equally divided between intrusion and interstratification.

About three miles below the first boundary crossing of Newhoialpitku River, gneissic rocks again make their appearance, and they are seen continuously for about forty miles, up to within about twenty miles of the mouth of the river. They include examples of almost every variety of granitic and syenitic gneiss, quartz rock in thin bands and a dark-green hornblende slate, the whole being finely laminated, and arranged in numerous small and irregular contortions. For a short distance, near the centre of the mass, a dip of lamination is observable at low angles of inclination, and ranging in direction between south-west and north-north-west, and in this part of the section most of the dykes of porphyry and greenstone, which are exceptionally numerous, are intruded in the lines of lamination. Some of the more homogeneous of these intruded masses weather out into thin tile-shaped laminæ due to irregular cleavage-planes which cross the mass obliquely to the walls of the vein. Near the eastern edge of the gneissic rocks, dykes of granite and micaceous porphyries are more abundant than the purer felspathic varieties seen further to the westward. In some places the granitic dykes are so well laminated, that they appear, when seen along a line of strike, to form part of the gneissic beds themselves. A remarkable example of this kind of structure is seen in the great bend of the Kettle River, where, in a cliff of well laminated and thinly bedded mica-slate, interstratified with bands of a white quartz-rock of a prismatic structure, and irregular masses of dark-green hornblende slate, thin beds of a finely crystalline gneissoid rock containing garnets are seen near the top of the section. When seen on a transverse section, the bands of this rock are observed to cross every one of the other beds in the section at a considerable angle, thus proving them to be merely intrusive masses. The dip of the lamination, and probably of the original stratification of the latter, is north-north-west at an angle of about 10°, while that of the dykes is much higher and is oblique to the walls. The appearance of this cliff with its regular alternations of quartz-rock and nodular masses of hornblende, is strangely suggestive of its original sedimentary character, quartzose and siliceous bands standing for siliceous sediments of various degrees of purity, while the lenticular hornblendic masses may be taken to represent alternating and irregular patches of clay. Instances of gneissic lamination in dykes, have been observed in a few other places in the same neighbourhood, but it is nowhere so strongly marked as it is in the example cited

Gneissic rocks

Dykes.

above. At the third boundary crossing of Kettle River, the gneiss is hard and firmly laminated without much contortion, after which a dark rotten mica slate, full of garnets, and very much contorted, prevails.

Lower Kettle Valley.

After leaving the gneiss a great mass of slaty and calcareous rocks is encountered in the lower part of the Kettle River valley. It extends in a south-easterly direction for about fifty-five miles across the Columbia to the head of the Chemikane Valley, the beds forming an irregular synclinal with a considerable amount of contortion on the western side. The lowest members of this series are beds of rather silicious slates and slaty limestones of a light green colour, which are occasionally variegated with white and black lines of lamination. The dip is to the south-east at about 50° inclination. Further to the eastward and next in order in the series, comes a mass of black and bluish-grey slate of a somewhat sandy texture, containing well formed crystals of iron pyrites. Associated with these are a few thin limestone bands, resembling those seen in the lower part of the Similkameen Valley. These beds are more contorted than the green series below them, and are occasionally nearly flat. At the mouth of the river the dip is again to the south-east. On the right bank of the Columbia opposite Fort Colville there is a thin bed of a pure white crystalline marble, at the top of the black slates, which is seen at intervals occupying the same position higher up the river towards Fort Shepherd. Above the white limestone comes the quartz-rock of the Kettle Falls. This is a white micaceous and quartzose slate, divided by well marked planes of stratification and nearly vertical joints, into flaggy or prismatic blocks. The finer laminations of the individual beds are, however, extremely contorted in very small and sharp turns. In some instances the laminæ are twisted into serpentine curves, in which case the straight ends are usually broken through at the tails of the S-curved portions, such fractures being generally accompanied by a small vertical dislocation. The total thickness of this rock is about 500 feet. It occupies both banks and the bed of the Columbia at the Kettle Falls, and is seen in small ridges sticking up through the alluvium of the plain on which Fort Colville is built, for about half a mile to the eastward of the river. In the cliffs of the left bank of the Columbia Valley, in the hills above them, and in those above the north side of the Colville Mill Valley, the rocks exposed are argillaceous and sandy slates and sandstones, with a few thin slaty breccias and conglomerates, and a number of thick limestone beds of a more or less impure or concretionary character occurring at intervals throughout the whole series. The following is a more detailed list of the apparent succession in ascending order in a line

Slaty and calcareous rocks.

Colville.

Remarkable contortion.

Section in Colville Mill Valley.

from north-west to south-east from the gneiss of Kettle River to the top of the synclinal in the Mill Valley:—

1. Green slates and limestones.

2. Black and bluish-grey slates with included crystals of iron pyrites and some thin limestone bands, dipping first to S.S.E., then S.W., then flat, and finally dipping S.E. near the mouth of the river.

3. White crystalline marble with silicious leaf-like films, or very thin beds.

4. Slaty quartz rock of the Kettle Falls.

5. Green shaly limestones and calcareous shales (left bank of the Columbia).

6. Fine-grained bluish-grey shales with irregular cleavage and thin beds of fine slaty conglomerate.

7. Bluish-grey slaty limestone with some bands of black slate.

8. Thickly bedded and contorted blue argillaceous limestones, with a few thin intermediate beds of a calcareous breccia.

9. Fine-grained hard yellow sandstones apparently made up of granitic or gneissic debris.

10. Blue argillaceous limestone, very impure and slaty, the upper beds much hardened by infiltration of silica.

11. Hard slaty breccia containing fragments of black silicious slate, white quartz-rock in clay slate.

The same kind of contortion in lamination accompanying regular stratification that is seen at the Kettle Falls, occurs in the higher parts of the section, more especially in the thick limestone beds in Nos. 8 and 10. The beds in Nos. 5 and 6 form a small flat anticlinal arch at the eastern edge of the Columbia Valley. They are broken through by numerous greenstone dykes which usually follow a north and south course. The largest of these intruded masses is about 200 yards wide, forming a prominent ridge for about two miles along the valley to the south of the falls.

The conglomerate, No. 11, is the highest bed in the synclinal. It is very hard and is much altered by silicious infiltration and affected by cross jointing. Further up the Mill Valley the dips assume a westerly direction, bringing the limestones again to the surface. The beds have, however, changed in mineral character, a nearly uniform mass of finely laminated, white, slaty and calcareous rock taking the place of the thick blue limestones with interstratified sandstones and conglomerates seen in the western side of the trough. About two miles south of the United States military post of Colville, a small granitic mass breaks through the limestones, and is exposed on a very oblique section as far as the Little Pend D'Oreille River. The rock is remarkable for its extremely rotten character, due to the rusted and decomposed state of the felspar of which it is chiefly composed. The lower or slaty members of the series are exposed below the limestones in the upper part of the

Granite mass.

Colville Mill Valley. They are nearly vertical, having been apparently compressed between the Little Pend D'Oreille granite and that of the Spokan lying further east. The supposed equivalent of the quartz-rock of the Kettle Falls, appears as a band of pure white quartz. The slates are mostly very silicious. The higher beds are covered with rusty stains from decomposed pyrites, the lower ones are chiefly black, brown and purple jaspidious slates or lydian-stones, bearing a considerable resemblance to the beds seen in the Similkameen Valley. The granite of the Spokan, like that of the Little Pend D'Oreille, is very rotten and concretionary, weathering down into rudely spheroidal blocks. At Chemikane bridge a small needle or obelisk projects from the face of the cliff. It is formed of a pile of soft decomposing blocks, which are held together by a number of small interlacing veins filled with a compact mixture of felspar and quartz. Similar veins are seen at intervals along the Chemikane Valley down to its junction with the Spokan. In the valley of the Columbia River, to the north of Fort Colville, the black pyritic slates form the mass of the river-cliffs as far as Fort Shepherd, and in the lower part of the Pend D'Oreille Valley they are in a very much disturbed condition, and the intruded greenstone and syenitic masses are more numerous than they are at Colville. The limestone series appears in its proper place on the Pend D'Oreille and is largely developed in the thickly wooded mountains to the eastward of Salmon River. At the Pend D'Oreille latitude-station, the dip is towards the south, and it is probable that the lower boundary of the series follows a direction nearly parallel to, and a little to the eastward of, the Columbia from Colville to this district. A curiously speckled, black and white sandy bed appears to be of common occurrence in the upper part of the thick limestones.

Columbia Valley.

Chemikane to Spokan.

In passing from the valley of the Chemikane to that of the Spokan River, the trail crosses a low pass, with a marshy flat at the summit between the low granite hills. The granite is of a rotten and concretionary character, presenting many overhanging and perched blocks which are very slighly coherent and scale off into a kind of coarse sand under a very feeble pressure.

Spokan River.

Basalts.

The Spokan River flows through a broad valley resembling an old estuary, bordered by hills of 1,500 to 2,500 feet elevation. Toward the south the great lava-covered table-land of the Columbia extends in an unbroken stretch for about 250 miles. The basaltic lavas forming the greater part of the surface of the plain, are represented on the Spokan by some large outlying patches which flank the granite mountains up to about 400 feet above the river level. They are also seen in smaller masses at various points along the Chemikane Valley, and one small fragment is found within the drainage area of the Colville Mill Stream.

Following the course of the Spokan River, the concretionary character of the granite continues up to the neighbourhood of Plant's house. Here the rock becomes harder and a gneissic, structure is developed, accompanied by the separation of large mica and felspar crystals.

Gneiss.

Near the edge of the wood on the Spokan prairie, the same coarse gneiss is seen and a finer variety is found on the eastern side of the Pend D'Oreille Valley opposite to Sinyakwateen, the ferry at the lower end of the Pend D'Oreille Lake. The dip of the gneissic lamination is S. 30° W. at Plant's house. On the Pend D'Oreille the direction is S. 15° E.

Sinyakwateen to Kootanie River.

In the district between the Sinyakwateen Crossing and the first ferry on the Kootanie River, there is a very small amount of evidence as to the nature of the rocks. The pass is in a wide valley filled with gravel and blown sand, between low hills which are rarely visible from the trail. The gneiss is seen at the top of the highest hill on the north side of the valley near the watershed of the two rivers. The country bordering the Pend D'Oreille Lake near Sinyakwateen is one of the most thickly wooded parts of the line. The ground is flat, and is intersected by deep and sluggish streams which are liable to sudden overflow from summer rains. The largest timber on the line is seen in the thick wood at Pack River, where the Californian sugar-pine (*Pinus Lambertiana*) attains a height of 310 feet, and cedar trees are found rivalling those of the Cascade Mountains.

Chelemto Crossing of Kootanie.

At the first or Chelemto Crossing of the Kootanie River, the gneiss is of a more granitic character, containing irregular micaceous laminations and much felspar. The prevailing dip of the lamination is towards the south-east, but this direction is not constant, being combined with much contortion. At the mouth of the Mooyie River the slaty rocks of the Kootanie Valley are seen for the first time.* They are bluish-grey and green finely granular silicious slates, and form steep cliffs from 150 to 200 feet in height, the laminations dipping 60° in the direction E. 10° S. On the right bank of the Mooyie, a curious boss of hypersthenic greenstone is seen, intermediate in position between the slates and the gneiss. A similar case of a greenstone dyke being intruded at the immediate contact of the slates and gneiss is seen about five miles below (north) of Chelemto, where hardened black slates are altered into a kind of mica-slate, the mica forming small dark green rounded masses, in a lighter coloured base.

Slaty series.

Mooyie River to Kootanie Post.

From the Mooyie River eastward as far as the Kootanie trading post, the sections present a succession of unfossiliferous slaty rocks and sandstones which are arranged in large folds of contortion as shown in the section. Many of the changes in dip are so sudden that they are probably accompanied by fracture

* the result of observations in 1883, these rocks are probably Cambrian.

and dislocation of the rocks. After passing the green silicious slates between Mooyie and Yakh Rivers, the beds become darker in colour and more argillaceous, containing nodular masses of iron pyrites and showing cavities where these have been removed by decomposition. A feature seen for the first time in these beds is the presence of ripple-marked surfaces, which are of almost constant occurrence throughout the Kootanie Valley as far as the trading post. At the second crossing of the Kootanie, some beds of hard, green sandstone are seen. They appear to be perfectly homogeneous on a fresh surface, but show small irregular false-bedding in green and white quartzose sediment, with included fragments of slate, on a weathered face. There are associated with these beds some laminated white and black shales with small concretionary points of carbonate of lime, which pass into an impure limestone, in which the carbonate of lime is intermingled with argillaceous patches in folds resembling the markings in the molar tooth of an elephant. There are very few intrusive dykes in this part of the country, only a single one having been observed to the east of the Mooyie River. There are, however, several apparently interstratified beds of amygdaloidal and compact trappean rocks, between the second crossing and Kootanie post. The most remarkable of these is a compact felspar-rock containing crystals of mica, hornblende and magnetite. Near the Kootanie post the slates are green and silicious, and are arranged in broad inclined steps across the valley dipping at an angle of 20° in the direction N. 60° E., all with ripple marked surfaces.

Ripple-marked surfaces.

Trappean rocks

Tobacco Plains.

At the Kootanie trading post the valley suddenly widens, the hills receding for about four miles from the river. The intermediate space is filled with flat-topped gravel terraces, which are known as the Tobacco Plains. In the mountains lying between the Tobacco Plains and Chelemto, and in the upper part of the Mooyie Valley, the rocks are similar in character to those seen in the Kootanie Valley and are probably arranged in a somewhat similar manner, the sections are, however, of small value, as they are only seen at rare intervals, owing to the thick growth of small timber which is almost universally present and is nearly as effective in concealing the rocks as the drift gravels in other places.

The high mountain which rises about 6,000 feet above the river on the west side of the Kootanie at the Tobacco Plains crossing, is made up of bluish grey slates with a belt of crystalline rock containing large starry masses of actinolite near the summit, probably a representative of one of the interstratified traps seen at a lower level further to the eastward. To the east of the Tobacco Plains, between the Kootanie post and the Flathead River, bluish-grey, green and purple clay slates are seen along the gorge of the Tobacco River, through which the

Tobacco Plains to Flathead River.

trail is carried. The dips are chiefly north-east, slope 30°. The flaggy surfaces of the beds are covered with ripple-marks and impressions of sun cracks. Near the summit of the dividing ridge, they are very red and sandy, containing numerous pseudomorphic impressions of salt crystals and some fossil-like markings, which have however been pronounced by Mr. Salter not to be of organic origin. The top of the pass is flat and swampy on the Flathead side of the slope. The dip of the red beds is 20° in the direction N. 10° W. About 300 feet below the watershed on the descent to the Flathead, the trail suddenly crosses a series of bluish-grey limestones which are exposed continuously on the slope to within a short distance of the alluvial gravels of the Flathead River. They are very hard, thickly bedded, and are divided into large blocks by open joints which are often filled with quartz crystals. The dip is 8° to 10° in an easterly direction. Mr. Salter's remarks on the fossils from these beds are appended as a note to this report.

Limestone outlyer.

They were chiefly found in a very compact bed in the middle of the section, where they are exposed on the weathered faces. At the lower end of the section, the limestones rest on a thin patch of false-bedded quartzose sandstone. Near the top of the hill they are lying unconformably on the red beds containing salt crystals. The limestones are cut through by the brook that runs down to the Flathead River, forming vertical cliffs varying in height from about twenty-five feet at the bottom of the hill, to about 200 feet about half way up, where the fossils are principally found.

Fossils.

Other beds of Carboniferous age are seen in the Kootanie Valley north of the Tobacco Plains, overlying the green slates with interstratified traps. They differ very much in appearance from the Flathead limestones, being principally argillaceous, the limestones occurring only in thin rubbly seams of a black colour. Only a few fossils have been found in them. The dip is north-east about 30°. The highest observed beds of the section are coarsely laminated quartzose shales with bands of black chert, possibly representing the millstone grit. At this point the trail turns off into the Mooyie Valley, but as Dr. Hector found the Carboniferous limestone further north in the Kootanie Valley, it is probable that it is continuous over the intermediate space.

Carboniferous beds.

The main chain of the Rocky Mountains lying to the eastward of the Flathead River, is made up of slaty and sandy beds resembling those seen north of the second Kootanie crossing, and in the pass of Tobacco River. The transverse valleys of the Akamina Brook and the South Kootanie Pass follow the strike of synclinal folds in the rocks. In the former the cliffs rise on each side of the stream like walls in particol-

Rocky Mountains.

oured masonry, and are cut back at intervals into semicircular hollows which usually contain small lakes. The projecting ridges which divide these basins may be taken to represent the buttresses, while, to complete the analogy, the mural cliffs are crowned with masses of red shales standing for pinnacles or buttress-caps.

Mounts Yarrell and Kirby and Spence.

The highest mountains near the pass are those named Mount Yarrell and Mount Kirby and Spence on Blackiston's map, near the western face of the range.* The first named rises about 6,500 feet above the Flathead River and is entirely composed of well stratified materials, principally shales and sandstones, the highest beds being of a brilliant red colour. At the final latitude-station on the watershed, the rocks bear a strong resemblance to those seen in the ridge dividing the Kootanie and Flathead Rivers. They are green and red argillaceous shales and sandstones with subordinate bands of limestone. Some of them are cleaved, but all are ripple marked and covered with the impressions of sun-cracks. The limestone is of a very peculiar character, being made up of spheroidal concretions which present on faces of weathering a confused series of irregularly concentric ringed masses, in which a stellar or radiated structure is occasionally developed from the presence of actinolite crystals. At the top of the hills above the limestone at the latitude-station, a height of 8,500 feet above the sea level, very red sandy shales resembling those of Mount Yarrell are found. They are in many places thickly coated with micaceous hæmatite.† Near the base of these red rocks three interstratified beds of a columnar greenstone or diorite are seen. The higher ones are very compact in texture and of a dark-green colour. They are occasionally vesicular, having crystals of hæmatite (iron glance) in the cavities. The lower bed is an amygdaloid of a dark reddish colour, the vesicles being filled with carbonate of lime crusted with green earth. Pseudomorphous crystals of rock salt are also found in the red beds, together with some concretiary nodules bearing a rough resemblance to fossils, none of which can, however, be pronounced to be of organic origin. A curiously furrowed slab from this locality has been submitted to Mr. Salter, who is of opinion that the markings have not been produced by burrowing annelids. On the nothern side of the synclinal forming the valley of the Akamina, the red beds are seen at the tops of the hills opposite the latitude-station, but the limestones are not exposed, being hidden by the rough talus of the upper beds.

Akamina Valley.

At the summit of the Indian trail in the South Kootanie Pass, about 7,000 feet above the sea level, fragments of one of the greenstone

* See Geology and Resources of the 49th Parallel, 1875, for a more detailed account of the rocks eastward from this point. The sections include beds from the Cambrian to the Triassic.

ese are probably Triassic.

bands are thickly scattered about the surface. They are probably nearly in place. In the descent from this point to the Buffalo Plains, the trail crosses a mass of blue, concretionary limestone at about the same level as that seen at the summit latitude-station. It is probably the same bed brought up by the longitudinal anticlinal of the main chain. Lower down the hill a peculiar condition of the red beds is seen, in the form of hardened clays of a blood-red colour, alternating with thin partings of a greenish-grey quartz-rock studded with small cavities containing grains of quartz and flakes of micaceous hæmatite. The whole resembling an altered mass of red marls with their green partings. They are overlaid by a thin bed of very crystalline greenstone.*

East slope of Kootanie Pass.

At Chief Mountain Lake, the cliffs in a north and south direction, along the eastern shore, expose the folds of the transverse synclinals in the plane of the concretionary limestone, which is contorted into a W-shaped curve between the eastern mouth of the South Kootanic Pass and the south end of the lake. The limestone is here underlaid by beds of purple and green silicious clay-slate much contorted, with an intercalated limestone which contains fragments of quartz and large nodular masses of chert. Ripple-marked surfaces are commonly seen in both slates and lower limestone. This is the last and most easterly section which was examined by the North American Boundary Commission.

Chief Mountain Lake.

The probable thickness of the upper beds of the mountains, *i.e.*, the concretionary limestone and overlying red and green beds and dioritic lavas, is about 2,200 feet.

In comparing the rocks seen at different points along the line of the larger section, the most apparent and striking difference is that between the unaltered beds of shallow-water origin on the eastern side of the Spokan gneiss, and the generally metamorphic sedimentary masses lying to the westward of that axis. In the Fraser River district, the rocks of the Chilukweyuk Valley, which are the least altered of any of those lying to the west of the Columbia River, have probably been deposited in deep water, as shown by their very thin laminations and the fineness of the sediment. The black slates and crystalline limestones on the Fort Hope road are sufficiently near in resemblance to the Chilukweyuk beds, setting aside the metamorphism produced in the latter by intruded greenstone and granitic masses, to allow of the assumption of these two being equivalent.†

Comparison of rock series.

The black and varigated siliceous slates of the Similkameen Valley, are probably again representatives of the lower part of the

* See section *op. Cit.* These lower red beds are at a different horizon, and are probably Cambrian.

† A paragraph, in which the age of the green beds forming a synclinal east of the Skagit is discussed, is here omitted, as they have since been shown to be Lower Cretaceous. See Report of Progress, 1877-78, and Trans. Royal Soc. of Canada, 1882, Sec. IV., p. 81.

Comparison of rock series.

Chilukweyuk slates, as they are of a similar fine texture, being altered by silicification into a black chert, and do not contain any of the thin bands of limestone by which the upper part of that series is distinguished. The limestones that are present on the Similkameen are very thin and concretionary. To the eastward of Larch Tree Hill everything is hidden by sands and gravels, but the black slates of Rock Creek are probably equivalent in position to those of the western valleys, as they are similar in texture and contain thin limestone seams. This part of the section is, however, much confused by the presence of intruded rocks and other marks of disturbance. On the east side of the great bend of Kettle River, the mass of rocks in the Colville basin is equal if not larger in amount than that in the Chilukweyuk Valley. The succession is also a similar one, the gneiss being overlaid by green slates with thin limestones, which are succeeded by sandstones and shales containing thick beds of limestone resembling those in the upper part of the western series, with this difference, that they have probably been deposited in shallower water, as they are less purely calcareous and there is a more rapid alternation in the mineral character of the intermediate beds from clays to sandstones and conglomerates, than is usual in the western district. The variable character of the limestones is further shown by the change of the thick blue beds of one side of the synclinal into white and shaly ones on the other.

On the eastern side of the Spokan gneiss, the slaty rocks of the Kootanie Valley have only one feature in common with those of the Columbia—the presence of interspersed crystals of iron pyrites. The great limestone beds are entirely wanting. This is most likely due to the shallow-water origin of the Kootanie beds, which is abundantly proved by the presence of ripple-marked surfaces, and as the higher parts of the section contain large quantities of thin false-bedded sandstones, it is probable that the shallowing went on as these were deposited. The concretionary "elephant's tooth" limestone of the second Kootanie Crossing appears to mark a new set of deposits, as it is above this point that amygdaloidal and other lavas are found interstratified with red sandy shales, containing hæmatite and numerous impressions of salt crystals.

Beds of the Rocky Mountains.

A similar mineral character and order of arrangement prevails in the upper beds of the Rocky Mountains, and if we assume them to be equivalents,* we must suppose that the greater part of the Kootanie Valley

* The conclusions stated in this paragraph, are based on the assumption of the identity in age of the Red rocks of the vicinity of the Kootanie Valley, with those of the upper parts of the Rocky Mountains near the 49th parallel. The remarkable lithological resemblance of these rocks might fully justify this hypothesis, which was, indeed, at one time entertained by the writer. It has, however, been proved by the exploration of 1883 that these red rocks are widely separated in age, the former being, as stated in a previous note, probably Cambrian, the latter Triassic.

rocks are actually present in the Rocky Mountains; the mountains on the western side showing a pile of stratified deposits more than 7,000 feet in height. In Dr. Hectar's map, in the Geological Society's Journal, (1861) Carboniferous rocks are marked as occurring in the South Kootanie Pass, but there does not appear to be any evidence for this view, as the red beds, &c., forming the mass of the rocks in that district certainly contain no fossils of Carboniferous or any other age. The Carboniferous rocks of the Kootanie Valley north of the Tobacco Plains, in addition to their very argillaceous character, are only conformable to the Kootanie slates in amount of dip and not in direction. The great outlier of the Flathead Valley, which is the nearest mass of Carboniferous rocks to the main chain of the Rocky Mountains, is markedly unconformable to the red beds on which it rests, is very compact and uniform in composition, and is of deep-water origin, presenting no indications of concretionary structure, false-bedding, or ripple-marked surfaces, all of which are seen in the concretionary limestones of Chief Mountain Lake.

As to the age of the slaty rocks, it is impossible at present to form a positive opinion. In Dr. Hector's map, the Kootanie slates are assigned to the Huronian period, probably from the fact of their containing no fossils. Sir W. E. Logan has also (in conversation) suggested that probably most of the western beds are of that age. By comparison of the collection of Canadian rocks made by Dr. Sterry Hunt, of the Canadian Survey, now placed in the Museum of Practical Geology, with that of the North American Boundary Commission, the following points of resemblance and difference have been obtained:— Probable age of slaty series.

1. The gneiss of the Spokan strikingly resembles the typical Laurentian gneiss of Canada, both being very coarsely crystalline and porphyritic with red felspar. The presence of garnet crystals is also common to the Canadian specimens and those from the great bend of Kettle River. On the other hand, the grey porphyritic gneiss of Osoyoos Lake, and the finely laminated variety of the same rock from Moodie's prairie, are conditions that are not represented in the Canadian collections.

2. The Huronian series of Canada is mostly composed of quartz-rocks, while the supposed beds of that age on the Pacific side are principally slaty. In some cases, however, as in the Similkameen Valley, they are sufficiently silicious to be only distinguishable from quartz-rock by their slaty structure and dark colours. Comparison with Huronian.

3. The interstratified greenstones of the Rocky Mountains are very much like those that occur in a similar manner among the Huronian rocks of Canada, and do not at all resemble those found under similar circumstances in the Lower Silurian rocks.

4. The manner in which micaceous hæmatite occurs as a component of the red beds of the Rocky Mountains is to a certain extent paralleled in the itabiarite, or slaty rocks of Canada, which are in places entirely composed of that mineral. These latter are, however, of Lower Silurian age.

The following are the estimated thicknesses of some portions of the metamorphic rocks in those areas in which it is possible to give them :

1. Schweltza to Chilukweyuk Lake, black slates and thick limestones about 24,000 feet, estimated at an average slope of 10° for twenty-eight miles.

2. Western limb of the Colville synclinal, from the Kettle Falls quartz-rock to the top conglomerates, about 14,000 feet. Estimated at an average of 30° for eight miles. Probably with the thickness of the black and green slates below them, which are contorted, the amount of these beds is equal to those in the Chilukweyuk Valley.

3. Kootanie slates from Mooyie River to the concretionary limestone at the second crossing, 15,000 feet. This is a very rough estimate obtained by prolonging the curves of contortion obtained from the observed dips. It is very probable, from the rapid change in the dip which occurs near the middle of the valley, that there are dislocations of the beds in this area.

4. Concretionary limestones red beds and dioritic lavas, about 2,200 feet, an estimate obtained from the mountains of the South Kootanie Pass.

Tertiary series.

Tertiary deposits.—The most considerable deposit of fresh water beds of Tertiary age occurring within the basin of the Columbia, is that seen at the confluence and in the valleys of the two branches of the Similkameen River at Vermilion Fork.* They are coarse sandstones made up of very slightly worn detritus of the neighbouring Ashtnoulou granite, above which are beds of fine white sandstone containing twigs and fragments of the wood of coniferous trees, and earthy carbonaceous shale or imperfect coals, containing plant remains and masses of retinite or amber similar to those seen in the Cretaceous coal of Nanaimo in Vancouver Island. The dip of these beds in the Tulameen Valley, at the Forks, is about 8° in a north-east direction. No other Tertiary beds are seen in the Similkameen Valley below this point.

Vermilion Forks.

Kettle River.

In the Kettle River Valley, about eleven miles east of Rock Creek, another patch of supposed Tertiary deposits is exposed on the north side of the river by an accidental slip of the covering gravels, in a place where the bank has been cut down to form a waggon road. The

* See Report of Progress, 1877-78, p. 129 B.

rock—which contains carbonaceous fragments—is a coarse shaly sandstone made up of the waste of a felspathic rock, probably furnished by one of the intruded porphyries in the adjacent metamorphic rocks. The height of the section is about twenty feet. The beds dip 60° south-east, and are exposed for a clear length of about fifty yards, when they are completely hidden by the superficial deposits. It may, therefore, be supposed that these rocks are present over a considerable portion of the Kettle River Valley, although hidden by deposits of a more recent period. No Tertiary rocks are seen in the Columbia Valley in the neighbourhood of Fort Colville.

In the Spokan Valley, on the eastern face of the low pass that comes from Chemikane, a small outlier of sandstones is seen about 300 feet above the river. The sediment appears to have come from some distance, as it contains small rounded and angular grains of quartz and flakes of clay slate and mica. The cementing material is carbonate of lime. This outlier is very small as the rock is only slighly coherent and has in great part been decayed by the action of the atmosphere. Spokan Valley.

Another fragment of loosely coherent sandstone is found on the Spokan River, close to the mouth of the Little Spokan. It is made up of the debris of the adjacent coarse rotten granite, and scarcely differs in appearance from the rocks from which it has been derived except by the presence of irregular planes of stratification.

Superficial Deposits.—The superficial deposits of the Fraser River and its tributaries near the sea, are principally derived from the redistribution of the blue boulder-clay of the northern drift period. This is especially the case in the Chilukweyuk Valley, where blue clay hills, with an occasional thin coating of coarse granitic gravels, form secondary ridges bounding the river and rising to a height of 400 to 600 feet. In Vancouver Island, about 200 feet of sand and gravel, getting coarser in the higher beds, is found resting on the eroded surface of the boulder-clay. These gravels are in many places covered by raised beaches made up of fragments of broken shells exactly resembling those forming the modern beach. They are found close to the shore at heights varying between six and ten feet above the present high-water lines. Further inland they are seen at higher levels up to about fifty feet, at a distance of nearly a mile from the present shore line. At New Westminster, raised shell beaches are found in a similar position, capping gravels and clay cliffs about thirty feet above the river. Boulders of grey syenite are found in great numbers at New Westminster and Point Roberts. On the western face of the ridge dividing Schweltza Lake from Sumass, there are a few boulders of a jaspidious and serpentinous rock which have their outer faces polished. They are perched on the hillside about 500 feet above the prairie. Probably many Superficial deposits. Vicinity of the coast.

similar blocks are scattered along the face of the hill, but they cannot be seen from a distance on account of the thick forest which prevails.

Columbia Valley.

In the valley of the Columbia, and in those of its principal tributaries, the gravels bordering the rivers rise to considerable heights on the flanks of the bordering mountains. They are usually arranged in steep flat-topped terraces. At the mouth of Methow River, a stream which falls into the Columbia about four miles below the confluence of the Okanagan, there are thirteen principal lines of terraces, the greatest difference of height between any two being about one hundred and twenty feet. The total height of the whole series is about 1,000 feet. The individual terraces are rarely continuous at the same level for more than 400 or 500 yards without breaking down into smaller or secondary terraces. On the Okanagan River, which flows through the widest valley in the country, measuring in places about twelve miles from cliff to cliff, the terraces bordering the river up to about 200 feet above it, are often from two to three miles in breadth and continuous at the same level for eight or ten miles. These great flats are usually impregnated to a considerable depth with alkaline salts. There are a few small lakes upon them in the spring time, which later in the year are dried by the sun, leaving a white crust of carbonate of soda.

Terraces.

In the widest part of the Similkameen Valley, broad terraces are also seen on the left bank of the river. Near the Ashtnoulou the gravel banks are steep, narrow, and slope at a small angle down stream. They are only seen in the hollows between projecting points of rock and are strikingly like railway embankments. In the Columbia Valley, at Fort Colville, in addition to well marked lines of terraces bordering the river, traces of older ones are visible on the right bank up to a height of nearly 1,800 feet above the present water-level. The lower ones and those bordering the plain on which the Hudson Bay Company's establishment is built, are formed of a finely laminated marl filled with nodular concretions, some of which assume the very unusual forms of crescents and perfect rings. This clay is usually only exposed at low levels, and is covered by a coarse gravel made of fragments of slaty and crystalline rocks, above which is a coating of blown sand. At the river-level the blown sand is from four to eight feet thick, forming a smooth surface, but on the left side of the valley, near the Kettle Falls, about 250 feet above them, there are curious indications of old sand dunes, the surfaces of which have become compacted and are now overgrown with large trees, but the steep-sided gullies in the drift hillocks are still plainly discernible.

The frontal slopes of the gravel terraces at Colville, are continually undergoing alterations from the action of the atmosphere. The greatest amount of modification is effected by the sliding of great masses of snow over them during the spring thaws. A few transported boulders of syentic granite are seen at various points in the hills on the north side of the Colville Mill River, and in two places the rocks are faintly scored with fine irregular groovings. Their direction, as far as can be seen, is from north to south. The height of these points is about 2,000 feet above the sea-level. One other instance only of ice-marking was observed. It is on the Okanagan River, about midway between Osoyoos and the mouth of the river in about the same latitude as Colville, but at a much lower level. The markings are seen on the face of a white limestone cliff. They follow the course of the valley. *Glacial striation.*

On the Spokan plateau several small boulders of granite are seen among the basaltic gravels about twenty miles south of the Chemikane granite hills, the nearest source from which they could have been derived. On the left bank of the Similkameen, about six miles below the Ashtnoulou, a very peculiar arrangement of the cliff-falls is worthy of notice. The cliffs, which are formed of a purple silicious slate, nearly quartz rock, are faced for more than two-thirds of their height by conical mounds of fragments. The highest is about 900 feet high. The larger masses that have reached the lower gravel terraces in the bottom of the valley, are extended in long lines along the front edge of the terrace for about 600 yards down the valley. Some of the blocks are of great size, measuring from 6,000 to 8,000 cubic feet. In the main chain of the Rocky Mountains there are a few small glaciers. The lowest is about 6,000 feet above the sea-level, but no ice-markings or transported blocks are anywhere apparent in the South Kootanie Pass. *Erratics.* *Talus.*

Auriferous gravels.—Gold is generally present in the lower level gravels of the Fraser, the Similkameen, Pend D'Oreille, Kettle and Columbia Rivers. The principal points at which workings have been carried on are as follows:—1. In the gorge of Fraser River, north of Fort Hope. 2. In the south branch of the Similkameen, near Vermilion Forks. 3. In the lower part of the Similkameen Valley, between Haynes' House and the Okanagan. 4. At Rock and Boundary Creeks, two small tributaries of the Kettle River. 5. In the lower part of the Pend D'Oreille Valley, near Fort Shepherd, and 6th, at various points on the Columbia between Fort Shepherd and Fort Colville. *Gold bearing regions.*

At Rock Creek the ground worked was the gravel filling the bed of the stream, the greatest thickness being about sixteen feet, with an average breadth of twenty-five feet. The claim allowed to each digger was one hundred feet, following the bed of the stream, and including the whole breadth of the valley. Three or four adjacent claims were usually worked as one adventure by the united strength of the claimants. The method of working is very simple. After *Rock Creek mines.*

Mode of working.

diverting the stream to one side in order to get at the gold-bearing ground, a rectangular trough of boards called a sluice is set up in an inclined position on rough stone piers, and a stream of water is kept constantly flowing through it. The gravel taken out of the bed of the stream is thrown on a rough grating made of bars of pine wood placed about two inches apart, which is fixed at the upper end of the sluice. The larger stones are kept back by the grating, and are removed from time to time by the filler, by means of a four-pronged steel fork. The floor of the sluice is lined with similar longitudinal gratings. The gold and other heavy materials fall into the hollows between the bars of the gratings where they are protected from the scour of the current of water passing over them. In some cases boards with shallow transverse notches which are filled with mercury are used in addition to and alternately with the gratings; an arrangement which is locally known as the Hungarian riffle. In order to get out the whole of the gravel it is necessary to provide some means of drainage as the hole gets deep. This is effected by a small undershot wheel placed in the free current of the exit water of the sluice, which lifts the water from a sump at the lower end of the claim, by means of a chain of buckets. The sluices are usually set up at much higher slopes than are generally employed in dressing machinery in European mines, the primary object being to obtain a rapid current and consequently power to work over large quantities of material in a short time, irrespective of the loss produced by such a method of working.

Some of the Rock Creek miners estimated the loss of gold at about half the total contents of the rough ground. The washing is carried on continuously for a period varying from three to six days according to the richness of the stuff worked, when the water is stopped off and the contents of the sluice are collected. They are of two kinds, fluid amalgam, from which the gold is obtained by filtration through buckskin and ignition of the solid alloy of gold and mercury remaining; and auriferous black *schlich* or sand, which is cleaned from magnetite and other heavy minerals by hand-washing in a wrought-iron pan, in the usual manner. In the month of September, 1861, about 300 men were at work at Rock Creek, their average earnings were stated to be about twenty to thirty-two shillings each, daily, but in the following September the place was deserted. At Boundary Creek, about seven miles below Rock Creek, the workings were commenced a little later, but were abandoned at about the same period, all the miners being drawn away by reports of the extremely rich deposits of the Cariboo country near the head of the Fraser River, and on the Salmon River in Oregon. The diggings on the South Branch of the Similkameen were

Boundary Creek mines.

chiefly carried on by Chinamen and were also abandoned at the beginning of the winter in 1861. On the Lower Similkameen and other large rivers, the period of working is limited to the early spring and the autumn and early winter months, before and after the annual floods. The ground washed is that lying between high and low water-mark and as much of the ordinary bed of the river as can be laid bare by running out wing-dams from the shore. On the Pend D'Oreille River a considerable quantity of gold has been obtained from the small and irregular deposits brought down by the river in flood time, and lodged in the hollows on the roughened edges of the slaty rocks. The dressing machinery employed is the ordinary California cradle or rocker, in which from two and a half to three tons of rough gravel can be dressed daily. In order to collect fine gold when using the rocker, it is customary to use plates of copper covered with a thin film of mercury, or when this is not obtainable to cover the tail-board of the rocker with silver half-dollar pieces amalgamated in a similar manner. In the Pend D'Oreille Valley, during the season of 1858, the gravel terraces lying above the present high-water level were successfully worked for gold, as much as £20 per man per diem having been realized by working sluices on ground about twenty-five feet above the river. On the Columbia River near Fort Colville the lowest level gravels only are worked, and even to reach these it is necessary to strip off the overlying cover of blown sand. At Hills Bar, in the gorge of Fraser River near Fort Yale, high level gravels are worked. At this place a rude stone mortar of unknown Indian workmanship was found in one of the gravel terraces, it is said at about thirty feet below the surface and about forty feet from the face of the slope. In the gold drifts of Thompson River elephant remains are found. A single molar tooth from this locality is in the possession of a surgeon in Victoria, Vancouver Island.

Lower Similkameen.

Pend D'Oreille River.

Other auriferous localities.

The gold dust obtained on the Fraser River is principally of a low degree of fineness, about $\frac{860}{1000}$ representing the average of the assay value, or percentage composition 86 gold, 10 silver, 4 copper and oxidisable substances. The alloy is principally silver and copper. The samples from the higher parts of the Fraser Valley are associated with osmiridium, platinum, rutile, magnetite, black spinel and garnet. The three latter minerals are often found in distinct but minute crystals. The scales of gold are, in the southern localities, mostly of small size, rarely exceeding one tenth of an inch in diameter, and are generally very much smaller. This very fine variety is called by the miners "float gold," and can only be collected with great difficulty, as it particularly liable to be carried away by a rush of water, instead of sinking, owing to the large surface of adhesion presented by the scales as com-

Character of the gold.

pared with their individual weights. Another and more formidable source of loss, lies in the fact that many of the scales are covered by a coating of rust, which protects them against the solvent action of the mercury when amalgamation is used.

Relations to rock series.

There does not appear to be any direct relation between the mineral character of the rocks forming the walls of the valleys, and the greater or less abundance of gold in any of the localities noted above; thus, in the lower diggings on Fraser River, the country is formed of gneiss and granitic rocks, at the Chinamen's diggings, near the Vermilion Fork, of Tertiary or Cretaceous clays and sandstones; at Rock Creek and the lower part of the Similkameen of black slate; and at the mouth of the Pend D'Oreille of the black slates, limestones and syenitic greenstones of the Colville series. This fact, together with the generally small size of the scales of gold obtained, leads us to suppose that most of these gravels are only the remains of older drifts lying further to the north, a supposition that is well born, out by the increase in size of the fragments of gold in higher latitudes. Thus the gold dust of the Cariboo country, in latitude 53° north, is made up of coarse lumps often $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in diameter and equal in size to the bulk of the selected nuggets obtained in the preceding years at Quesnel River and at points near the head of Thompson River. It is also difficult to suppose that the gold can have been derived from the slaty rocks, as the quartz veins in them are few and insignificant, unless it had resulted from the decomposition of the contained iron pyrites, which is not a very probable source.

Argentiferous galena.

Very pure galena of a moderately argentiferous character occurs on the Kootanie Lake, yielding by assay 83 per cent. of lead with 20 oz. of silver to the ton. The specimens were obtained from Mr. A. C. Anderson, of the Hudson's Bay Company at Victoria. The locality is, however, practically inaccessible, the only means of approach being by the Kootanie River, which is barred by falls and rapids near the mouth and can only be navigated by light canoes.

Silver at Hope.

At Fort Hope a large quartz vein has been found on the right bank of the Fraser River. It contains at the outcrop a small quantity of iron and copper pyrites associated with an earthy black copper ore (probably resulting from the decomposition of an argentiferous fahlerz) some of which yields about 40 ounces of silver to the ton. A level was commenced on this lode in September, 1861, but was subsequently abandoned, owing, I believe, to the high price of driving, from the hardness of the ground. In the Harrison River Valley, Dr. Forbes, R. N. reports the presence of traces of silver in many places, but neither the native metal nor any of the known precious ores of silver had been discovered in quantity up to the end of 1861. Many so-called silver ores were brought down to Victoria from this locality during the autumn of 1861 by a travelling Mexican miner. The bulk of the specimens, however, were ordinary crystalline rocks, such as hornblende slate with a little iron pyrites, hornblende crystals, &c., and as a silver mania prevailed in the town at the time, it was difficult to persuade the would-be speculators, even by actual assay, that these so-called ores were utterly worthless.

Basalts of the Columbia.—The table-land that extends southward from the Spokan River down to the Dalles of the Columbia, and eastward from the inner face of the Cascade Mountains nearly to the head of the Snake River, is entirely covered with volcanic substances, basaltic and trachytic lavas, tuffs and conglomerates. The most abundant of these rocks is a species of scoriaceous basalt which extends, without any marked change in mineral composition, over a space measuring 220 miles by 150 miles, or about 33,000 square miles. The best sections in this country are those seen on the road from the Dalles to Fort Okanagan* by the right bank of the Columbia, the basalts and ashes being well seen in the transverse ridges dividing the valleys of the Nachess, Yakima and other tributary streams. At the Dalles, the white chalk-like ashes are seen above the basalt, the lower beds containing thin bands of hard red conglomerate. These white beds contain remains of diatomaceæ, but it does not seem to be quite clear whether they are of fresh-water or marine origin. On the right bank of the Columbia the ashes form a grassy hill about 2,500 feet high, the higher beds containing fragments of opalized wood, which are thickly strewn over the surface. The conglomerate beds at the bottom of the series contain large fragments of a grey trachytic porphyry often several tons in weight. On the high ground between the Yakima River and the Columbia, at Wenatchee River, the basalt and ashes together make up a mountain mass 7,000 feet in height. This is probably about their maximum thickness. On the Spokan plateau, the basalt forms a gently inclined plane between the Spokan Valley and Walla Walla, having a southerly slope of about one in 500. The sections exposed in the ravines and water-courses show a nearly horizontal or slightly undulating stratification, combined with an irregularly columnar structure. Where the beds are undulated, the columns are usually arranged in a radiated manner, the rays diverging from the inner to the outer face of the curve. The white ashes are seen on the lava-plain about half way between the Spokan Ferry and Walla Walla, forming rounded outlying hills from 200 to 500 feet in height. They are entirely covered with grass, so that the rock can only be obtained by digging. It resembles the

Basaltic Plateau.

Section at the Dalles.

Thickness of volcanic materials.

* See Geology of Central Washington Territory by Gibbs in Pacific Railway Reports. Vol I. and Geology of U. S. Exploring Expedition by J. D. Dana.

white ashes of the Dalles, but usually contains angular fragments of the underlying basalt. The presence of these white ash outliers, as well as the basaltic ones noticed in the Spokan and Chemikane valleys, furnish, as well, a measure of the enormous amount of denudation to which this country has been subjected in recent times. The basalt is of comparatively modern date, as it overlies Miocene Tertiary strata at Walla Walla and it is evident that the valleys of the Spokan and Chemikane had been excavated before its eruption, as the outliers are found at the lower levels as well as high up on the hillsides. The presence of marine infusoria in the white bluffs, necessitates a great amount of subsidence for their deposition—at least 2,500 feet at the Dalles—and it is probably during re-elevation that they have been removed from the Spokan plateau and that the terraced gravels of the higher valleys have been arranged in their present forms. After the removal of the ashes, the denudation of the basalt has probably been effected by the streams, as it is easily decayed away owing to its columnar structure. Very fine examples of these valleys of erosion are seen on the Yakima and Untenun (?). The latter, a small brook only about ten feet wide, is bounded by vertical walls about 500 feet high. Many old river courses are also found on this rock. The most important is the well-known Grande Coulée or old channel of the Columbia, which is fifty miles long, eleven wide at the north end, and bounded by nearly vertical cliffs 800 to 1,000 feet in height.

Erosion.

Courses of rivers.

There is one curious feature in the eastern tributaries of the Columbia which is deserving of special notice. The Colville Mill River, the Pend D'Oreille and the Kootanie all flow in a generally northerly direction for the latter part of their courses, and force their passages into the Columbia over great obstacles ;—thus the Colville Mill Stream has a fall of seventy feet over rocks about two miles above its mouth, the Pend D'Oreille presents a succession of step-like falls and rapids for about five miles above its month, and the Kootanie is not navigable at its northern end from similar obstacles. The watersheds between these streams, on the other hand, are almost imperceptible, not being marked by transverse rock-ridges or any salient feature in the north and south valleys. It may, therefore, be urged with a fair show of probability, that at some former period the two former rivers, and perhaps, also the latter, discharged their waters through the Spokan Valley, which, from its great size, far exceeding that of the Columbia at Colville, appears to have performed a more important office in the drainage of the country in former times than it does at present.

Mr. Gibbs, of the United States Commission, has suggested the probability of a similar change of drainage having taken place in the

Okanagan Valley by the diversion of waters which now discharge by the Fraser and Thompson Rivers. Such a change would account for the great size of the valley, which is now occupied by a comparatively insignificant stream.

Terraces.

The question of the probable origin of the terraced gravels of the Columbia, as well as those of the Sacramento River is discussed in the geology of the U.S. Exploring Expedition, pp. 171-2. Prof. Dana, however, does not appear to have been aware of the great height of the terrace-levels in the higher part of the Columbia Valley.

Palæontological note.

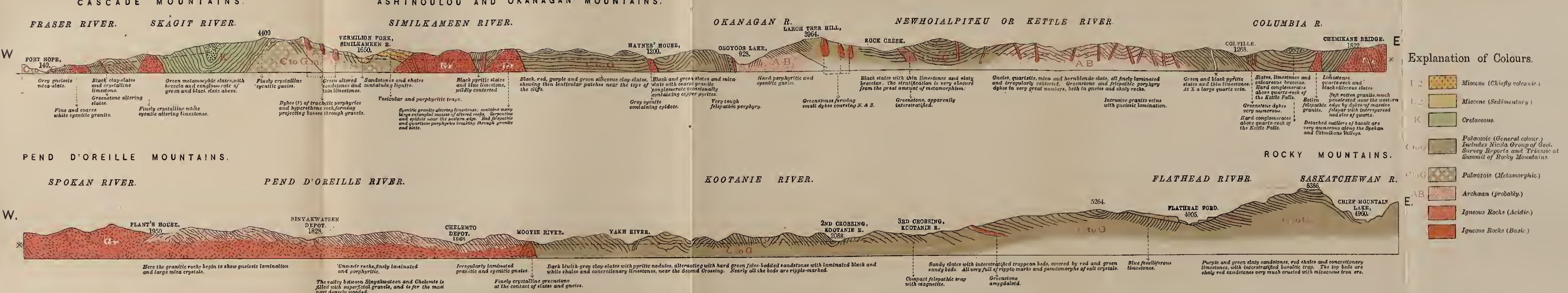
LIST OF FOSSILS FROM THE CARBONIFEROUS OUTLIER IN THE FLATHEAD VALLEY, BY J. W. SALTER, ESQ., F.G.S.

Retzia Verneuiliana (Hall Geology of Iowa, pl. 23, fig. 1.)
Rhynchonella mutata (" " " pl. 23. fig. 2.)
Athyris subtilita.
" (allied to *A. squamosa.*)
Spirifer Keokuk (Hall Geology of Iowa, pl. 24, fig. 4).
" *setigerus ?* (Hall Geology of Iowa, pl. 27, fig. 4).
Productus semireticulatus.
" (a small spiny species like *P. aculeatus* or *P. spinulosus*).
Flat bryozoon (resembling *Ptilodictya*).
Pleurotomaria.
Euomphalus (impression of a small form resembling *E. carbonarius*, probably young of *E. latus.* (Hall Geology of Iowa, pl. 12, fig. 7*a*).
Archeocidaris (spine).
Actinocrinus (stems).
Platycrinus (coral plate).
Lithostrotion, *Zaphrentis*, *Aulophyllum* } Fragments, mostly transverse sections.

Most of the fossils are very fragmentary, the best being procured from weathered blocks of a very hard and compact grey limestone. The *Retzia* at the head of the list, has been identified by Mr. Davidson, but with a mark of doubt, as there is a depression down the centre of the dorsal valve, and the foramen and beaks are larger, so as to give a somewhat more oblong shape to the shell than that of the figured specimen from Iowa. The striations agree closely. The *Spirifer* referred provisionally to *S. setigerus*, is a small transverse species, smooth, with a very slightly raised sinus and numerous short interrupted impressed striæ. Hall's *S. setigerus*, ? has no defined sinus, whereas it is well defined in the specimen from Flathead Valley. The striation is, however, much the same in the specimens from both localities.

Only three specimens were obtained from the limestone in the Kootanie Valley north of the Hudson's Bay Company trading post. They are only fragments, such as a spirifer (like *S. alternatus*) with a very slightly raised, but well defined sinus. *Rhynchonella*, a large coarsely-ribbed species. *Streptorhynchus* resembling *Orthis robusta* (Hall, Geology of Iowa, pl. 5, fig. 28).

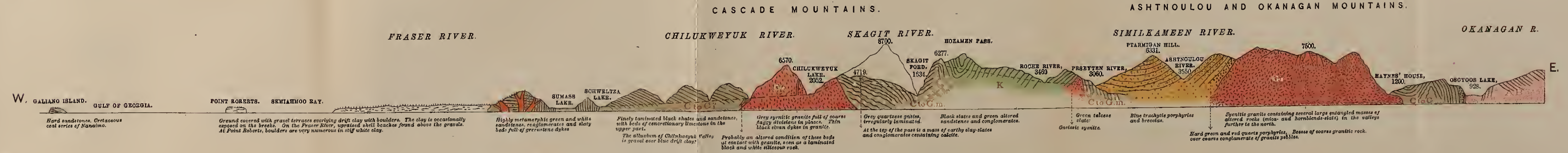
In accordance with a very general character of American mountain limestone fossils, all the specimens are of small size. Crinoids are remarkably rare.



SECTION FROM FORT HOPE, FRASER RIVER, TO WATERTON, OR CHIEF MOUNTAIN LAKE, ON THE BUFFALO PLAINS.

Constructed from observations made on the Brigade trails from Fort Hope to Colville, from Colville to the Kootanie Post and the South Kootanie Pass of the Rocky Mountains. Projected into an East and West Line.

Horizontal Scale, 10 miles to an Inch. Vertical Scale, 10,000 feet to an Inch. Heights expressed in feet above the sea level. Broken lines represent water-courses.



SECTION FROM POINT ROBERTS, ON THE GULF OF GEORGIA, TO OSOYOOS LAKE.

SKETCH SECTIONS ACCOMPANYING REPORT BY H. BAUERMAN, ESQ., F. G. S.

THE BURLAND LITHOGRAPHIC CO MONTREAL

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

REGION IN THE VICINITY OF THE

BOW AND BELLY RIVERS,

NORTH-WEST TERRITORY.

EMBRACING THE COUNTRY FROM THE BASE OF THE ROCKY MOUNTAINS EASTWARD TO LON. 110° 45′, AND FROM THE 49TH PARALLEL NORTHWARD TO LATITUDE 51° 20′

BY

GEORGE M. DAWSON, D.S., F.G.S.,
ASSOCIATE ROYAL SCHOOL OF MINES.

ASSISTED BY

R. G. McCONNELL, B.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1884.

To Alfred R. C. Selwyn, Esq., LL.D., F.R.S.,

Director Geological and Natural History Survey of Canada.

Sir, I beg to present herewith a report on the region in the vicinity of the Bow and Belly Rivers, embracing the southern part of the District of Alberta and a portion of the western part of Assiniboia, with illustrative maps. This district is the first in the North-west Territory of which a systematic and proximately complete examination has been made, and is of special importance in consequence of the proximity of its valuable coal and lignite deposits to the line of the Canadian Pacific Railway.

I have the honour to be,

Sir,

Your obedient servant,

GEORGE M. DAWSON.

Ottawa, March, 1884.

NOTE.

Most of the elevations stated in this report are the result of aneroid barometer observations, based on the height of Fort Benton, which is assumed at 2,700 feet. General Hazen having kindly furnished a copy of the regular barometric observations at that place, the whole of the aneroid readings have been carefully compared with these. Where several observations have been obtained at a single locality, and separately calculated, the results generally agree very closely, and the limits of error are probably, in all cases, within fifty feet. A few points on the line of the Canadian Pacific Railway have been obtained, since the date of the explorations here reported on, by actual instrumental levelling.

Where not otherwise stated, the bearings given throughout are with reference to the true meridian.

G. M. D.

REPORT

ON THE

COUNTRY IN THE VICINITY OF THE

BOW AND BELLY RIVERS,

NORTH-WEST TERRITORY.

This report, and the maps which accompany it, cover the greater part of the area drained by the Bow and Belly Rivers, and portions of that tributary to the Red Deer and Milk Rivers. With the exception of the latter, the whole of its waters eventually reach the South Saskatchewan. It includes the southern part of the district of Alberta, with a portion of the south-west of the neighbouring one of Assiniboia, and from the base of the Palæozoic rocks of the mountains eastward, includes an area of about 26,960 square miles of prairie and plateau country, based on the softer and newer formations designated as Cretaceous and Laramie. This district is the first in the western territory which has been subjected to a systematic and proximately complete exploration, and was selected for this purpose because of the known and reported value of its coal deposits, and its relation to the adopted transcontinental railway route. It further appeared, that from its general prairie character and the number of the river-valleys traversing it, it might likely serve geologically as a typical region, in which the order and succession of the various formations could be determined, and in the light of which, future explorations in the great plains and in the foot-hills of the mountains might be carried on. Its investigation has in no wise disappointed these expectations. The coal deposits have proved to be wide-spread and practically inexhaustible, and while in the detail of its geological structure much addition is yet to be desired, most of its main features are clear and easily read, and it is hoped that the present geological map and report may answer all practical purposes for a number of years to come.

Region covered by report and maps.

Area.

Importance of the region.

Such uncertainty as to the details of geological structure as may still

Circumstances rendering geological investigation difficult.

remain is due chiefly to two circumstances which may be briefly alluded to. While the river-valleys generally afford fine sections, great intervening tracts are so thickly drift-covered that the underlying rocks seldom come to the surface, and absolute certainty as to the position of the outcrops of certain beds and coal seams in these regions can only be arrived at by boring operations. Again, in the foot-hill region, where the beds are sharply folded and even overturned, and other accidents occur to complicate the structure, while it is doubtless possible to trace out the subdivisions of the Cretaceous and Laramie with greater completeness, this would require so much time and labour that it has not been judged advisable at present to undertake it, in view of the great importance of defining and publishing its general structures.

History of its geological exploration.

The first geological notes on the district are those in Dr. Hector's reports, based on his explorations in the North-west as a member of Captain Palliser's expedition in 1859. No addition was made to these till in 1874 the writer examined the country near the 49th parallel as geologist to H. M. North American Boundary Commission. In 1881 the entire summer season was spent by me and my assistant Mr. R. G. McConnell, B.A., on the area of the accompanying map, and in 1882 Mr. McConnell, having wintered at Calgary, continued the exploration independently. In 1883 the month of June was devoted by me to the further examination of a number of localities on the southern part of the map, in regard to the structure of which doubts still remained, and Mr. McConnell completed the traverse of the portion of the Red Deer included on the sheet. Additional light on the general geology has also been obtained through Mr. McConnell's subsequent work in the adjacent region to the east. While the main geographical outlines of the map are based principally on the instrumental surveys of the Dominion Lands Branch, much of the topography has been added from our own surveys, I would mention especially in this regard the area of the foot-hills from the North Fork of the Old Man to the Elbow Rivers which was mapped by Mr. McConnell in 1882, and had not previously been penetrated by any survey lines. Nearly all the trails and travelled routes were also laid down from our own odometer surveys, and canoe traverses of the Bow, Belly and St. Mary, part of the Old Man, and those portions of the Red Deer and South Saskatchewan, included on the map, have added much to the topography previously delineated on these streams.

Data of the map.

MAIN TOPOGRAPHICAL FEATURES OF THE DISTRICT.

Three natural divisions.

The district may be divided naturally by its physical characteristics, into the following parts enumerated in order from east to west:—(1) Plains and low plateaus. (2) The Porcupine Hills. (3) The foot-hills.

The Rocky Mountains, which form its natural western boundary, are not included in this report, except in so far as incidental mention of their structure may be necessary.

The routes within the area of the map, traversed and examined by myself and Mr. McConnell during the progress of the exploration, may be thus approximately stated, no account being taken of those which were twice traversed or passed over a second time without measurement and examination. Routes traversed.

Measured by odometer	2315	miles.
Distances estimated, and checked by observations for latitude	835	"
Measured by pacing	275	"
Total	3425	"

The bearings given throughout this report, unless otherwise qualified, are with reference to the true meridian. Bearings.

In conformity with the general eastward slope of the plains from the Rocky Mountains, the eastern is low as compared with the western portion of the district here described. East of the 113th meridian, which nearly bisects the map, a great portion of the plain is less than 3,000 feet in altitude, while westward from the same line, with the exception of inconsiderable tracts along the river-valleys, the whole country exceeds this elevation. East of the above line, however, considerable tracts still rise above the 3,000-feet contour-line. The most important of these lies in the vicinity of the Milk River, and forms a raised southern border to the district, the whole region in the vicinity of the 49th parallel west of the 111th meridian exceeding 3,000 feet in altitude. To the north, the plateau of the Rocky Buttes forms an insular area of considerable extent above this contour-line, being separated from the plateaus to the west by the Snake Valley, while at the extreme northern edge of the map the Hand Hills again encroach upon the lower plains. General elevation.

Along the base of the mountains, the elevation at which the rivers leave the Palæozoic rocks is pretty constant, and averages about 4,300 feet. The Rocky Mountains, for some distance north of the 49th parallel, where the foot-hills are comparatively inconsiderable, form a distinct and almost mural eastern front, the peaks of the first or outer range frequently attaining a height of 6,000 to 7,000 feet, while an elevation of over 9,000 feet is not infrequently reached by the summits at some distance back. Further north, the eastern outline of the mountains is to some extent masked by the high and crowded foot-hills which here press upon them, but the altitude of the summits is little if at all inferior. Elevation of western part.

Such being the outlines of the region in regard to elevation, a brief description of the general features of its three natural divisions as above defined may now be given.

General character of the three divisions.

THE PLAINS.

The plains. The plains proper may be considered as extending westward to the foot-hills near the St. Mary River in the vicinity of the 49th parallel, but further north, find their western limit at the base of the Porcupine Hills. Their surface is generally undulating or rolling, though in some localities considerable tracts occur which are almost perfectly level. The undulations vary much in amount locally, but are seldom—and then only in limited areas—entitled to be called hills. Deep, trough-like valleys, occupied by rivers, or, in some cases, by quite inconsiderable streams, and then denominated "coulées" trench the plains at intervals, but wide intervening areas are entirely destitute of drainage channels, the rainfall collecting in lakes, or in the innumerable small pools and sloughs which dot the surface, but which frequently dry up completely during the summer. Rising above the general level are a number of elevations which are generally called "ridges," but are properly speaking plateaus. The heights of these seldom exceed by more than one hundred or two hundred feet that of the surrounding plain, and their slopes are usually very light. As viewed from a distance, however, in this flat country, they are frequently conspicuous objects, and are generally in close and evident connection with the geological structure. The more important of these may be enumerated as follows:—Milk River Ridge, west of the MacLeod-Benton trail and north of the Milk River, average elevation 4,100 to 4,200 feet. Belly Butte and associated ridges between the St. Mary and Upper Belly Rivers, running eastward into Wild Turnip Hill. The Chin, on Chin Coulée, forming the western end of a diffuse plateau. Plateau south-east of Lake Pā-kow-kī, and high ground stretching eastward from the Three Buttes. Bull's Head, east of Seven Persons River, forming the southeastern front of the Peace Buttes. Black Spring Ridge, elevation 3,550 feet. The Thigh Hills. Buffalo Hills, 3,850 feet. The Rocky Buttes, about 3,100 feet. Spy Hill, Carcass Hill, Spring Hill, and Little Rolling Hills. Outer and Inner Rainy Hills, about 2,700 feet. Wintering Hills, about 3,000 feet. The Hand Hills, with, according to Dr. Hector, an elevation of 3,400 feet.

Drainage.

Plateaus.

Uniformity of surface. The general uniformity of the surface of the country is largely due to the covering of boulder-clay and other drift deposits. These have been apparently laid down in greatest thickness in the pre-existing hollows, while the higher plateaus are comparatively thinly covered; and the result has been the general levelling up of the surface, and the production of wide flat plains in the less elevated tracts. The underlying Cretaceous and Laramie rocks are seldom seen except in the scarped banks of rivers and streams. The same circumstance has caused a remarkable uniformity in the general character of the soil, which, below the sod, is usually composed of the rearranged materials of the boulder-clay. It may be described generally as a clayey loam, of brown or grey tint, and mingled locally with a varying proportion of gravel. Gravel is most usually found in the subsoil in the higher tracts, and is almost or altogether wanting in many of the lower, which are characterized by fine water-deposited loam. No large areas of loose sandy soil, or sand-hills, have been observed in this district, the most extensive covering only a few square miles, of these the following may be noted:—Sand hills north and east of Lake Pā-kow-kī. About forks of Bow and Belly Rivers. In the South bend of the Belly east of Little Bow. Near the mouth of the Little Bow. The Drifting Sand Hills, and the Peigan Sand Hills west of Blackfoot Crossing and near the Bow River.

Uniformity of soil.

Sand hills.

In a few places the surface is pretty thickly strewn with boulders, but these areas are quite inconsiderable, and the prominence of the boulders is generally to be traced to the removal by denudation,—owing to some local circumstance—of a considerable depth of the finer materials of the drift. The general absence of boulder-strewn tracts thus shows how small must have been the effect of denudation since the deposition of the boulder-clay and other glacial materials.

Boulder-strewn tracts.

Speaking generally, the soil may be described as fertile, and in some places is eminently so, but over a large part of these plains the rainfall is probably too scanty for the successful growth of crops. The surface is almost uniformly grassed, and no tracts of an absolutely barren or desert-like character occur. The grass is usually the short crisp variety known as "buffalo grass," which becomes to all appearance dry about mid-summer, but is still green and growing at the roots, and forms nutricious pasture both winter and summer. In some particularly dry areas about the lower Bow River, the grass becomes scanty, but on almost all the plateaus above enumerated it is particularly good, while a heavy growth of grass suitable for hay is found in many of the river bottoms, and surrounding the numerous lakes and sloughs. This whole region, a few years since, contained numerous herds of buffalo, and though these have now practically disappeared, it will not be long before they will be replaced by cattle and horses.

Soil, rainfall and grass.

The entire region of plain included on the map may be characterized as treeless, and except in the river valleys, or here and there in some steep-sided coulée, no arboreal or shrubby growth of any kind exists.

Treeless character.

THE PORCUPINE HILLS.

The Porcupine Hills.

The Porcupine Hills, properly so-called, extend from the north bank of the Old Man River, west of Fort MacLeod, to the head-waters of Mosquito Creek, a distance of fifty-five miles in a north-north-west direction. Their greatest breadth is pretty uniformly maintained at from eighteen to twenty miles. The Hog's Back or Sitoko-pawaghko, south of the Old Man, is really, however, a part of the same range, while to the north it is continued by more or less isolated areas of high plateau to the Bow River, and beyond that stream by the Nose Hill.

Physical features.

The Porcupine Hills consist of rocks forming the upper part of the Laramie, and mark the axis of a wide synclinal. Mr. McConnell, who examined this region in 1882 thus describes the physical features of the hills proper:—

"The hills are highest near the southern end, where they rise about 2,000 feet above the plains to the east (at least 5,000 feet above the sea) and about 1,500 feet above the valley lying along their western base. To the north they become much lower, and near Highwood River are only about 400 feet above the general level of the country."

"The surface of the hills is very rough, and is generally cut up by the deep and wide valleys of numerous small streams. The great valleys which even the most insignificant of these streams have excavated, give evidence of an erosive activity at one time, far exceeding anything which is now going on. The grassy slopes which nearly all the valleys present at the present day, showing how small the denudation in progress is."

"The principal drainage of the hills is to the east and south, in consequence of the difference of elevation of the country east and west of them, which amounts to over 450 feet. Viewed broadly, their surface is composed of the broken remnants of a wide plateau with an eastward inclination."

Prairie and wooded areas.

The lower slopes of the hills on both sides are open grassed land. At a somewhat greater elevation scattered trees begin to occur, but it is only on some of the higher western points that any areas of continuous woodland occur. The Hog's Back to the south carries no wood, but on the isolated plateau areas north of Highwood River, thickets and groves begin to appear in a few places, in consequence of the greater humidity of the climate in that region.

Cattle country,

The eastern margin of the Porcupine Hills is nearly identical with the western border of the buffalo-grass country previously described. In consequence of the greater rainfall met with on approaching the mountains, the buffalo-grass is here replaced by the more luxurient bunch-grass, and within the area of the Porcupines and their northward and southward extensions some of the best cattle ranching country of the entire North-west is situated.

THE FOOT–HILLS.

The foot-hills.

Stretching along the whole length of the base of the Rocky Mountains, is a region with peculiar characteristics which is appropriately named the "Foot-hills." This is conterminous with a belt of sharply folded and disturbed rocks of Cretaceous and Laramie age, and the character which these impress on the region is so well marked that it can scarcely escape the notice of any traveller. Long ridges, sometimes covered with vegetation to the summit, in other cases showing projecting rocky crests formed by the outcrop of the harder sandstone beds, alternate with parallel valleys in which the smaller streams flow, while the rivers which have their sources in the mountains have carved for themselves channels to the plains beyond, nearly at right angles. The streams here fresh from the mountain snows are limpid, flow over gravelly and rocky beds, and are often full of fine trout. That part of the region which is not wooded is covered with luxuriant bunch-grass, and fine timber (generally the Douglas fir) exists in considerable quantities in some of the more retired valleys.

Mountain streams.

The ridges, with the strike of the rocks which they indicate, show a nearly complete parallelism with the base of the Palæozoic rocks of the mountains, and follow it in its light sinuosities. The width of the geologically disturbed region and of the foot-hill belt is, on the St. Mary, Upper Belly and Waterton Rivers, about sixteen miles; On Pincher Creek, Mill Creek and the southern branches of the Old Man, about thirteen miles; on the north fork of the Old Man, twelve miles; on the Highwood River and its tributaries, sixteen miles; and on the Bow River, twenty-seven miles. The base of the older rocks of the mountains at the last named locality, falls back in a wide bay, which accounts for the increased width of the foot-hills at that place.

Width of foot-hill belt.

For twenty-four miles north-westward along the base of the mountains from the 49th parallel, the foot-hills are comparatively low and inconspicuous, and there are no connected areas of wooded land, except on the upper part of the Belly Valley. The country is covered with fine bunch-grass, and the woods are chiefly massed along the river valleys. From this point northward the foot-hills become well developed, there are considerable wooded tracts, especially in the immediate vicinity of the mountains, and before the Bow River is reached a large part of the foot-hill region is more or less densely wooded. About the branches of Highwood River some of the foot-hills become so bold as almost to rival the outer

Prairie and woodland tracts.

range of the mountains in height, and a few districts have become nearly inaccessible from the quantity of burnt and fallen forest.

Agricultural and grazing lands.

The whole of the open country in the foot hills is admirably adapted for grazing purposes, the rainfall is ample, and in consequence of the greater humidity of the climate, the soil to a considerable depth usually consists of a rich, black, vegetable mould. In the lower valleys which exist in the Porcupine Hill region and its southern and northern continuations, and in those of the foot-hill belt, the greater part of the land really valuable for agricultural purposes in the district now reported on, lies. Such at least is my opinion, founded on the results of farming already initiated, and the comparison of the different classes of country met with in this district with those of a similar character, and bearing a similar flora elsewhere. The greater part of the Porcupine Hills proper, together with the higher regions of the foot-hills, though otherwise well adapted to agriculture, are too frequently subject to early and late frosts. Where agriculture succeeds, the crops produced are eminently satisfactory.

Pastoral wealth of the district.

It would thus appear that apart from the mineral wealth of the district, and particularly the inexhaustible stores of coal and lignite which are fully described in a succeeding portion of this report, the resources of the country are mainly pastoral, and there are few regions which can excell, or indeed equal this one in that respect. The stocking of this district may be said to have been systematically begun in 1881, and it is now being rapidly occupied.

Climate.

A few words may be added in regard to climate. We are yet without full and trustworthy observations of the temperature and rainfall, but these will doubtless be supplied ere long by the meteorological service. The climate of that part of the district included under the general title of Plains, probably closely resembles that of a large portion of the southern part of the great plains of the North-west Territory. The total annual precipitation of moisture is evidently small, the summer heat is frequently great during the day, and is quite sufficient in intensity and duration for the ripening of all ordinary grains, wherever sufficient moisture is found for their healthy growth. The winter is severe, and the exposed and treeless character of the country causes its rigor to be more keenly felt, but there is no reason why tree-planting should not succeed at least in the river valleys and on broken ground, even in many of the dryer portions of the plains; and wherever the rainfall is sufficient for crops, the growth of trees with proper precautions is undoubtedly possible. It is stated that the winter climate in the neighborhood of Fort MacLeod is milder than elsewhere, and though little instrumental proof of this can yet be adduced, it may probably be the case, and arise from the less elevation of that part of the district, combined with its vicinity to the mountains. The snow-fall is light over the entire district, and in the Porcupine Hill region and foot-hills, its amount and persistence is largely a matter of elevation, the higher tracts receiving and bearing much more snow than those with a less altitude. The country in the neighbourhood of the mountains has undoubtedly a milder climate than that remote from them, and this—up to a certain point—notwithstanding its greater average height. The set of the aerial currents from the westward, and particularly the strong westerly winds known as "Chinooks" play an important part in this amelioration. It is not the case that low passes in the mountains account for the influence of the westerly winds. It is on the contrary the fact that the passage of these winds over a high mountain barrier, and their subsequent descent into low ground in a comparatively dry and warm state, in correspondence with well known physical laws, enables them to affect the rapid dissolution and evaporation of the snow. This result is most perfectly attained where the descent from the summits of the range to the valleys below is greatest, and as the lowest tracts are generally in the river-valleys, is there most marked. As I have elsewhere discussed this subject pretty fully, * it is not proposed in the present report to enter into it at length.

Mild climate near the mountains.

Chinooks.

GENERAL DESCRIPTION OF THE DISTRICT.

In this division of the report, a general systematic description is given of such physical features and facts, in the district as appear to be of economic importance. The various river-valleys, and the tracts intervening between them are described in order from south to north, the arrangement being the same with that followed in the succeeding strictly geological section of the report.

Orders followed.

MILK RIVER AND COUNTRY IN ITS VICINITY.

Milk River rises in the foot-hills south of the 49th parallel, and, crossing that line near the 113th meridian, pursues a course not far north of the parallel for a distance—without taking into consideration its minor flexures—of one hundred and three miles, within the limit of the present map. A short distance beyond the eastern edge of the map, it recrosses the 49th parallel on its course to join the Missouri. It is known as Ke-nuh-si-suht or Little River by the Blood Indians and possesses some peculiar and interesting features. In that part

General course of Milk River.

Tributaries unimportant.

* Report of Progress, Geological Survey, 1879-80, p. 77 B.

part of its course above defined it receives besides the South Branch which is about equal to the main river or North Branch, a few small tributaries from the south, of which Red Creek is the most important, and probably holds running water at all seasons. The tributaries from the north are all very small brooks, even at times of high water. The river cannot be considered as navigable even for canoes. It is rapid and in some parts of its course very tortuous on a small scale, but in many places difficult to cross on account of quicksands. In the season of 1874—a more than usually dry year—we found its bed completely dry in some places a few miles south of the 49th parallel, a short distance east of the limit of the present map. Between the 113th and 112th meridians, the country has a general northward slope, which, on the MacLeod-Benton trail, from the high southern edge of the Rocky Spring Plateau to the 49th parallel—a distance of twelve miles—amounts to 405 feet, or about thirty-four feet to the mile. The wide clayey and barren plain southeast of this plateau has an elevation several hundred feet less than that of the bed of the Milk River in the same longitude. Between the MacLeod-Benton trail and the flank of the West Butte, near the 49th parallel, are several wide irregular trough-like valleys, holding very small streams, or entirely without flowing water, for which the present conditions of the country fail to account. The drainage of the northern flanks of the Buttes, which is very small in amount, also finds its way to the Milk River by a system of valleys, some of which are of considerable depth.

Small quantity of water.

Northward slope of country.

Dry valleys.

In the report on the Geology and Resources of the 49th Parallel,* I have described the general aspect of the country south of the Milk River, and west of the West Butte in the following terms:—As compared with the tract east of the Butte and south of the Cypress Hills, it improves in appearance, and shows evidence of a greater rainfall, and the cactus, grease-wood and *Artemisia* cease to appear. It is generally much broken, but shows evidence of a former more elevated surface, in somewhat extensive flat-topped hills, which, when ascended, are found to be nearly of equal height, and show much drier and more gravelly soil than elsewhere found in the region. There is usually a close thick growth of grass, and the swamps and sloughs, which are numerous, generally hold grasses and *Carices* to the exclusion of the rushes formerly most abundant.

Country south of Milk River.

Three wide valleys join the Milk River from the north—the Lonely Valley, Verdigris Coulée, and the Lake Pā-kow-kī Coulée. The two first carry very small streams and the latter is dry. In fact, at a dis-

Low country to north.

* A very limited edition of this report was issued by the Boundary Commission, and as it is now completely out of print, I have not hesitated to incorporate such parts of it as refer to the district here under discussion.

tance of a few miles north of the Milk River, the whole country is below the level of its bed. Thus, five miles north-west of the point at which it first crosses the 49th parallel, the plain is fifty-seven feet lower than the nearest part of the river. Twelve miles north-west of the mouth of Lonely Valley, beyond the Milk River Ridge, it is one hundred and seventy feet lower; eight and a half miles north-west of the MacLeod-Benton trail-crossing, nearly on the course of the trail, thirty-two feet lower. The most remarkable instance is found, however, in the Lake Pā-kow-kī Coulée, where the south-western arm of the lake reaches to within three and a half miles of the river, but is eighty feet lower than it. Here, by a small cutting, the river might be turned into the lake, and would then flow round by Many Berries Creek, returning to the present valley near its intersection with the 49th parallel.

Peculiar features of Milk River.

The Milk River thus actually occupies the central line of a long broken plateau region, of which the Milk River Ridge, the Rocky Spring Plateau and other elevations, constitute the higher parts, and its waters at the point at which it first crosses the 49th parallel are at a greater elevation than those of any of the other large streams in the district, except when these are in the immediate vicinity of the mountains. The greater part of the Milk River Ridge, and a considerable portion of the Rocky Spring Plateau exceed 4,000 feet in elevation.

Valley west of MacLeod-Benton trail.

The country in the immediate vicinity of the river-valley from the 113th meridian to the point at which the MacLeod-Benton trail crosses, may be described as generally affording fair to good pasturage. The lower tracts and valleys are invariably covered with good grass, while some of the higher tracts are gravelly and rather bare. The valley itself probably averages about a mile in width—though narrow and about 300 feet deep for a few miles below Lonely Valley—and invariably produces very fine grass, of which a considerable portion is sufficiently long to be cut as hay. The Milk River Ridge, to the north, is elsewhere more fully described. Its surface though high, is well grassed, and dotted with numerous sloughs and pools. It will constitute a fine summer grazing-ground. No arboreal or shrubby vegetation is met with except a few bushes in one or two deep coulées.

MacLeod-Benton trail to Dead Horse Coulée.

For about seven miles east of the trail-crossing, the valley is remarkably wide with low sloping banks in many places, but is equally destitute of wood. Thence to the mouth of Verdigris Coulée it seldom exceeds half a mile in width, and the pasturage to the north for some distance is rather short and indifferent. No wood occurs in the Verdigris Coulée, which is a trough-like valley about three-quarters of a mile wide, and holds several lakes in its course. From this point, for eight miles, the Milk River valley expands, and is about a mile wide north of the West Butte. The bottom is well grassed, and small groves of cottonwood occur in it. Sandstones, which weather into monumental and fantastic forms, elsewhere fully described, border its sides. The pasturage in the plains immediately to the northward may be characterized as fair, though occasional patches of cactus occur.

Dead Horse Coulée to Pa-kow-ki Coulée.

The river next turns abruptly to the north, in a comparatively narrow valley, while a wide trough, evidently that formerly occupied by the stream, and known as Dead Horse Coulée, continues in the main direction for six miles when it is rejoined by the river. Thence to the Pā-kow-kī Coulée the valley is at least fifty and sometimes over one hundred feet deep. It continues wide, and the edge of a low diffuse plateau runs nearly parallel to it some miles to the north. The country between the river and the plateau-edge affords fair to good pasturage, and pools and swamps are in some places frequent. The level of the plateau further to the north slightly exceeds 3,000 feet, with an undulating surface, and generally affords a good close growth of buffalo-grass. It is diversified by numerous small pools and swamps, most of which become dry before the end of the summer.

From Pa-kow-ki Coulée eastward.

Near Pā-kow-kī Coulée the valley again holds a few trees. The Pā-kow-kī Coulée between the river and arm of the lake is wide and flat-bottomed with patches of sage brush and some good grass. From this place to the edge of the map, the Milk River valley continues wide, but is deep and forbidding in aspect, with high bare clay-banks and a few groves of trees. Thence to the point at which it finally crosses the 49th parallel, it is in some places very deep and difficult of access, but is never without well grown cottonwood trees.

Lake Pa-kow-ki.

Pā-kow-kī is the largest lake in the district embraced by the present report. It is very irregular in shape, holds several islands, and is evidently shallow. The north-west and south-west arms are bordered by high banks, and doubtless represent old drainage channels, but the country on the north-east side is low, and as viewed from a distance presents wide areas of bare sand hills. The water is of a greyish milky colour and slightly saline.

Sweet Grass Hills or Three Buttes.

The following description of the Three Buttes and their vicinity is again quoted from my report on the Geology and Resources of the 49th Parallel :—The isolated mountains called by the half-breed hunters *Montagnes du Foin de Senteur*, are known to the traders of the Missouri region as the "Sweet Grass Hills." They are roughly indicated on most good maps of the west, and are there found under the geographical appellation of the "Three Buttes." As indicated by the latter name there are three distinct mountain masses. A line passing from the peak of the eastern through the central mass of the West Butte, would have a direction of about N 70° W., the central Butte lying between them, but some miles to the south. The highest summits are those of the eastern and western Buttes, which are about twenty miles apart, and rise nearly 3,000 feet above the level of the plains at their base. The height of the summit of the East Butte, as ascertained by the aneroid barometer, and taking the mean of two readings separated by about an hour, is 6,200 feet. That of the West Butte was found to be 2,746 feet above the dêpot camp at its base, by comparison with nearly simultaneous readings there; and taking the height of the latter locality at 3,737 feet, the height of the West Butte above the sea would be 6,483 feet. Elevation.

The central masses of the Buttes are composed of eruptive trappean rock, and around them the previously horizontal beds of the plains have been tilted up, those immediately surrounding the igneous masses resting at very high angles. The West Butte is the most important, and forms quite a little mountain region, having numerous peaks and ridges, with round or blunted tops, and deep, almost precipitous, valleys. The East Butte is next in importance, and consists of four main peaks, arranged nearly as the angles of a square. The north-western of these is the most prominent and conical; the south-western is round topped and connected with the north-western by a ridge, and not far below it in height. The north-eastern and south-western summits are nearly equal in elevation, but considerably less than the others. The central Butte was not ascended, but appears to be notably smaller than the others. It has, however, an exceedingly symmetrical conical form, as viewed from almost every direction, and its slopes must form an angle of nearly 45° with the horizon. Like the East and West Buttes it is surrounded by grassy foot-hills, which are especially prominent on its northern slope. Summits of the Buttes.

The height and mass of the Buttes is sufficient to cause the formation and arrest of clouds in their immediate vicinity, where the rainfall is in consequence much more copious. These mountains and the broken ground around them form a favourite haunt of the buffalo [in 1874] where they find abundance of food and water. The springs arising from some parts of the Buttes are very copious, and form streams, which, on leaving the shelter of the wooded valleys and issuing on the plains are rapidly absorbed by the dry soil and atmosphere, at least in the summer season. One of these was observed to be a rapidly flowing brook during the night and morning hours, but in the afternoon became quite dry. The timber of the Buttes is chiefly pine; much of it has been burned, but it shows a tendency to renew itself. The trees are not of great size and generally in somewhat inaccessible parts of the mountains, but cannot be considered unimportant in a country so treeless. A few of the plants found at elevations above Streams and timber.

6,000 feet in the Rocky Mountains appear also on the summits of the Buttes.

The following paragraph, though written in 1874 and referring to conditions obtaining at that time, may also still have some interest:—

A neutral territory.

The country surrounding the Buttes is said to have been for a long time a neutral ground between various tribes of Indians. That it has been so is evidenced by the almost complete absence of buffalo bones in the neighbourhood, and the rare occurrence of the circles of stones marking camping places. The region is at present a debatable ground between the Blackfeet, Peigans, and Bloods of the west; the Sioux and Assiniboines of the east, and the Crows and other tribes of the Upper Missouri. It is not passed through save by war parties strong in numbers and travelling rapidly. Ten miles north of the Middle Butte the bodies of over twenty Crow Indians were found, unburied, on the scene of a conflict.

Plains between Milk River and Belly River.

Decreased elevation to the north.

Beyond the region of plateau and high plain which borders Milk River valley on the north, the whole surface of the country slopes gradually northward toward the Belly River, till, between Coal Banks and the Chin the elevation is about 3,000 feet, and between Seven Persons River and the South Saskatchewan about 2,500 feet only. It must not be supposed, however, that the surface is quite uniform.

Plateaus and hilly tracts.

Besides the valleys of some important coulées, several low plateaus appear, of which the Chin, and that midway between Seven Persons River and the Saskatchewan are most important. The Bull's Head constitutes the most prominent portion of a still more elevated plateau at the extreme east of the map known as the Peace Buttes. Ten miles south-east of Coal Banks a limited tract, characterised by irregular low hills, is crossed on the MacLeod-Benton trail. The region south of the Belly, between Drift-wood Bend and its mouth, is rolling or rather hilly, with intervening pools and lakes. Some small sand-hills also occur immediately south of the confluence of the Bow and Belly. South of the crossing of Seven Persons River by the Cypress trail, is another broken hilly tract, apparently composed of drift materials, and strewn with numerous boulders. To the south of this is a valley three miles wide, not resembling that of a river or related to that of any existing stream. The bottom slopes gently southward, but the main course of the valley is nearly east and west. This is again bordered to the south by a well marked hilly ridge, which separates it from the Lake Pā-kow-kī valley, and is also about three miles wide.

The Chin Coulée is the most remarkable of the valleys traversing this part of the plain, and from the Chin to its junction with Peigan Creek at the eastern crossing of the Cypress trail, has a length of nearly seventy miles. It is a trough-like valley from half a mile to a mile in width, and depressed from 150 to 250 feet below the prairie level. A number of small lakes lie in the valley and are connected by a little flowing water at seasons of flood, but during the summer some of them dry up completely. Boulders are quite abundant in some places, having been concentrated by the removal of the finer portion of the drift deposits, and the underlying Cretaceous rocks are exposed in a number of places in its banks. On the south side a little scrub occurs, and in the bottoms occasional thickets of sage brush. The Forty-mile Coulée which joins it from the northwest is similar in character, but both this and the upper part of the Chin Coulée appear to die out entirely before reaching the bank of the Belly River. Chin Coulée.

The Peigan Creek above alluded to, is really the upper part of the Seven Persons River. Its valley is narrow and evidently of more recent origin than the Chin Coulée, and when the stream reaches the latter, it immediately adopts it, and flows in it to the South Saskatchewan River. The valley of the Seven Persons River, north of the Cypress trail, therefore, constitutes the continuation of Chin Coulée, and is wide and important. It holds, at least in its upper part, a few small trees. Peigan Creek.

South of the Chin Coulée is a second and very similar valley, which runs in a nearly parallel direction at a distance of from six to eleven miles, and may be denoted by its Blackfoot name Etzi-kom. This valley also holds several small lakes, and at its eastern end contains a small stream which flows into the north-west arm of Lake Pā-kow-kī. The coulée originates in the region east of the Fifteen-mile Butte on the MacLeod-Benton trail. Kipp's, Middle, and Ed. Mahan's Coulées—crossed south of this point by the same trail—were, by the exploration of 1883, found to be branches of Verdigris Coulée, the mouth of which has already been referred to in connection with the description of Milk River. There are in all seven lakes in Verdigris Coulée east of the MacLeod-Benton trail. Of these the largest is about seven miles in length. This coulée in its steep banks and flat bottom resembles those above described, and like them cannot be accounted for by the present conditions. Not only do the small streams now flowing into it loose themselves in its lakes so completely that not even a permanent flood-channel connects the lakes in its upper part, but its bed is almost absolutely flat from the trail-crossing of its upper branches to its mouth on the Milk River. Etzi-kom Coulée. Verdigris Coulée.

As a grazing country, the region of plains between Milk River and the Belly may be described generally as of fair quality. It varies from Grazing land.

indifferent, to fair and good, and may be classed as very good in a few limited tracts. The best and most extensive areas of grazing land are found in the vicinity of the MacLeod-Benton trail and westward, including the Milk River Ridge region; between Cherry Coulée and the Seven Persons River north of the Cypress trail; south of the Cypress Trail near the 111th meridian; and west of Lake Pā-kow-kī, in the angle between it and the Milk River.

Cairns.

The cairn on the south side of the Saskatchewan near the confluence of the Bow and Belly is regarded with much veneration by the Indians, who call it O-max-ŏkotok, but I have been unable to discover any reasonable explanation of its origin or meaning. It is a pile of rough boulders about six feet in height, with a breadth of base of about fifteen feet, and occupies a commanding situation on the brow of the hill overlooking the river. A few other small cairns occur in this district, but are probably only landmarks. Ten miles south of the Cypress trail on the 111th meridian, and in a few other places, some old stone-piles, now nearly imbedded in the sod, appear to cover shallow graves. In the Etzi-kom Coulée, a couple of miles from Lake Pā-kow-kī, a cairn, apparently of pretty recent date, probably marks the scene of a fight, as some rough low breastworks of boulders were also noticed there.

THE ST. MARY, UPPER BELLY, AND WATERTON RIVERS AND COUNTRY IN THEIR VICINITY.

St. Mary River.

The valley of the St. Mary River may be characterized generally as narrow, and the river is extremely tortuous both in its main direction and on a smaller scale within the limits of the valley. Its length from the 49th parallel to its mouth, measured in five mile stretches, is about fifty-seven miles. It rises in a large lake in the mountains south of the 49th parallel, and for some distance after crossing the line continues clear and blue. It is extremely rapid, falling about 1,100 feet from a point five miles north of the 49th parallel to its mouth, or at a rate of twenty-one feet to the mile—its course being again measured in five miles stretches without regard to its minor flexures. It was not without much trouble and some danger that we descended it in a small canvass boat in the summer of 1881, and at the low water stage it would be nearly if not quite impossible to do so.

Character of the valley.

For the first ten miles below the point above indicated, it may be discribed as almost a continuous rapid, and is filled with innumerable flat islands, some of which are lightly wooded. Five miles north of the 49th parallel, a large cultivable flat occurs on the east bank, and for about twelve miles, or to the mouth of Lee's Creek, the valley is moderately wide, attaining in some places a width of a mile. From the flat above alluded to, however, to its mouth, it cannot be said to hold any land of a cultivable character. Two miles below Lee's Creek the scattered trees come to an end. There are a few more in sheltered situations in the Gooseberry Cañon but with this exception it is treeless to near the crossing of the MacLeod trail. At a point five miles below Lee's Creek, the river turns abruptly to the north, and for about five miles flows through a cañon with scarped banks nearly continuous. This has been called the Gooseberry Cañon, and a fall a few feet in height occurs near its lower end. Below the fall, on the west bank, a remarkable horse-shoe shaped valley, formerly occupied by the river, occurs; but the narrow rocky tongue which separated the two sides of the bend having since been cut through, it is now dry. The present aspect of the St. Mary River valley is such as to indicate that it has an age less than that of most others in the district, and this feature is particularly marked when it is compared with the parallel trough of the Upper Belly River.

Recent origin of valley.

The pasturage on the prairies and rolling hills—constituting the edge of the foot-hill belt—about the upper part of its course, may be classed as very fine, and to the Gooseberry Cañon as good. Thence a drier country is entered, but the grass on the surrounding prairies to the mouth of the river, is generally good, and always fair.

Pasturage.

Though the St. Mary River carries much more water than either the Upper Belly or Waterton, the valley of the Upper Belly is larger and more important than that of either of the others. From the vicinity of the 49th parallel northward to the MacLeod trail-crossing, it probably averages a little less than a mile in width, and is seldom less than half a mile. It is generally more or less wooded, and presents numerous bottoms suitable for farming, some of which near the confluence of the Waterton and crossing of the trail are already occupied. Below the trail-crossing, to the mouth, it averages about a mile and a half in width, and the banks are seldom scarped. The Upper Belly rises in lakes in the mountains south of the 49th parallel, which it crosses at an elevation of about 4,728 feet, and falls about 1,800 feet in its course of sixty-five miles (measured as before in five mile lengths) to its mouth. Near the MacLeod trail-crossing the valley is depressed about one hundred feet below the level of the prairie.

Upper Belly River.

The Waterton River, from its source in the lake of the same name to its confluence with the Upper Belly, is forty miles in length, and has a descent in that distance of nearly 1,000 feet. It flows nearly parallel to the Upper Belly, and a narrow belt of foot-hill and prairie country is included between the two streams.

Waterton River.

Waterton Lake (or Chief Mountain Lake, sometimes also erroneously called Kootanie Lake) is nine and a half miles in total length. The

Waterton Lake.

bearing of the upper portion, seven miles long, is nearly north and south. It lies between grand and rugged mountains, and constitutes without doubt the most picturesque locality in the whole district. The lower part of the lake, two and a half miles long, is nearly separated from the last by a constriction formed by a rocky spur from the east side, and turns abruptly to the east. A short stream connects this with a second lake, which lies entirely in the foot-hills, is three miles in length, and gives issue to the Waterton River.

Waterton River valley.

The valley of the river averages about half a mile in width, and contains more or less timber along nearly its whole length. Scarped banks are of frequent occurrence, but they are generally low, though cliffs about one hundred feet in height occurs at one point six miles below the mouth of the Drywood Fork. The valley, however, offers little land suited for cultivation. Three tributaries join the river from the west. The first a large brook, two miles below the lake, and further down the North Fork and Drywood Fork. The latter is the most considerable, and the lower part of its valley is nearly as large as that of the Waterton.

Name of the river.

The Waterton River has appeared under this name on the map for about twenty-five years, but of late some confusion has arisen, owing to the circumstance that settlers recently entering the country have re-named it the Kootanie, and that this name has even appeared on some maps. There is nothing to be said in favour of this change, and the fact that another and much larger river on the west side of the range has long been known by the latter name, renders its introduction here particularly inconvenient and misleading. Nothing but complete ignorance of the earlier geographical work in the district, can excuse the perpetuation of this name as applied to the stream and lake now described.

Country in the vicinity of these rivers.

The general character of the country about the Upper Belly and Waterton Rivers requires but a few words of description. A great part of it belongs to the foot-hill belt already characterized, and yields everywhere magnificent bunch-grass pasturage. Near the confluence of the two rivers the grass is somewhat shorter, but still very good. Below this point, on both sides of the Upper Belly, the grass may be described as generally fair to good, though considerable tracts which must be classed as indifferent, also occur. The Belly Butte, with its scarped and furrowed western front, is a prominent object near the confluence of the two streams. The Little Rocky Ridge, a few miles south of the mouth of the Drywood, between the two rivers, is another rather noticeable landmark. South of this the most marked feature in the foot-hills—particularly to the east of the Upper Belly and near the head of Lee's Creek—is the remarkable parallelism of the sandstone ridges, which often run for miles, scarcely varying more than a degree or two in their general direction. Near the upper part of the river, there are also some areas completely dotted with almost innumerable small lakes and pools.

The Old Man and Belly Rivers.

The Old Man and Belly Rivers, with the upper part of the South Saskatchewan, occupy the centre of a wide depressed area, which runs across the entire district with a course a few degrees north of east. This important feature originates at the mountains precisely opposite the remarkable gap in the Palæozozic rocks of the outer ranges, and both are doubtless due to some general structural circumstance not yet clearly ascertained. Remarkable depression.

The streams which unite west of the central axis of the Porcupine Hills, to form the Old Man, originate in the mountains ; some of them far back in the range, and most of them, in common with the other streams of the district, flow nearly at right angles across the foot-hill belt. The more important of these streams are as follows, in order from south to north :—Pincher Creek, Mill Creek, South Fork, Middle Fork or Crow Nest River and North Fork. Pincher Creek issues from the base of the mountains as a rapid stream twenty-five feet wide, which is not subject to heavy floods as it does not rise far back in the range. It flows north-eastward five miles, passing between the ends of two remarkable, high, wooded ridges, and then nearly north for about ten miles, before resuming its eastward direction. At the crossing of the road near the Police Farm, it is a stream sixty feet wide and generally rapid and shallow. Mill Creek flows northward, and rises far back in the mountains south of the gap in the Palæozozic before referred to. For five miles from the point at which it leaves the Palæozozic rocks, the country about it is very rough and wooded. Thence for three and a half miles, to its mouth, it is bordered by wide terrace-flats and more gentle slopes covered with fine grass, which rise at a short distance to wooded hills. It is a larger and more rapid stream than the last. The South Fork of the Old Man issues through the above-mentioned gap in the Palæozozic mountains, and in its main direction flows nearly eastward, receiving Mill Creek and then uniting with Pincher Creek. It is much larger than either of these. The Middle Fork, about equal in size to the last described, may be said to rise in the Crow Nest Lake, in the pass of the same name, with an elevation of 4,426 feet; and where it crosses the eastern base of the old rocks it has an elevation of 4,170 feet. It also flows nearly due east, in a wide valley, at first bordered by high wooded

Tributaries of Old Man River.

Pincher Creek.

Mill Creek.

South Fork.

Middle Fork.

foot-hills, but before joining the North Fork passes into a prairie country. The North Fork, fed by numerous streams which have their sources in the main watershed, issues from the mountains through a narrow gorge at a height of 4,437 feet, and is more important than any of the other tributaries of the Old Man. For thirteen miles it flows south-eastward, crossing the foot-hill ridges, which are here very distinct and prominent, somewhat obliquely, and falling in the above distance about 350 feet. Its main valley through the foot-hills is wide, but the stream itself is almost everywhere bordered by low rocky cliffs affording a fine section. From the direction indicated, it turns abruptly southward, and flows in a wide well grassed and partly wooded valley, parallel to the base of the Porcupine Hills, thirteen miles further, to its junction with the Middle Fork.

North Fork.

Country about branches of Old Man River.

The part of the foot-hill belt through which the upper branches of the Old Man flow, is for some miles along the base of the mountains pretty densely wooded, with only occasional prairie valleys, and the higher ridges continue to bear a few trees throughout. Wherever it is open, however, it presents a magnificent growth of bunch-grass and constitutes a remarkably fine grazing region. In the valleys of some of the streams, and in their vicinity, there are considerable tracts of land which may be cultivated, though no exact estimate of the extent of these can be given, owing to the uncertainty still existing as to the height in different localities at which frosts become too severe. The most important of these is, however, doubtless that on which the Police and Government Indian farms are situated. This is a tract about three miles in width, which runs south-eastward from Pincher Creek toward the Waterton River, and is based on the outcrop of a series of soft rocks.

Old Man River west of Fort MacLeod.

The valley just referred to, with that in which the lower part of the North Fork of the Old Man flows, limits the Porcupine Hills to the west. To the eastward, the Old Man River, occupying the centre of a depressed area nearly ten miles wide, flows through these hills to Fort MacLeod. The hills to the north are here wooded at the summit, but the southern detached portion bears no trees. The banks of the river are fringed with timber, and some fine bottoms occur. Before reaching Fort MacLeod the bunch-grass has entirely given place to the shorter buffalo-grass.

From Fort MacLeod eastward.

From Fort MacLeod to the confluence of the Upper Belly, at which point the Belly River proper may be said to begin, and thence to Coal Banks, the course of the river is circuitous. The hard sandstones of the St. Mary River subdivision, and the shales of the Pierre, appear to have offered two lines of considerable resistance to the stream, the first of which has been overcome by a northern, the second by a southern flexure. The distance by the river from Fort MacLeod to Coal Banks,

G. M. D. Photo. June 29, '83.
Geological Survey.

Artotype—G. E. Desbarats & Co., Montreal.

OLD MAN RIVER.

Looking South-west from North Bend, nine miles below Fort MacLeod. Rocks of St. Mary River Subdivision, Laramie.
Porcupine Hills in the distance.

measured in two mile lengths, is thirty-six miles, the relative elevations being 3,096 and 2,732 feet respectively, giving a fall of about ten feet to a mile. The river is consequently rapid, and being encumbered with boulders in many places is only navigable for boats during high water in early summer. The banks vary from fifty to one hundred and fifty feet in height, and are often well grassed, though generally scarped and cliff-like at the convex bends. Some fine bottoms for farming occur, particularly near the mouths of the Upper Belly and St. Mary Rivers, and the river is more or less fringed with trees and bushes throughout this part of its course. The reach of the valley which turns south from the great bend north-east of MacLeod, is for some miles continuously narrow, with low rocky banks and cliffs and no bottom-lands. Below the St. Mary, the south bank is high and weathered into rugged bad-land forms, and just above Coal Banks several large wooded islands occur. Fort Kipp, one of the old trading posts, but now entirely destroyed, was situated at the confluence of the Upper Belly. Fort Whoop-up, still in good preservation, is at the mouth of the St. Mary.

Fall of the river.

Banks and bottom-lands.

At Coal Banks ferry, the high water channel of the river is 437 feet wide. From this point it runs northward for twelve miles to Big Island Bend. The prairie level is 300 feet above the river, and scarped banks occur, with fine sections, occasionally over 200 feet high. The valley is of the usual trough-like form, about a mile in average width in the bottom, with the river meandering from side to side and still evidently actively engaged in widening the trough by the constant waste of the cliffs at its convex bends. The flats are generally covered with fine cottonwood and luxuriant foliage, in which the choke-cherry bushes are prominent, and several of the bottoms are adapted to agriculture.

Coal Banks to Big Island.

On turning eastward the valley becomes somewhat more confined, and is still nearly as deep as before, but with the banks more gently sloping and grassy, and fewer good sections, to the mouth of the Little Bow. From its first bend below Big Island to within a mile and a half of the Little Bow, there are no trees. The country evidently becomes dryer in this direction, and the low cactus abounds on southward-facing banks. About the mouth of the Little Bow are wide bottoms with some timber and probably a thousand acres of cultivable land.

Big Island to Little Bow.

From the Little Bow to the mouth of the Belly, there are practically no trees or shrubs, with the exception of those on a few islands. The bottom of the valley averages scarcely more than half a mile in width, and the banks are from one hundred to one hundred and fifty feet in height. They are often for considerable distances grass-grown, and the sections of the rocks are not nearly so good as before. Wolf Island, nine

From Little Bow eastward.

miles above the mouth of the river, is the largest in this part of its course, being half a mile long. It supports some cottonwoods on its lower end.

A mile and a half from the mouth of the river is a flat with a grove of cottonwood and thickets of large *Artemisia* bushes. Opposite this point the river is 720 feet wide, with a velocity of 3·6 miles per hour, being here rather less swift than in most places on its lower course.

Fall of the river.

The height at the confluence of the Belly and Bow is 2,212 feet, giving a difference from Coal Banks of 520 feet. The distance, measured in two mile stretches, is seventy-six miles, and the average slope is at the rate of 6·8 feet in a mile, though considerably more in the upper part and less in the lower. In the autumn the volume of the river is much decreased, and it would not be easy to descend some parts of it in a large flat-bottomed boat. During high-water, in the early summer, it would probably be possibe to make a few trips with a small stern-wheel steamer, as far up as Coal Banks, but it cannot be counted on as a means of carrying eastward any large quantity of coal from the fine seams in that vicinity.

In 1881 no sign of habitation existed below Mr. Sheran's house at Coal Banks, and in descending the river we saw but a single Indian.

South Saskatchewan River.

The island at the confluence of the Belly and Bow supports a ew cottonwood trees, but from this point to the edge of the map, wood is extremely scarce along its course. Between the confluence and Cherry Coulée, high, scarped, desolate banks occur on both sides of the South Saskatchewan, and the general level of the prairie is nearly 250 feet above the river at the latter point. At the same place the width of the stream was found to be 1,013 feet, and the current three miles an hour only. This river is generally tranquil to Medicine Hat at the eastern border of the accompanying map, but the valley is narrow, and in places almost cañon-like with banks 250 to 300 feet high.

Plains between the Belly and Bow Rivers.

Western portion.

Bounded by the Belly and Bow Rivers to the south and north, and between the edge of the Porcupine Hills to the west, the Snake Valley and lower part of the Little Bow to the east, is a region about forty miles in width by sixty-five in length, which is drained by Willow Creek, the upper part of the Little Bow and a few small streams running into the Bow. The tributaries joining these streams in this region are, however, small and few, and it is evidently one of comparatively limited rainfall and from which the surplus moisture is for the most part removed by evaporation. Its western portion, lying along the base of the Porcupine Hills, is a lightly undulating or almost level

General character.

plain with an average breadth of over twenty-five miles, and a mean elevation of about 3,300 feet. Its eastern part is much more broken in character and largely composed of plateaus, which include the Black Spring Ridge, the Thigh Hills and Buffalo Hills, of which the summits rise from 300 to over 500 feet above the plain. The trail from MacLeod to Calgary, north of the 50th parallel closely follows the western edge of the level country.

One branch of Willow Creek rises in the mountains in latitude 50° 7′, while the two other main branches derive their water from the Porcupine Hills and foot-hills behind them. It is, except at seasons of flood, an insignificant stream, and in the lower part of its course is extremely tortuous with small sharp bends, and not much depressed below the level of the prairie. Trees occur along the borders of its tributaries near and in the Porcupine Hills, but are very scarce on the lower part of its course. Willow Creek.

Musquito Creek, where it crosses the Calgary trail, is a small, rather sluggish stream, full of water-weeds, and flows in a wide shallow valley showing no rock. It is joined near the trail by Spring Creek, a smaller stream also derived from the edges of the Porcupine Hills. Mosquito Creek.

The Little Bow does not cross the Calgary trail, but rises in springs a short distance to the east of it, and quite close to the bank of the Highwood River, with no intervening high land. The valley of the Little Bow, even above the confluence of Musquito Creek, is about a mile wide and one hundred feet deep, while the stream, where rapid, is ten to fifteen feet wide only, but frequently forms long sluggish pools of greater width. At its mouth, Musquito Creek is considerably larger than the Little Bow, but flows in a valley comparatively small. Thence to the Belly River, the Little Bow continues to occupy a large flat-bottomed valley of similar character, and pursues a very tortuous course in it. There is no wood whatever in the Little Bow Valley. Little Bow.

The Highwood or High River, rising from several branches in the mountains, carries a considerable volume of water and is a rapid stream with stony bed. Where it crosses the Calgary trail it is nearly one hundred and fifty feet wide, and the level of the country is but little raised above it for a considerable distance on each side, but particularly to the north. Its tributary Sheep Creek, is a smaller stream, similar in origin and character, but its valley where crossed by the trail is narrow. The Highwood is thickly wooded eastward to the trail-crossing, and Sheep Creek for some distance further east. Some groves again occur near the mouth of the Highwood on the Bow. Highwood River. Sheep Creek.

It appears very probable that the waters of the Highwood have at a former period followed the Little Bow Valley to the Belly.

While the greater part of the tract above defined, between the Porcu-

Grazing lands. pines, the Snake Valley and lower part of the Little Bow, belongs strictly to the buffalo-grass country, its western border blends with the bunch-grass district, and this character even extends over a portion of its north-western corner. The pasturage may be characterized as generally good, and though in some places indifferent, it can seldom be classed as poor, while extensive areas are very good. The country is also pretty well supplied with water, in pools and swamps, many of which last throughout the summer. It may therefore be described as an excellent grazing region, and will doubtless before long be fully utilized in this way. The grass on the plateaus of its eastern part, is generally good, though according to Mr. J. C. Nelson's description, the Thigh Hills include a considerable area of land with dry, hard clay hills and indifferent grass. Boulders are very abundant in a few localities where the surface has been considerably lowered by denudation, particularly near the valleys of streams.

Cultivable area. The western, or more level portion of the tract now under description, differs considerably in the character of its soil from any other area of similar extent included in the present report, being very frequently covered with several inches, and occasionally by a considerable depth of dark mould or sandy loam, which overlies the pale grey or yellowish loamy or clayey soil more usually found. On account of its comparatively low elevation and not exceedingly dry climate, it is probable that a considerable area along the eastern base of the Porcupines may eventually be cultivated. In the vicinity of Willow Creek, north of Fort MacLeod, the prairie averages about 200 feet above the water of the Old Man River, and much of it possesses a good soil. Several farms are already established along the Highwood River, and there is every prospect of this settlement growing to considerable proportions.

Sun-dial Hill. A point of note to the Indians in this region, is that called Sun-dial Hill by Mr. Nelson. There is here a cairn with concentric circles of stones and radiating lines. I have not seen it, and therefore cannot describe it in detail. It is named *Onoka-katzi*, and regarded with much reverence.

Snake Valley. The Snake Valley appears, like that of the Little Bow, to have carried at some former period a considerable volume of water, but now contains marshes and shallow lakes only, most of which dry up in the autumn. It is throughout below the 3000-foot contour, and its banks show occasional low exposures of the clays and sandstones of the Laramie. An extensive tract of rolling hills and plateaus lying east of it, is known

Rocky Buttes. as the Rocky Buttes, and many parts of it afford very fair pasturage, though boulders and smaller stones are scattered thickly over some portions. The elevation is often considerably over 3,000 feet, but has not been accurately ascertained. A northern outlyer of this plateau, which abuts on the Bow River, is known, as Jumping Buffalo Hill.

The southern portion of the tract west of the Little Bow and between it and the Bow, is a level or lightly undulating plain of a very arid character, with a general elevation of about 2,600 feet, and clayey or sandy soil. The southern portion of the Rocky Buttes extends in the form of a gently swelling rise even to the Belly River. It rises with a long light slope from the Driftwood Bend of the Belly to a height of about 2,800 feet, and then falls rapidly westward to the valley of the Little Bow. A wide shallow valley runs north and south between the Bow and Belly thirteen miles east of their confluence, and like most of the depressed areas evidently caused by denudation, is thickly boulder-strewn. The grass on these plains is generally very short, and must be classed as fair to poor, and in places very poor. In the latter part of the summer, water is extremely scarce and as a grazing region this is of comparatively small value.

Angle between Bow and Belly.

The Bow River.

The Bow is the most important river of the entire district, and might I believe be navigated by light stern-wheel steamers to the Blackfoot Crossing, though the vicinity of the Canadian Pacific Railway to its north bank will prevent its extensive use as a chanel of communication. The Bow rises in the heart of the Rocky Mountains, about latitude 51° 40′, and flows between high Palæozoic ranges for many miles in a general south-eastward direction, after which it turns abruptly to the eastward and cutting across the last of these ranges nearly at right angles issues through the "Gap" on the region of the great plains, with an elevation of 4,100 feet. It is already at this point a noble stream, with clear, blue and sparkling water and a rapid current. The unsullied character of this and the other streams flowing from the mountains in the district here described, would alone be evidence of the absence of true glaciers of any size in those parts of the range supplying their waters, and though numerous snow-fields of varying dimensions appear about the higher peaks, true glaciers seem to be almost or altogether absent to the east of the watershed. In common with the other rivers, the Bow after leaving the mountains soon becomes charged with suspended matter, by the wear of the soft formations forming its banks, which are constantly being brought under its action by slides, and in seasons of high flood the river becomes muddy nearer to its exit from the mountains than at low water.

Sources of the Bow.

Clear water of its upper reaches.

For three miles from the Gap the banks of the Bow are quite low, and the sandstone and shale rocks, here filling a bay in the edge of the

The Gap to Morley.

Palæozoic, lie at very moderate angles. It may be forded here at several places, at low water. At this point the Kananaskis or Swift River, also from the mountains, joins it from the south, and the rocks assume the flexed and disturbed aspect characteristic of the foot-hill region. Immediately below the mouth of the Kananaskis, the Bow forms a fine fall of which the vertical portion is about twenty-five feet in height, constituting the best and most available water-power in the entire district. The fall occurs over hard sandstone beds, which dip up stream, and the river immediately below is bordered by high, nearly perpendicular banks of dark Cretaceous shales. Thence to Morley—a flourishing little settlement originated as a Wesleyan mission—the river is extremely rapid and rocky, and flows between high banks, which often become almost vertical.

Bow Valley in the Foot-hills.

The valley of which this part of the Bow occupies the axis, is wider and more important than that of any other stream traversing the foot-hills, and between the river and bases of the hills there are wide stretches of terrace or bench land, through which portions of moraine ridges, evidently formed in connection with a previous large glacier from the mountains, occasionally project. The soil of these terraces is unfortunately often sandy or gravelly, and the region is rather liable to summer frosts from its height and proximity to the mountains. The bordering hills are high and broad, with comparatively narrow intervening valleys, and do not precisely resemble the long parallel ridges elsewhere more usual along the base of the mountains. These on the south side are pretty densely wooded, and most of the country for some distance to the south of them partakes of the same character. On the north, the hills are much less uniformly wooded and separated by wider valleys, and in the aggregate there is a large area of fine grazing land.

In 1881 I descended the Bow River from Morley to its mouth in a canvas boat for the purpose of carefully examining the rock sections in its banks. The description of its geological features is elsewhere given in detail, and in this portion of the report it is proposed to give merely some general notes on the character of the river, its valley and the country bordering it.

Morley to Calgary.

Eight miles below Morley, the Ghost or Deadman River joins the Bow. This is usually a small stream, but near the mountains has a gravelly bed about a quarter of a mile wide, and evidently carries a great quantity of water at some seasons. Near its mouth is situated the worst rapid which occurs on the Bow between Morley and Calgary. Six miles lower, a brook known as Coal Creek flows in, also from the north, and at this point the foot-hills may be said to come to an end, and are replaced by high, nearly level plateaus of irregular

G. M. D. delt. *Artotype—G. E. Desbarats & Co., Montreal.*

BOW RIVER ABOVE MORLEY, LOOKING WEST.

outline, which must be regarded as forming the northern continuation of the Porcupine Hill region. The Jumping Pound, a stream of considerable size, which rises in the foot-hills to the south, flows in three miles below Coal Creek. Thence to Calgary the river receives no tributaries of importance.

Throughout this part of its course, the banks of the river and some of the flats are frequently well wooded, and there are also many wooded islands. The bordering plateaus are everywhere covered with luxuriant bunch-grass.

The total distance by the river from the Gap to Calgary—measured in two-mile stretches—is fifty-four miles, and the rate of fall, deducting twenty-five feet for the waterfall above described, is fifteen feet to the mile. Fall of the river.

The situation of Calgary is remarkably beautiful. The plateaus here retire to some distance from the river, which is bordered by wide flats thickly covered with bunch-grass, and well adapted to agriculture. The river is fringed with trees, and from the higher points in the neighborhood the Rocky Mountains are still visible. The Elbow River, which here reaches the Bow, has flowed parallel with it a few miles to the south for some distance. It also rises in the mountains, but on leaving the foot-hills,—which on its upper course, are wooded and rough—its valley is wide, with long light slopes on either side, and almost without the high scarped banks which characterize the Bow in the same part of its course. The hills to the south of the Elbow are all more or less densely wooded, but the slopes to the north bear a fine growth of bunch-grass, and the whole valley is very attractive in appearance. A considerable quantity of timber has already been cut and floated down the Elbow to Calgary, and small rafts have also been run down the Bow River from the vicinity of Morley. The elevation of the Bow at Calgary is 3,366 feet. Calgary. Elbow River. Lumber.

Separated from the lower reach of the Elbow by a very narrow strip of high land, and parallel to its course and that of the Bow below Calgary, is another of the remarkable old trough-like valleys which indicate former river action. Dry valley.

For fourteen and a half miles below Calgary, the Bow flows nearly due south on the 114th meridian, after which it turns eastward eight miles to its confluence with the Highwood. The banks are generally about one hundred feet in height along the river, and though sometimes scarped, often bear groves of cottonwood. The bottoms are not usually large, but are sometimes well adapted to farming, and the country generally, is very well grassed. Calgary to mouth of Highwood.

The so-called Pine Cañon extends for about nine miles below the mouth of the Highwood. The immediate banks of the river are here Pine Canon.

almost 200 feet in height. They are steep and generally scarped, but in the hollows well wooded with a mixture of spruce aud broad-leaved trees. This is the furthest eastward occurrence of coniferous trees on the Bow. From this point the valley again widens, and the banks are scarped only at the convex bends of the river. They are at first much lower, often from fifty to sixty feet only, but on approaching the Blackfoot Crossing, gradually rise and attain a height of from one hundred to one hundred and fifty feet. The greater part of this stretch of river is moderately direct in its course, but before reaching the Crossing it makes several great bends and a great number of minor flexures. The stream is often wide and shallow with innumerable sloughs and channels, and in two parts of its course—twelve and two miles respectively above the Crossing—forms a complete plexus of islands and shoals. These appear to have been produced by the action of the river on great landslides from its banks. This part of the valley may be described as well supplied with timber on flats and islands throughout, and there are some fine cultivable bottoms. The width of the valley is irregular, but probably averages three quarters of a mile between the abrupt slopes. The country above is well covered with fine buffalo-grass, but evidence of increasing dryness of climate is found on approaching the Crossing. The soil also becomes sandy in many places near the Crossing, and areas of sand-hills occur on the plains in the vicinity of the river near that place.

Pine Canon to Blackfoot Crossing.

Fall of the river. Rapids.

The elevation of the Bow at the Blackfoot Crossing is approximately 2,575 feet, as compared with 3,366 feet at Calgary. The distance by the river eighty miles, and the resulting fall 9·76 feet to the mile. The worst rapids occur in a reach of a few miles in length below the mouth of Fish Creek, and are both rough and strong. The swiftness of the current, together with the numerous shallow bars and boulders, render this part of the river unsuited for steamboat navigation.

Blackfoot Crossing.

About the Blackfoot Crossing are wide flats partly wooded and adapted to agriculture. This point has, however, attained its importance as being from time immemorial a place of resort to the Indians, partly, no doubt, on account of the existence here of a good ford.

Old fortified camp.

On the north bank of the river near the Crossing, are the remains of a fortified camp, which is attributed to the Indians, and doubtless correctly so, but does not bear marks of any great antiquity. It is a shallow trench of semicircular outline, four hundred feet in greatest diameter, with ten well-defined hollows along its inner margin, which have been shelter pits. The unfortified side is formed by the descending slope of the edge of a low terrace, and the included area is naturally broken.

From the Crossing to Horse-shoe Bend, the valley averages about three quarters of a mile in width of bottom, and continues generally well fringed with wood. The banks are everywhere over one hundred feet in height and frequently show high scarps, which are principally of boulder-clay. Two important abandoned channels are observed, one on the south side, a few miles below the Crossing, evidently dating from a remote period. Blackfoot Crossing to Horse-shoe Bend.

Islands continue numerous to the point now reached, but beyond Horse-shoe Bend are seldom met with. The total number of islands —small and large—noted from Morley to Horse-shoe Bend is two hundred and thirty-five. This enumeration is of course only approximately correct, owing to the difficulty in some cases of deciding, while rapidly descending the stream, which portions of the low ground are actually surrounded by water, but may serve to give some idea of their frequency. Islands.

At Horse-shoe Bend, are some rather remarkable bare band-land hills. From this point to Grassy Island the width of the bottom of the valley averages about half a mile, and the banks rising immediately from the river or at a little distance back from it, are generally about one hundred and fifty feet high. There are but four small islands, and the banks are generally barren and desolate in appearance, being composed of dark Cretaceous clay-shales of the Pierre group, with little covering of drift material. The plains above bear short buffalo-grass and would yield but indifferent pasture, and the low-growing cactus begins to abound on stony and sandy tracts. This part of the valley is absolutely treeless and the whole region is evidently very arid. Horse-shoe Bend to Grassy Island.

Grassy Island—one mile in length—is notable only as marking the position of the outcrop of an important coal seam. Thence for about twenty miles the valley is of a markedly different charcter. The banks near the river probably average fifty feet in height only, and the country does not reach an elevation of one hundred feet for some distance away from it. There are scarcely any true flats, but light long slopes extend in most places almost from the water's edge. There are still no trees or bushes anywhere to be seen, but the plains are covered with a somewhat better growth of buffalo-grass. River below Grassy Island

At the point now reached, south of the Little Rolling Hills, the river cuts through a higher tract which is evidently in connection with the occurrence of these hills. The banks become one hundred feet high, and on the south side are broken and deeply scored by ravines, while the country rises to hills 200 feet in height at a short distance. About ten miles below this place, bad-land banks from one hundred to one hundred and fifty feet high again occur, and in the intervening reach the banks are seldom less than eighty feet in height. Narrow flats here again appear, but the valley does not average half a mile in width Little Rolling Hills.

of bottom. Near this place the river turns abruptly to the south, and continues to flow between banks about one hundred and fifty feet high to its junction with the Belly, while its valley averages half a mile in width, the scarps generally showing boulder-clay.

Fall of the river.

The total distance from Blackfoot Crossing to the mouth of the Bow, by the river—measured as before in two mile lengths—is 103 miles. The elevation at the latter point is 2,212 feet, and the average slope of the river 3·53 feet to the mile. This fall is pretty uniformly distributed throughout, and three feet of water was found in September, 1881, on all the bars, so that it may be considered navigable for light stern-wheel steamers from the Crossing down. A few large boulders occur in the channel, and at one point, thirteen miles north of the confluence, a number of large sandstone blocks were observed to interrupt its course, but it is probable that even these would not offer any serious impediment to the passage of a steamer. The width of the river, determined at a point four miles below the Blackfoot Crossing, is 573 feet, at a point ten miles below Grassy Island, 560 feet, and it averages probably 500 feet throughout this part of its course.

Navigability.

Treeless character of lower valley.

With the exception of two islands, within ten miles of the confluence, on which a few cottonwood trees have formerly grown, the valley is quite treeless from Horse-shoe Bend. Below Crowfoot Creek it receives no tributary which carries running water at all seasons, and the whole region is without doubt arid.

The portion of the South Saskatchewan below the confluence of the Bow and Belly has been described in connection with the latter river. (p. 26 c).

Country between the Bow and Red Deer Rivers.

The following notes, with those on the Red Deer River, are by Mr. McConnell.

"In a traverse made from the Blackfoot Crossing to a point on the Red Deer River, about five miles below the mouth of the Arrow-wood, the country passed over was found to be almost entirely of a rolling character.

Lord Lorne trail.

"Leaving the Blackfoot Crossing on this trail, the country gradually rises until the summit of the Wintering Hills is reached. These hills, although their slope southward is very light, present a steep escarpment to the north. From their base the country continues rolling to the river. The soil over most of this region consists of a greyish or yellowish loam, the loam passing occasionally into almost pure sand or clay. A varying quantity of gravel is also usually present. This country seems to be especially adapted to summer grazing, the grass being very good and the supply of water quite sufficient.

"After descending the Red Deer River in a canoe to a point about twenty miles below the crossing of the Lord Lorne trail, another traverse was made from that point back to the Blackfoot Crossing.

Country east of Lord Lorne trail.

"This trail passes for a number of miles over low sandy ridges, separated by wide shallow depressions containing alkaline lakes. East of the trail low sand hills were seen. Approaching Crowfoot Creek the country becomes more rolling and the soil contains a larger proposition of clay and gravel. The grass along this trail is inferior both in quantity and quality to that further west.

General character of surface

"Speaking generally, the country included on the map between the Red Deer and the Bow and east of the Lord Lorne trail, is with the exception of a few limited areas, of a very inferior description. Areas of drifting sand-hills are of frequent occurrence, while the dry rolling hills which characterize the greater part of the region support but a very scanty vegetation. West of the Lord Lorne trail the country improves rapidly, the grass covering the hills grows longer and thicker and many of the hollows contain small fresh-water lakes.

Red Deer River.

Valley of Red Deer

"The valley of the Red Deer River, from the mouth of the Arrowwood, the point where my examination commenced, down the stream for about twenty miles, varies in width from half a mile to a mile and a half, and in depth from 350 to 550 feet. Its steep naked banks give it an extremely cañon-like appearance and afford magnificent and continuous sections of the rocks overlying the Pierre shales.

"Below that point the influence of the Pierre shales makes itself felt, the valley gradually widens and the scarped banks are replaced by rolling hills sloping easily up to the prairie level. Further down, the slopes become more even and are covered with grass, and the valley decreases in depth to about 200 feet.

Hunting Hill.

"Approaching Hunting Hill, scarped banks re-appear, and the valley is again narrowed in by the harder rocks belonging to the Belly River series. High scarped banks prevail nearly all the way down to the 111th meridian. Between this point and the forks, the valley is as a rule wider and shallower than it is further up, and with the exception of a few miles at one place, the banks are grass-covered nearly all the way.

"The Red Deer River varies in width from 150 to 300 yards, its bed is usually sandy, and sand-bars and sandy islands occur at intervals all the way down. The current at the beginning of July ran at an average rate of about one and three quarter miles per hour."

DESCRIPTIVE GEOLOGY.

Formations represented

The rocks described in this report, exclusive of the boulder-clay and other "drift" deposits, are referable to the following series :—

LARAMIE	Porcupine Hill beds.
	Willow Creek beds.
	St. Mary River beds.
CRETACEOUS	Fox Hill sandstones (inconstant).
	Pierre shales.
	Belly River beds.
	Dark shales of Rocky Spring Ridge, etc., supposed to underlie the last.

A more detailed description, with a discussion of the relations of these beds, will be found on a subsequent page.

SECTION ON MILK RIVER, AND IN THE VICINITY OF THE 49TH PARALLEL.

SWEET GRASS HILLS.

General character of section.

The Milk River flows across the 49th parallel northward near the 113th meridian, and after pursuing an eastward course of about one hundred and fourteen miles, recrosses the same parallel about twenty miles east of the 111th meridian, a short distance beyond the limit of the district embraced by the present map and report. It is ten miles north of the 49th parallel near the crossing of the MacLeod-Benton trail, this being its most northern point.

Taking into consideration the length of the stream, the rock section is much inferior to that afforded by some other rivers in this region, but still presents a few points of special interest. In this portion of the report it is proposed to describe its geologicaal features briefly, and to include such geological notes as may be necessary of the country lying to the south of the river as far as the edge of the map.

North branch.

Where the Milk River first enters the district, it is flanked to the west by a plateau which may be considered as forming the western prolongation of the Milk River Ridge. The rocks here shown in the immediate valley of the river, have been described by me in the Report on the Geology and Resources of the 49th Parallel (p. 131) where this part of the stream is designated as the Second Branch. They belong to the St. Mary River subdivision of the classification now adopted. The banks show about fifty feet of pale bluish- and greenish-grey sandstones and sandy shales, generally soft, but with a few harder layers consisting of calcareous and ferruginous sandstone bands. In one of these, which may be described as a nodular ferruginous limestone of about a foot in thickness, and is at a level of about forty feet above the stream, numerous fossils were found. These include *Bulinus disjunctus* (?) *Limnæa*, *Physa*, and *Sphærium*.

In 1874 a loose block of similar material was found about fourteen miles eastward, at the crossing of the 49th parallel and South Branch of Milk River (First Branch of report above quoted), and the bed above referred to is again evidently the same as that described in a subsequent page as occurring on the upper part of the St. Mary.

Plateau of Willow Creek beds.

The plateau alluded to as flanking this part of the river, is traversed by one or more narrow valleys, the scarped sides of which show 150 to 200 feet of reddish and purplish-grey clayey and sandy beds belonging to the Willow Creek subdivision of the Laramie. These beds have a light eastward dip, and though for a considerable part of the distance between the Milk and St. Mary rivers no exposures are found, the western edge of the plateau formed of the Willow Creek beds is so well defined, that there is every reason to believe that the lower country at its western base marks the position of a low anticlinal, which separates this area of the Willow Creek from that occurring on the St. Mary.

Sandstones at base of Laramie.

From the point at which the Milk River crosses the 49th parallel, for about ten miles north-eastward, the rocks observed are chiefly sandstones of brownish and yellowish-grey tints. These, in several of the lateral ravines, assume monumental forms from the unequal resistance of the several layers to weathering. At the point last defined, rather massive beds of these sandstones are found, on the south bank of the river, to be underlain by the blackish shales of the Pierre, and they may therefore be assumed to represent the Fox Hill series, but possibly also include the lower beds of the St. Mary River subdivision. The discovery of the Pierre shales, which, owing to the rounded character of the banks are here very poorly exposed, is due to Mr. R. G. McConnell. These shales are here, probably, much thinner than further north, and cross the valley with a width of less than three miles. They appear to form the southern edge of the plateau of the Milk River Ridge, which here borders the valley to the north, for about seven miles, or nearly to the point at which the Lonely Valley enters. Beyond this point, for about five miles, the river flows south-eastward, and cuts through a higher tract of country, forming a narrow and almost cañon-like valley, three hundred feet in depth and less than a mile in width from rim to rim. The rocks here shown belong to the pale upper portion of the Belly River series, and underlie the Pierre shales above referred to. They consist chiefly of greenish-grey sands and sandy clays, and thin layers of soft sandstones with calcareous or ferruginous concretions. They are to all appearance horizontal, and no fossils were observed. These rocks and the Pierre shales were more carefully

Pierre shales.

Canon near Lonely Valley. Belly River series.

studied in the Milk River Ridge to the north, and their relations are described on a succeeding page.

Sections near South Branch.

South of the Milk River, and near the 49th parallel, about six miles west of the South Branch, rocks belonging to the same area of the Belly River series were observed by me in 1874, though at that time erroniously supposed to belong to the "Lignite Tertiary" of my report.* As this locality has not since been visited and the volume referred to is now out of print, the following description of these rocks is quoted from it:—

Belly River series.

The best exposures are found in a group of small hills, which assumes in miniature the appearance of bad-lands, and stands like an island of older rocks among the drift deposits, which lap around its base. It is an outlyer of a plateau, which, with irregular edge, runs northward with a little easting where it crosses the line. The beds are horizontal, and are exposed for a thickness of about sixty feet. The lower portion of the section is of pale greenish-grey clays, while above, the greenish colour is not so marked, and there are somewhat massive sandstones. In some places the latter are almost conglomerates, and hold many small pebbles, the majority of which are of greenish shale. They also hold fragments of reptilian bones and large *Unio* shells. Small nodules occur abundantly in some layers of the lower greenish clays, of a tint similar to the matrix. The bones are found in considerable abundance in all parts of the section, but are much crushed and fissured. When imbedded in the bank they are purplish-black in colour, but on weathering assume whitish and rusty tints. It is very difficult to dig the bones out of the bank itself, from the great hardness of the dry clay relatively to that of the fossils, and where washed out by the rains they are found only as broken fragments, difficult to re-construct. From specimens obtained here, however, in the course of a few hours, Prof. Cope finds, besides many broken fragments of Dinosaurians, new species of *Cionodon* and *Compsemys*, which he has called *C. stenopsis* and *C. agmius*, respectively.

Dinosaurian remains.

The greenish clay beds are doubtless formed of the disintegrated material of beds of green shale, similar to those represented by the pebbles in the conglomerates. A microscopic examination of the clay did not reveal any recognisable fragments of green mineral or rock, the colour apparently residing in the very fine argillaceous matter, through which a few large partly rounded grains of transparent quartz are scattered.

South Branch.

The South Branch of Milk River where examined by me near the 49th parallel in 1874, shows drift deposits only. Between this point and its

* Geology and Resources of the 49th parallel, p. 130.

mouth, the valley shows at one point yellowish-weathering sandstones irregularly hardened and bedded, and holding some ironstone. These appear to be practically horizontal. Several miles further down, near the confluence of this with the North Branch, these beds re-appear, with much the same aspect, but are overlain by beds of a different character, which, from analogy with those seen in the Milk River Ridge and elsewhere, with little doubt represent the base of the Pierre. These are well shown in a scarped bank about one hundred feet high, a mile and a quarter up the South Branch, and consist of greyish and blackish well-bedded shales and shaly sandstones, containing one highly carbonaceous layer which almost resembles a coal. The bedding of the whole is very uniform, but no regular direction of dip could be determined. A few fragments of shells, among which is a *Unio*, occur.

Base of Pierre shales, coal beds.

In following down the main valley of Milk River below the mouth of the South Branch, sections occur at frequent intervals for some miles, of beds quite similar to, and evidently on the same horizon with, those last described. The carbonaceous character of the beds here, however, becomes more pronounced, and they hold three or four coal seams which occasionally attain a thickness of over six inches. After a concealed interval of about a mile and a half, at a point about four miles west of the MacLeod-Benton trail-crossing, yellowish and grey sandstones of variable hardness and appearance, again appear. These were at the time regarded as probably overlying the Pierre shales last described, but as more fully shown on a succeeding page, reasons have since been found to show that they probably represent those described as occurring at the mouth of the South Branch, and really underlie these shales.

Exposures east of trail-crossing.

Sandstones of the character of those just described were the only rocks seen in the Milk River valley from this point eastward for many miles, but the exposures are infrequent and small on this part of the river. East of the trail-crossing, occasional outcrops occur in low bluffs. At a point four miles east, a small section of grey, yellowish-weathering sandstones with intervening yellowish-grey and blackish shaly beds, holding *Nucula cancellata*, was examined. There is here an appearance of light northerly dip which may, however, be merely a local undulation.

Red Creek.

Ten miles south of this part of Milk River, very similar rocks are again exposed in the valley of Red Creek, where it crosses the 49th parallel. In a bank about seventy feet high the following succession of beds was observed, though no exact measurement of them was made :—

Gravel and boulders, underlain by obscurely stratified drift	10 feet.
Greyish and yellowish, sandy shales	30 feet.
Yellowish, soft, clayey sandstone	
Purplish-grey shale	
Yellowish sandstone	

Yellowish, shaly sandstone............................	30 feet.
Irregular, harder, yellowish sandstone..................	
Greyish sandy shales, with thin layers of blackish carbonaceous clay at base..................................	

The beds are here believed to have a low northerly dip, and rise southward and eastward with the general surface of the country to the summit of the Rocky Spring Plateau, south of the 49th parallel, where they are probably represented by those forming the upper layers in the section in the eastern escarpment of this plateau, referred to on a succeeding page.

Sandstone outcrops.

From the point on Milk River last alluded to—four miles east of the trail-crossing—to the mouth of Verdigris Coulée, sandstones not dissimilar in appearance to those above described are seen at intervals, but generally in small exposures, and presenting no points of special interest. They appear throughout to be horizontal, or affected by light indefinite undulations only, but the sections are so inconsiderable that it is by no means certain that sandstones really preponderate among the rocks of this part of the river. It is frequently the case throughout this district that the harder sandstone layers alone appear in the rounded and grassy banks, while other and more characteristic beds, owing to their inferior induration, are concealed.

Mouth of Verdigris Coulée.

The rocks exposed on Verdigris Coulée are described subsequently, in connection with those of Milk River Ridge. At its mouth, a peculiar series of castellated or monumental sandstones first appears, the summit being here not much above the level of the Milk River, and overlain to the north by the beds seen further up Verdigris Coulée. From this point to that part of the river immediately north of the West Butte (nine miles) and beyond into Dead Horse Coulée, these sandstones appear almost uninterruptedly, and disregarding minor undulations, they rise persistently eastward and attain a greater height in the banks. They often characterize both sides of the valley, and though occasionally forming vertical cliffs, generally weather out into fantastic monumental forms, one group of which has already been illustrated in connection with the preliminary note on the geology of this district.* The greater part of the sandstone is soft and whitish, but certain harder, finely stratified or false-bedded layers, generally yellowish in color, have served as protective cappings, or project in cornice-like forms, which in some of the lateral ravines give rise to very remarkable instances of weathering. At a point three miles east of Verdigris Coulée, the sandstones were observed to be roughly false-bedded and to include blackish shaly intercalations and rolled fragments of shale, indicating proximity

Castellated sandstones

* Report of Progress Geol. Surv. 1880–1882.

to, and some local denudation of, the underlying series. This, about a mile further east, was observed in small exposures below the sandstones, and doubtless represents the upper part of the shaly series of the Rocky Spring Plateau (p. 42 C) and that of the mouth of Pā-kow-kī Coulée. The thickness of these sandstones is rather variable, but where greatest is about seventy feet. The beds overlying them are not well shown till that part of the river north of the West Butte is reached. Here, about one hundred feet of softer brownish and greyish sandy beds, which at times becomes blackish from the addition of carbonaceous matter, appear, and are interbedded with friable sandy clays holding occasional nodularly hardened layers of sandstone or ironstone, in which no fossils could be found. The same sandstones, with the last mentioned overlying beds, continue in the banks through Dead Horse Coulée to its east end, though in consequence, apparently, of the absence of calcareous matter, the castellated forms here become less characteristic and eventually cease to appear. Underlying shales.

In going from the Milk River, near the west end of Dead Horse Coulée, to the west flank of the West Butte—eight miles south-westward—the country gradually rises, and the beds above described appear to follow the slope and are seen in isolated exposures in some of the valleys. The massive sandstone observed on the west flank of the Butte, elsewhere described, is doubtless the same which forms the castellated rocks on the Milk River. Rocks near West Butte.

The tract south of the Milk River and between the West Butte and Red Creek was examined by me in 1874, and has not been revisited. Though numerous exposures occur in the various coulées, they are as a rule small and unsatisfactory. Westward from the Butte, the beds are found to assume a gentle synclinal form. About six miles from the base of the Butte, a zone of sandstone appears, which seems to hold a position much higher in the series than that on its flank, above referred to. This sandstone, two miles further west, was again seen, with a light eastward dip, the two outcrops forming the eastern and western escarpments of a low plateau. A short distance west of this synclinal, sandstones evidently representing the castellated beds of Milk River appear, and are doubtless also the same with those capping the eastern edge of the Rocky Spring Plateau. These beds are thus described in the report already several times referred to:— Rocks west of West Butte near Boundary line.

In a system of ravines south of the line, about twenty miles west of the Butte, these sandstones are again well exposed, and have an estimated thickness of thirty feet. In these valleys they occur not much below the general level of the prairie, and forming the upper parts of the banks, give them a most picturesque and remarkable appearance. The lower layers of the sandstone are generally very regularly bedded, and some of them are exceedingly fine and thin, and show worm-tracks and other obscure markings. The upper beds are more massive, and have a nodular character, which causes them to weather out into castellated forms, resembling in some places those of the Roche Percée. Underlying the sandstones are less permeable clays, or arenaceous clays, of light colours, of which I did not succeed in finding good exposures, but which turn out numerous springs of a highly saline character. The beds appear to be quite horizontal in this locality.

Rocky Spring Plateau.

The escarpment mentioned in the succeeding paragraph of my Boundary Commission report is that of the Rocky Spring Ridge or plateau.* Originating near the place last described, it runs south-eastward, gradually increasing in elevation, till, where crossed by the MacLeod-Benton trail, at a distance of fourteen miles, it has a height above the plains at its eastern base, of over 800 feet. The following section, in descending order, was measured near the point at which the trail descends from the plateau :—

	FEET.	INCHES.
1. Beds imperfectly exposed, but evidently soft, and wherever seen greyish, shaly sandstones, or sandy shales, thinly bedded	90	0
2. Sandstones, one rather massive bed of thirty to fifty feet near the top. Other beds flaggy sandstones, passing in some places into sandy shales. The bedding of all the sandstones regular, and surfaces often showing ripple-marks and annelide tracks. Two series of jointage-planes, causing the beds to weather into castellated forms. General colour on weathered surfaces, dark brownish	135	0
3. Pale greyish, and in places yellowish-grey sandy shales, all finely bedded, and occasionally holding calcareous nodules	90	0
4. Grey, finely-bedded sandy shales, rather hard. (Fossil bed No. 2.) *Baculites*, *Inocerami*, &c.	20	0
5. Lead-grey, soft sandy shales	55	0
6. Ferruginous ripple-marked sandstone. (Fossil bed No. 1.)	0	6
7. Lead-grey and blackish, thin sandy shales, with lenticular masses of dark argillaceous limestone, and calcareous concretions	70	0
	460	6

* The south-eastern front of this plateau, is roughly represented on some maps, and named the Snake Head Hills.

From the base of this section, the beds are concealed for a thickness of about 300 feet, when the surface of the lower plain is found to be composed of blackish shales, which continue southward to the Marias River.

The Sweet Grass Hills and country immediately adjacent to them, are described together on a subseqent page. From the point to which the description of the rocks on Milk River has been carried, that stream bends abruptly to the north, following a narrow valley which is evidently of comparatively recent origin, while a wide trough-like valley, now dry, and above alluded to as Dead Horse Coulée, runs through eastward, and is again joined by the river six and a half miles further on. On the river to the north of this valley, a few exposures of sandstones and sandy-clays with ironstone were seen, and at one place, three miles north of the river, in the front of the low plateau which here runs parallel to it, a bed of lignite-coal, three feet six inches in thickness and of fair quality, occurs. This is underlain by a few feet of whitish soft sandstone, but the exposure is small. For a mile or more further north, similar pale sandy beds are occasionally seen, and there is some reason to suspect a light southerly dip. Unimportant layers of lignite also appear in the banks of Dead Horse Coulée.

Milk River near Dead Horse Coulée.

Coal seam.

About half a mile east of the east end of this coulée, in the Milk River valley, the sandy and generally pale beds shown in the coulée are replaced in the bank by dark shales. The actual junction was not seen, but the shales are supposed to be the underlying series. A short distance further east, these shales are again replaced by sandstones, which seem to occupy a light synclinal, but are here very poorly exposed. At a point five miles west of the Pā-kow-kī Coulée, they are found capping the high bank of the river on the north side, of which the greater part is composed of the dark shales. These sandstones are yellowish in general tint, hold a few valves of *Ostrea* and are the same with those more fully described as occurring at the mouth of Pā-kow-kī Coulée. East of the point last referred to, in consequence of a light anticlinal or perhaps merely owing to the decreased height of the bank, the shales alone are seen for about two miles, when grey and yellowish generally soft sandy clays and sandstones again form the the summit of the section, and continue with increased thickness, due to a light easterly dip, to Pā-kow-kī Coulée.

Dead Horse Coulée to Pa-kow-ki Coulée.

It is probable that a light narrow anticlinal crosses the Milk River and runs into the mouth of Pā-kow-kī Coulée. The coulée is, in any case, in pretty evident connection with the existence of a subordinate intrusion of the igneus rocks of the Sweet Grass Hills. A small mass of dark mica-trap appears in the middle of the coulée near the point at which it joins the river. This includes fragments of hardened

Mouth of Pa-kow-ki Coulée.

Trap intrusion.

blackish shale, and is much cracked and fissured. Calcite, pyrites and some zeolitic mineral occur in small quantities. A similar little trappean projection, which may be connected with this, is seen about two miles off to the south-east on the opposite side of the river. The dark shales and shaly sandstones occur on both sides of Pā-kow-kī Coulée at its mouth. They form about eighty feet of the lower part of the bank to the west, but are not so well exposed to the east, owing to the persistent light easterly dip which here affects the strata. In both places the overlying rocks are grey sandstones and sandy clays, some layers of which are charged with innumerable well preserved specimens of *Ostrea glabra*. On the opposite or south side of the valley of the river the shales are not seen. In the spot first referred to, they hold a few badly preserved fossils, among which fragments of *Nucula cancellata* and *Liopisthes* (*Cymella*) *undata* were detected.

Milk River east of Pa-kow-ki Coulée.

For some miles eastward from the Pā-kow kī Coulée there are fine exposures of the banded sandstones and clays above referred to. These beds are evidently the same with those observed on the Lower Belly and Bow, and on the South Saskatchewan, and belong to the Belly River series of this report. They include, east of the coulée, some beds rich in molluscs, among which *Corbula subtrigonalis*, *Corbula perundata*, *Neritina baptista*, (?) *Melania insculpta*, a *Rhytophorus*, a *Viviparus* and a *Goniobasis* have been determined. The following section was obtained about five miles below the mouth of the coulée in the north bank of the valley of the river:—

Belly River series.

	FEET.	INCHES.
1. Greyish, sandy clays	6	0
2. Laminated, carbonaceous shale, with four-inch seam of lignite	6	0
3. Brownish and greyish, sandy clays	6	0
4. Shell-bed, with rusty, ferruginous cement. *Corbula perundata*, &c	1	6
5. Lignite (variable)	0	4
6. Brownish and greyish clays, *Corbula*, &c	12	0
7. Brown, thinly bedded, ripple-marked sandstone	0	6
8. Greyish, sandy clay, regularly bedded	4	0
9. Oyster bed	3	0
10. Brownish and greyish, banded sandy clays	70	0
11. Brown, hard sandstone	1	0
12. Greyish, sandy clay	10	0
13. Laminated, carbonaceous shale	1	6
14. Brownish-grey, sandy clays, many small *Ostreæ*		
Similar beds poorly exposed. To water of river	132	0
	253	10

Adding one hundred feet to represent the portion of the formation not included in the above section, the total thickness of these beds is raised to about 350 feet. The whole series has, as above stated, a light eastward dip, and the beds above described can easily be distinguished, even at a considerable distance, in the scarped banks which are here almost continuous, from their prevalant brownish and yellowish colours and earthy appearance.

Upper part of Belly River series.

About seven miles below the mouth of Pā-kow-kī Coulée, the banks become considerably higher, and on the south side, paler ash-grey beds appear at the top of the section. These, at a distance estimated at eleven miles from the same point, form the upper two-thirds of the bank. The same upper pale portion of the Belly River series forms the high plateau south and south-east of Lake Pā-kow-kī, as elsewhere mentioned, and it is of this part of the series that a section was measured on the Milk River near the 49th parallel crossing, a few miles beyond the edge of the present map, in 1874.*

Sweet Grass Hills or Three Buttes.

The rocks displayed in and about the remarkable isolated mountains known as the Sweet Grass Hills or Three Buttes are of great interest, but owing to the constant danger of having our horses stolen by wandering parties of Indians in this vicinity, and the fact that these mountains lie to the south of the International boundary-line, it was not deemed expedient to remain long in the neighbourhood. A general description of the Sweet Grass Hills, in which the main features of their geological structure are referred to, has already been given. (p. 16 c). Since my examination of the East and West Buttes in 1874, the only point re-visited has been the flank of the latter mountain, and the following description is, therefore, almost literally quoted from my Report on the Geology and Resources of the 49th parallel.

East Butte.

On approaching the East Butte from the north to within ten or twelve miles, the hitherto nearly horizontal beds are found to assume a distinct dip away from its central mass. In the valleys of the streams which seam the flanks of the hills and furrow the surface around them, numerous more or less extensive exposures of rocks evidently representing the Belly River series of this report, occur, which it is unnecessary to describe in detail.

Trap dykes.

Dykes of eruptive material traverse the sedimentary rocks surrounding the Buttes, in some places, and appear generally to have a direction radiant from the higher peaks. In a valley about ten miles north of the summit of the East Butte, one of these is well exposed. By the wearing away of the softer surrounding beds, it stands up like a massive partly ruined wall, the resemblance being increased by the fact

* Geology and Resources, 49th Parallel, p. 120.

that the rock has been broken up by the weather into quadrangular blocks. Its observed course is nearly east and west. The rock is a mica-trap of dark greenish-grey colour, and not very hard, in which small tabular crystals of a brown mica are thickly scattered. It may probably originally have been of the same nature with the central masses of the Buttes, but has become more basic by the incorporation of portions of the surrounding sedimentary rock, and has acquired a different mineralogical character from this circumstance and from more rapid cooling. The clays and sandstones on either side are nearly horizontal, except immediately in contact with the dyke, where they are contorted and much altered. Valves of *Ostrea* are abundant in some of the surrounding beds, and specimens of *Corbula perundata* were also recognized.

Rocks surrounding East Butte.

On ascending the East Butte, the harder beds are found constituting more or less continuous ridges round the central mass, while the softer intervening strata are not usually well exposed. The total thickness of the beds seen is not very great, as the ground rises almost equally with the increasing dip. The sedimentary rocks, in some places, rise to within about one thousand feet of the summit, and are then found much hardened and altered, and dipping very steeply away from it. They are here traversed, like the igneous rock itself, by many small seams of crystalline quartz, in which a careful examination failed to detect a trace of any metallic mineral.

Sequence of rocks, East Butte.

Nearest the igneous mass, and lowest in the series, on the East Butte, occur beds of hardened sandstone, not of great thickness. On these rests a considerable thickness of hard, blackish, fissile shale, in which no characteristic fossils were found, but which doubtless represents those subsequently described as occurring at the West Butte. Above this is a rather important sandstone series, much of which is regularly bedded, but which in some places is nodular, and gives rise in the valleys which cut through it, to castellated, step-like and fluted rocks of picturesque appearance. These, with little doubt, represent the castellated sandstones described on Milk River, and are followed by the beds above alluded to as probably referable to the Belly River series.

Eruptive central mass.

The igneous material composing the higher peaks and central masses of the mountains, though very hard and compact, is seldom seen actually *in situ*, the solid rock being concealed under a great depth of its own fragments. These fragments are very irregular in form, but generally angular, bounded by plane faces, and vary in size from a few inches to about two feet in greatest diameter. The rock is very uniform lithologically, in appearance and composition. Mr. F. D. Adams has examined microscopic sections of it, and states that it may be called a hornblende-trachyte, rich in plagioclase. Mr. Adams writes "it is composed of orthoclase and plagioclase, both present in large amount, and some hornblende. It is therefore intermediate in composition between andesite and trachyte, and to which class it may best be referred can only be ascertained by a partial analysis."

The highest peak of the West Butte, is at its eastern side, and is a large blunt-topped mountain, which to the east presents vertical rocky cliffs. West and north of this summit lie several important peaks and ridges, enclosing a rugged, pine-clad and rocky area of some extent. The foot-hills of the West Butte are also on a larger scale than those of the others. The sedimentary rocks are, as in the East Butte, found to dip away from the central igneous intrusion on all sides, but a considerable mass of stratified rock has here been, as it were, caught up by the eruptive material, and occupies the depressed central portion of the group of mountains. A great part of these beds dip south-eastward at a rather high angle. They have been considerably altered and now consist of slaty shales, and hard, thin-bedded sandstones in which no fossils were found. The trappean nucleus of this Butte is indistinguishable lithologically from that of the East Butte, and it forms shattered and rubbly hill-tops in the same way.*

West Butte.

Included stratified mass.

The clearest sections of the rocks surrounding this Butte were met with on its western side, where a considerable brook issues from the central valley. Dark, somewhat indurated shales, precisely resembling those described on the East Butte, here occur, with a light westward dip. The sections are not such as to admit of exact measurement, but the thickness of the shales was roughly estimated in 1874 at 800 feet. A few fossils were found in sandy and nodular layers associated with these shales, which were at the time supposed to represent the Pierre group In consequence of the importance of deciding their relations, the locality above described was again visited in 1881, and additional collections obtained, in which the following species have been determined :—

West flank of Butte.

Ostrea congesta, *Pteria Nebrascana*, *Pyrifusus Newberryi*, *Aporrhais biangulata*, *Scaphites Warreni*, *Baculites ovatus*, var., etc.

Underlying these clay-shales in some places, are rather massive sandstones tilted at high angles against the flanks of the eruptive rock, which evidently represent those found occupying a similar position on the East Butte. Overlying the shales, are massive sandstone beds, yellowish in colour, which, from their superior hardness, generally form a prominent ridge at a little distance from the base of the Butte. On the west flank of the Butte these dip away at an angle of about 12°, and a thickness of over forty feet is exposed. The investigations of

* I have been credibly informed of the occurrence of galena on the east side of the West Butte.

1881–83 appear to show that the shales here described represent those of the Rocky Spring Plateau and Milk River north of the Buttes, while the overlying sandstones are those referred to as the castellated series on the same river.

Age of the Buttes.

With regard to the age of the isolated igneous masses here so prominently displayed, all that the sections prove is that they are later than the surrounding Cretaceous rocks, which have been disturbed by them and are cut by their dykes. They are probably protrusions quite local in character, though with possible deep-seated connection with the similar intrusive masses near the Missouri to the south. They have not, however, at all the character of modern volcanic cones, and no rocks were seen in connection with them which had even probably cooled at the surface. If of the nature of volcanoes they must be very ancient ones, of which the cones or stumps now only remain, and from about which the whole of the ejected material has been removed. The denudation affecting the rocks tilted up round the Buttes has been very great, and must have occurred for the most part in Tertiary time and before the glacial period.

Milk River Ridge and Vicinity.

Milk River Ridge.

The following notes are based in part of Mr. McConnell's work in 1882 in part on my own in 1883.—Milk River Ridge is a rough irregular plateau varying in width from six to twelve miles, and extending from near St. Mary River, eastward, parallel to the Milk River for about forty miles. Its northern edge is rather abrupt, and rises in some places as much as 600 feet above the plains. Its southern border is not so well defined and is worn into a succession of deep bays by small streams which flow into Milk River. The Lonely Valley cuts completely through its western portion, and there are several similar but less important gaps running through it from the Milk River valley near its intersection with the 49th parallel. The plateau to the south-east of the South Branch of Milk River, is evidently a portion of the same area of high land which constitutes the Milk River Ridge proper. As already stated on a previous page of this report, the plains to the north of the ridge are at nearly the same level as—and in many places even lower than—the water of Milk River to the south.

Complex geological structure.

Milk River Ridge is remarkable on account of its complex geological structure. Its western portion, composed of beds of the Willow Creek subdivision of the Laramie, has already been noticed in connection with the description of sections on the upper Milk River (p. 37 c). In proceeding eastward the St. Mary River subdivision, the Fox Hill, Pierre and Belly Rivers beds, are found to outcrop successively, in consequence of a light westerly dip, which, though locally interfered with by light undulations, appears on the whole to be persistent. The last named series, though well displayed in the eastern part of the ridge, was in no place observed to form the surface of the plateau. The high land above alluded to as existing south-east of the South Branch, is probably chiefly composed of Pierre shales; and in bare plateaus connected with it to the south-west, some miles south of the 49th parallel, these were seen from a distance overlying the pale beds of the Belly River series. The central and eastern portion of the plateau is composed of the Fox Hill, Pierre and Belly river beds. The sandstones of the Fox Hill, are well exposed about seven miles north of the plateau, in a low hill which is cut through by the Pot-hole River, where Mr. McConnell observed the following section:— Fox Hill sandstones.

	FEET.
Yellowish-weathering, soft, coarse sandstone, showing branching fucoidal markings in many places	60
Black shales	15
Flaggy sandstones	20
Black shales (to base of section)	60
	155

The massive sandstone forming the top of this section, and which undoubtedly represents the Fox Hill,* forms a steep cliff facing the stream and extending up it about half a mile. Following the strike southward, it is again seen in conspicuous exposures about half way up the northern slope of Milk River Ridge, where the castellated and fantastic forms which this rock frequently assumes on weathering are well displayed.

In the valley of the west branch of Pot-hole River, where it leaves the plateau, the sandstones above described form the upper part of the section, and overlie about one hundred and fifty feet of black shales. The occurrence of this sandstone on the Milk River, south of the plateau, has already been alluded to. It is there about sixty feet in thickness.

To the east of the outcrop of these sandstones, the Pierre shales come to the surface in a belt of which the width is extremely variable. North of the plateau the outcrop is about five miles in width, but in following it southward it is found to spread eastward over the entire summit of the plateau, and reaches probably to within a few miles of the MacLeod-Benton trail; while the western edge, or summit of the shales, appears to run almost directly across the plateau to the Milk River. In many places along the northern slope of the plateau, the valleys of small streams afford good sections of the base of the Pierre, and the clays, sandstones and sandy clays of the underlying Belly River series. Of these the best observed are in and near Fossil Coulée, about Belt of Pierre shales. Base of Pierre.

* Compare with its development on the neighbouring part of St. Mary River.

ten miles west of the Nine-mile Butte. The actual base of the Pierre is best shown in the head waters of a small stream which flows into Middle Coulée Creek. The shales here to some extent loose their characteristic dark tint, become greyish or brownish and earthy looking, and hold several small seams of coal and carbonaceous shales. The most considerable coal seam is not more than eighteen inches thick, and the section here is closely comparable with that previously described in Milk River south of the ridge (p. 39 c). An oyster-bed identical with that observed at the mouth of St. Mary River at the same horizon, occurs in association with the coals. In this, in some places, the calcite of the shells has been largely replaced by iron oxide. The exposures on the head-waters of Ed. Mahan's Coulée are small, but probably represent the top of the Belly River series. On Fossil Coulée, fine exposures of the series last mentioned occur, in bare, bad-land banks. The following is a section of the greater part of the beds there shown, in descending order:—

Coal seam.

Belly River beds.—Section on Fossil Coulée.

	FEET.	INCHES.
Dark grey, soft, sandy clay	6	0
Yellowish sand or soft sandstone	4	0
Grey, soft sands, with some bands of clay	15	0
Grey, soft sandstone	1	0
Greenish-grey clay	5	0
Grey, soft, shaly sandstone	1	0
Grey, soft, sand and sandy clay	4	0
Greenish-grey clay	5	0
Nodular layer of impure calcareous ironstone	1	6
Yellowish, fine sand, or soft sandstone	4	6
Dark grey, sandy clay	3	6
Greenish-grey sands, irregularly hardened and forming projecting cornice-like layers of sandstone	8	6
Greenish clay, with large impure septarian ironstone nodules	8	0
Greenish-grey, sandy clays and clays	10	0
Yellowish-grey, sandy clay, with layer full of small clay pebbles at top	10	0
Yellowish-grey, fine, soft sand	3	0
Brown-weathering, shaly sandstone, becoming conglomoritic with small clay pebbles in some places (locally developed)	1	6
Grey, soft, fine sand	3	0
Grey, fine-grained sandstone	1	0
Pale greenish-grey clay, slightly banded	15	0
Pale greenish-grey, soft, sandy clay	4	6
Grey, soft, clayey sand. The upper portion full of small soft ironstone concretions	3	0
Grey, soft sandstone	0	2
Greyish, soft, clayey sand	5	0
	123	2

This section may be regarded as a representative one of the upper or pale portion of the Belly River series. Mr. T. C. Weston, who accompanied me to this locality in 1883, made here a considerable collection of fossils, which included *Unio* and other fresh-water shells resembling those abundant in the lower yellowish portion of the Belly River series. These were unfortunately lost *in transitu*. Mr. McConnell collected from the same locality, in 1882, a few fossils which indicate that some of the beds are brackish-water or marine in character. Among these are: *Pteria Nebrascana, Cymbophora alta* (?) *Volsella, Natica* (fragment), *Anchura, Spironema, Anodonta* and *Unio*. Fossils.

The eastern edge of the Pierre shales on the Milk River Ridge, owing to the lack of exposures, can only be very approximately defined. It probably crosses the ridge nearly opposite the head-waters of Ed. Mahan's Coulée. These shales are, wherever seen in this region, very uniform in appearance. With the exception of the lower beds above alluded to, the mass of the series appears to be made up of very dark shales, in which sandstone beds, which in some other localities form a prominent feature, scarcely occur. Thin layers of red-weathering ironstone, however, are occasionally found, and numerous concretionary masses of the same material are scattered throughout. The only fossils observed in these beds in this neighbourhood were fragments of an Inoceramus, of an Ammonite and of a Baculite. General character of Pierre.

The exposures in Ed. Mahan's, Middle and Kipp's Coulées, north of the slopes of the ridge, are comparatively insignificant, and not sufficiently continuous to form a good connection between the rocks of the ridge and those of Verdigris Coulée. At the trail-crossing of Ed. Mahan's Coulée, a thin seam of lignite or shaly coal occurs in a bank of greyish sandy clays, the whole being underlain, in the bed of the stream, by a hard nodular calcareous layer, much fractured, and showing crystals of calcite lining the irregular crevices. The horizon of these beds is somewhat uncertain, but they may possibly represent the base of the Pierre. Two or more species of *Sphærium* and fragments of *Goniobasis* and *Viviparus* were obtained here. Near the junction of this coulée with Middle Coulée, yellowish soft irregularly bedded sandstones appear, which possibly underlie the beds just described. On the south bank of Middle Coulée, between this point and the trail-crossing, a carbonaceous layer, probably representing that above mentioned, occurs, but the exposures are poor. West of the trail-crossing on Middle Coulée, are occasional banks showing yellow sandstones and grey clays, for about three miles, where beds of the same character and on about the same horizon with those of Fossil Coulée appear, and are well shown in scarped banks west of the entrance of Middle Coulée Creek. Similar inconsiderable exposures occur both east and west of the trail-crossing Rocks on Ed. Mahan's Middle, and Kipp's Coulées.

on Kipp's Coulée. These doubtless represent the Belly River series. In a narrow valley which connects Middle and Kipp's Coulées, west of the trail, scarped banks afforded the subjoined section :—

	FEET.	INCHES.
Greyish, flaggy sandstone	10	0
White, arenaceous clay	20	0
Yellowish sandstone (to base of section)	8	0

Rocks on Verdigris Coulée.

Verdigris Coulée, already referred to in connection with the discription of sections on the Milk River, affords almost continuous sections, for many miles, of the Belly River series; though from their character it is difficult to decide whether they represent its upper or lower portion. In the lower part of the coulée, near McConnell's Lake, the banks show a tendency to bad-land weathering and are in general tint greenish or purplish-grey. Yellowish sandstone beds are prominent and very irregularly hardened. Silicified wood is very abundant in some of the banks, but no other fossils were observed. The beds are to all appearance, perfectly horizontal. Similar beds at the same or nearly the same horizon, continue to and along the shores of Verdigris Lake, but are generally poorly shown. In the valley of a small stream which enters the lake from the south, near its north-west end, there are considerable sections of grey and yellowish shales and shaly sandstones, thin-bedded and rather hard; these appear to have a very light westward dip.

Fossiliferous locality.

About a mile west of Verdigris Lake, in the north bank, a thin bed very rich in well preserved fossil shells of a few species, was found. Among these are *Corbula perundata*, *Corbicula cytheriformis* (?) *Ostrea* and *Unio*, but the specimens were unfortunately lost, with other collections from this district. The rocks in the vicinity are more thinly bedded than those near the mouth of the coulée. Thin yellowish and reddish sandstones occur, with pale or dark grey shales, which occasionally become impure lignite. Similar rocks, but in very imperfect exposures, in which the sandstones as a rule alone appear, occur on both sides of Tyrrell's Lake and westward to Suds Lake. Their horizontal attitude, wherever observed, and the absence of slope in the bed of the valley, would indicate that nearly the same horizon is represented throughout. Some of the beds on the higher part of the coulée present a marked resemblance to those seen at the trail-crossing of Ed. Mahan's Coulée, but it is impossible to trace out minor subdivisions of the series in this region.

Rocks on Etzi-kom Coulée.

In Etzi-kom Coulée, about the meridian of the West Butte, sections were examined about fifty feet in thickness, which evidently represent the yellowish or lower portion of the Belly River series. The rocks seen were soft whitish sandstones and sandy clays, yellowish sandstones, and carbonaceous purplish-grey shales, which in some places approach lignite. They are apparently horizontal, *Ostrea glabra* (?) and a few other shells in a very poor state of preservation were observed.

Fourteen miles westward, on the same coulée, similar rocks, again associated with lignitic shales, and holding fragments of *Unio*, were noted by Mr. McConnell, A few miles west of Lake Pā-kow-kī on the same coulée, yellowish sandy-clays and sandstones, holding *Corbula perundata* were observed in 1881. This long coulée was not followed throughout its course, though Chin Coulée, running parallel to it a few miles to the north, was pretty carefully examined, and the horizontality of the beds leaves little room for doubt that practically the same horizon is represented on both.

The following notes on Chin Coulée are by Mr. McConnell :—

"Chin Coulée runs entirely through rocks belonging to the Belly River series, good sections of which occur at many points. The Chin, a name given to a small plateau lying north-east from the crossing of the Cypress trail and abutting on the coulée, is composed of brownish-yellow coarse sandstones, thickly bedded, and overlying some brownish flaggy sandstone. Section on Chin Coulée.

"Between the Chin and a point about twenty-seven miles further east the coulée was not examined. Below that point, the banks of the valley are usually more or less scarped, and show almost continuous sections nearly all the way down to its mouth; the rocks consisting mainly of greyish sands and sandy clays, yellowish and greyish sandstone, lignitic shales and ironstone. Near the mouth of Forty-mile Coulée, a darker band containing a number of beds of carbonaceous shale appears in the section. Fossils were found in many places. *Corbula perundata*, *Corbula pyriformis* and *Ostrea glabra* being the most abundant. The last named fossil forms in one instance the greater part of two beds, in the same section, each about three feet thick. North of Chin Coulée and near the point where the Cypress trail crosses Forty-mile Coulée, a small coal seam, about fourteen inches thick, occurs. This seam is probably about the same horizon as the coal at Medicine Hat." Coal seam.

St. Mary, Upper Belly and Waterton Rivers.

The St. Mary, Upper Belly and Waterton (Kootanie) Rivers, flow north-eastward nearly parallel to each other, toward the main Belly River. The tract of country embraced between the first and last mentioned, scarcely averages over twenty miles in width, and the sections formed by these streams may in consequence well be treated together.

The slightly convergent courses of the Upper Belly and Waterton Rivers bring them together at a point about nineteen miles above the main Belly River, the united stream bearing the last mentioned name, though in point of volume and length of course, the Old Man River has a better claim to the title. As a matter of convenience, I have distinguished that part of the so-called Belly River which is above its junction with the Old Man, as the Upper Belly.

General character of sections.

The rocks exposed by the upper parts of these streams, from the base of the mountains, belong to the disturbed foot-hill belt, The rivers then cut across a considerable width of Willow Creek rocks, forming the southern extension of the wide synclinal in which, further north, the Porcupine Hills lie. They next traverse the rocks of the St. Mary River subdivision,—the river of the same name affording the best and most typical display of these rocks found in the district,—and enter the Pierre shale region before reaching the Belly.

Sections near boundary-line.

The eastern edge of the disturbed belt crosses the forty-ninth parallel only a few miles east of the St. Mary River, so that the portion of that stream within the limits of the present report, which traverses the region of flexed rocks, is small; being in fact not more than about six miles. The rocks in the immediate vicinity of the boundary-line have been described in the Report on the Geology and Resources of the 49th Parallel (p. 132), from which the following notes are extracted with little change:—

The lowest rocks seen in the part of the river nearest the line were at the Boundary Commission trail-crossing about two and a half miles north of the parallel. They are sandstones of greyish and yellowish tints, regularly bedded and quite hard, with some surfaces showing ripple-marks and worm-tracks. They have a south-westerly dip at an angle of 20°, and are present in considerable thickness. About half a mile south of these lower beds, and overlying the upper layers of the same sandstone zone, a bed of fuel with all the mineralogical characters of true bituminous coal, was found. It has a thickness of about eighteen inches only, and occurs just at the level of the water in the river, by which it is partly covered. It breaks with a clean fracture into cuboidal fragments with bright faces, and is indistinguishable in appearance from many coals of the true Carboniferous system. Below the coal is a foot or two of dark carbonaceous shale, somewhat indurated, and holding imperfect remains of plants. A similar shale, but only a few inches in thickness, rests upon the coal, and is followed in ascending order by a hard shell-bed eighteen inches to two feet thick, dark coloured from included carbonaceous matter, but in the main composed of shells of *Ostrea* and *Corbicula occidentalis*. Above this is a considerable thickness of flaggy and ripple-marked

Coal seam.

sandstones, greyish and brownish-grey, with a dip of S. 40° W. < 35°. The ripple-marks indicate a current with a direction of S. 36° W.

A few hundred yards south-east of the last exposure, sandstones similar to those overlying the coal are found in a steep bank. They are sharply folded into an anticlinal form, and are overlain by a considerable thickness of greenish-grey clay beds. The latter are charged with small flat masses of calcite, formed apparently in fissures, but now scattered over the surface of the clay-bank, giving it a remarkable appearance. A shell-bed very similar to that found in connection with the coal, but probably not identical with it, as it wants the carbonaceous colouring matter, also appears here. It probably underlies the sandstone, but though large blocks of it are strewn about, it is not well exposed. The rocks are so abruptly folded that they appear in some places to be slightly overturned, and in the absence of large and continuous sections, the precise relations of the beds cannot be traced. Anticlinal.

Four miles west of the St. Mary River, and about two north of the 49th parallel, a hard fossiliferous bed comes to the surface, forming the crest of a ridge. It dips west-north-west at an angle of 20°. Where exposed it is an almost solid mass of fossil shells, forming a rough limestone. The same molluscs are represented here as in the other sections in the immediate vicinity of St. Mary River. A short distance further west, a bed of hard sandstone appears, again forming the crest of a ridge, which can be traced for miles in a north-westward course. The strike of the sandstone itself, as shown by the stratification lines, is N. 20° W., with a south-westerly dip at high angles. The persistence of this bed in the direction of its strike, seems to show that though the strata are so much disturbed, the folding has taken place very regularly parallel to a single direction. The sandstone evidently underlies the shell-bed last referred to, and must be some hundreds of feet below it. It is yellowish, and not so much indurated as that seen in the river, some layers being still quite soft. In this bed was found a trunk of silicified wood. Rocks west of St. Mary River.

The shell-bearing bed referred to in the above quotations, evidently represents the well-marked and wide-spread horizon of brackish and marine waters near the very base of the Laramie. It was not again seen on the St. Mary. Base of Laramie.

North of the old Boundary Commission trail, for a couple of miles, the river cuts its way between high rocky banks, and for a short distance becomes almost cañon-like. The sections here were not particularly examined in 1874, but this point was visited in 1881 for the purpose of connecting with the Boundary Commission work. The rocks displayed are those of the St. Mary River series, overlain by the Willow Creek beds, characterized by their usual reddish colours. The strata in the part of the valley bordered by steep cliffs lie at various angles up to 40°, and the direction of dip is less regular than usual.

Section of St. Mary River and Willow Creek beds.

The following section will serve more clearly to illustrate the character of the beds. The order is descending:—

	Feet.	Inches.
1. Shales and sandstone interbedded, brownish and reddish-weathering, giving the bank a general ruddy appearance	20	0
2. Hard, yellowish-weathering sandstone	4	0
3. Sandstones and shales, interbedded, greyish and reddish-weathering	15	0
4. Grey, soft sandstone and sandy shale	15	0
5. Brownish sandstone	0	4
6. Grey, soft sandstone	5	0
7. Hard, purplish-weathering shale	0	4
8. Purplish-grey shale	4	6
9. Reddish-brown sandstone	0	3
10. Grey shale	2	6
11. Grey sandstone	2	0
12. Soft, purplish and bluish-grey shale	14	0
13. Grey and bluish-grey crumbling shale	3	0
14. Hard, grey sandstone	4	0
15. Grey, crumbling shale	4	0
16. Hard, grey sandstone	1	6
17. Soft, greyish sandstone and sandy shales	18	0
18. Hard, grey sandstone	6	0
19. Greyish and purplish crumbling shales	3	0
20. Brownish sandstone and shale with some ironstone	8	0
21. Grey shaly sandstone	8	0
22. Bluish-grey sandstone	3	0
23. Grey, sandy clay	1	0
24. Irregular arenaceous ironstone	0	2
25. Soft clays and sandy clays	15	0
26. Brownish-red clay	15	00
27. Soft grey and bluish-grey shales with many small irregular calcareous nodules	20	00
28. Harder flaggy sandstones and sandy shales. Finely ripple-marked (Current S. 50° E. or N. 50° W.)	12	00
29. Thinly bedded sandstones and sandy shales	15	00
30. Brownish sandstone	2	6
31. Soft, grey sandy shales	18	00
32. Hard, ripple-marked sandstone		4
33. Grey, sandy shales	4	0
34. Hard, grey sandstone	4	0
35. Greyish and bluish-grey sandy shales and sandstones (partly concealed)	15	0
36. Calcareous ironstone, traces of fossils	1	0

37.	Grey sandstone and sandy shales	5	0
38.	Brown and grey flaggy sandstones, with fucoidal markings and worm-burrows	2	0
39.	Greyish and bluish-grey sandy shales and sandstones	10	0
40.	Impure ferruginous and arenaceous limestone with fresh-water shells (*Bulimus disjunctus? Sphærium*, &c.)	0	6
41.	Grey, sandy shales	4	0
42.	Brown sandstone		4
43.	Greyish, sandy shales	6	0
44.	Brown sandstone	1	0
45.	Bluish-grey, soft sandstones and sandy clays	48	0
		341	4

Below the base of the section is about fifty feet in thickness of sandstones and shales of general bluish-grey tints. These, owing to the difficulty of the hill-side, could not be measured. The upper beds, down to about layer 27, may be assumed from their colours and appearance to represent a portion of the Willow Creek subdivision, though indicated at this place. The sandstones, throughout, vary much in regard to induration, some being quite hard, while others are scarcely consolidated. No carbonaceous layers were observed, but abundance of little plates of calcite, like those alluded to on a former page occur in some of the beds. Layer 40 appears to be identical with that seen on the Upper Milk River to the east (p. 37 c), and carries similar fossils. It is the only part of this section in which fossils were observed. The beds at the base of the section dip S. 15° W. < 40°, but the upper layers lie at a much lower angle, and appear to assume a synclinal form.

General character of the rocks.

Down the river from this point, the banks for a distance of two to three miles, appear to be occupied by the St. Mary River beds, but owing to the existence of a wide low flat, a portion of the river-section is concealed. At the lower end of the flat, well characterised Willow Creek beds appear, and occupy the valley for a distance of over seventeen miles northward. They may be described generally as grey and bluish-grey, purplish and reddish beds, chiefly clays and arenaceous clays, forming crumbling banks, but with some sandstones. The horizon appears to be nearly the same throughout, and the whole may be considered, in a broad way, as resting in the southern extension of the Porcupine Hill synclinal; though light undulating local dips render it impossible here to recognise the general structure. No fossils were anywhere observed in these exposures. The banks frequently show a considerable capping of boulder-clay, but the underlying quartzite shingle is not here found.

Wide area of Willow Creek beds.

Sections of St. Mary River beds.

Light westerly or north-westerly dips, however, eventually prevail, and bring the grey, bluish, and yellowish-grey thin-bedded sandstones, sandy shales, and argillites of the typical St. Mary River series, to the surface. Near the top of these, a layer holds *Viviparus*, and other fresh-water shells, badly crushed, with some imperfect plant remains, consisting of fragments of *Physagenia Parlatorii*. In correspondence with the harder character of these beds, the river-valley again becomes cañon-like, and turning north-eastward runs for five miles between banks from one hundred, to one hundred and thirty feet in height presenting continuous exposures of the rocks, which are almost perfectly horizontal, though the slope of the river gradually brings somewhat lower beds to view. At the lower end of this reach, a bed containing the species above alluded to again occurs.

From this point, the general course of the river is nearly due east, for three and a half miles, but the stream is exceedingly tortuous. The banks are somewhat lower and less scarped, but a well-marked wide ridge here impinges on the valley on the north side, and runs thence north-north-eastward toward the Belly Butte. The dips appear generally to be north-westward, at angles less than five degrees. Some scarped banks, eighty feet in height, are composed entirely of boulder-clay to the water-level.

Gooseberry Canon.

The river here again turns northward, and nearly following the 113th meridian for three and a half miles, is closely hemmed in on both sides by high banks, which are frequently almost vertical cliffs one hundred and fifty feet high, and afford fine sections of the bluish- and yellowish-grey beds of the St. Mary River series. Sandstones here preponderate, and there is a distinct tendency to northerly and even to north-easterly dips, implying a broad lightly-marked anticlinal arrangement of the beds. Crushed fresh-water molluscs occur in several places, and at one point large masses, evidently from the immediate vicinity, were found holding remarkably well-preserved shells, including *Bulimus disjunctus* (?), *Corbicula Nebrascensis*, *Viviparus*, *Goniobasis*, &c. Ripple-marks, denoting currents in a direction S. 50° E. or N. 50° W. were noted at one point.

Sections below Gooseberry Canon.

The river in this part of its course, which has been called the Gooseberry Cañon, is almost one continuous rapid, and at one place an actual fall a few feet in height occurs. It is exceedingly dangerous for canoeing even at high water, and is probably quite impracticable at a low stage owing to the great number of boulders in its bed.

The St. Mary River series continues for a further distance of five miles by the course of the valley, which though with lower banks, still yields an excellent section. The direction of dip now changes to southward and south-westward at similar low angles to those before observed, and probably in no case, even locally, exceeds ten degrees. No marked change in the character of the rocks was noted till within a short distance of the base of the series, where the sandstones were observed to become yellowish in colour and less massive, and to be interbedded with blackish-grey shales. Poorly preserved specimens of fresh-water molluscs, among which *Unio* is conspicuous, occur at this horizon. Fragments of bone were also found, and carbonaceous matter becomes rather prominent.

Fox Hill sandstone.

At the base of the Laramie, a massive sandstone of a grey tint and fifty feet in thickness appears, dipping S. 55° W. $<$ 3°. It forms a mural cliff of its full thickness at one point, and a little further down the river was seen to overlie about thirty feet of blackish clay-shale of the Pierre group, which holds marine fossils. Among these, fragments of *Inoceramus* and *Baculites*, with others doubtfully referable to *Protocardium*, were found. The massive sandstone doubtless represents the Fox Hill horizon, and there are few places in the district embraced by this report in which it is so well marked.

Pierre shales.

For the remainder of its course—ten miles in a straight line—the St. Mary displays the rocks of the Pierre group of the Cretaceous only. Numerous sections of the blackish- and bluish-grey clay-shales of the Pierre occur, sometimes with a volume of one hundred feet in a single bank, to the mouth of the river, and the characteristic molluscs were found in abundance in several places.

Coal-bearing zone.

The coal-bearing zone marking the base of the Pierre, first appears in a low anticlinal, near the water's edge, nine miles above the mouth of the river. Light variable dips bring it occasionally to view for about three miles, when, at about two miles above the crossing of the trail, it passes below the base of the section, and is not again seen till the mouth of the river is reached.

Sections of coal seams.

In the annexed section, the first column represents the first-mentioned exposure, while the second is a continuation of the first at a spot about one hundred yards down stream :—

	Feet.	Inches.		Feet.	Inches.
Rusty, ironstone layer	0	8			
Blackish and rusty shale	5	0			
Coal	0	3			
Blackish shale	6	0			
Coal	0	6			
Soft, carbonaceous shale	0	4			
Coal	0	8			
Soft, thin, shale, highly carbonaceous in upper part	0	6			
Ironstone shale	0	6			
Blackish shale	3	0			
Coal	0	8	*Coal*	1	0

	Feet.	Inches.		Feet.	Inches.
Carbonaceous shale (some coal)	1	6	Shaly coal	0	6
Coal (partly below water)	1	6	*Coal*	1	3
			Shale	0	2
			Coal	0	9
			Grey shale	4	0
			Coal	1	4
			Grey shale (to water)	4	0

About two miles further down the St. Mary, where the coals next appear, they have the following development:—

Coal (rather shaly)	1	0
Coal	1	4
Shale	0	3
Coal	0	9
Shale	10	1
Coal	3	8
Shale (with obscure plant impressions)	6	0

The same horizon, as displayed in the section at the confluence of the St. Mary and Belly, is described in connection with the geology of the latter river.

Boulder-clay.

Though not generally referred to in the foregoing notes, the boulder-clay, in greater or less thickness, caps nearly all the river sections and, in some places forms entire banks. It was first seen to overlie the shingly quartzite deposit at a point about four miles from the mouth of the river.

Upper Belly River.

Sections near 49th Parallel.

The Upper Belly Valley, for about five miles from the point at which it crosses the 49th parallel, lies between high and more or less densely wooded foot-hills, which form a connection between Chief Mountain and the Mount Wilson Range. Even in the contracted upper part of the valley, however, sections are infrequent, and chiefly display drift material. At about four miles north of the 49th parallel, I examined some beds of thin sandstones and clays, dipping northward at an angle of 15°, which appeared to be Laramie. A short distance further down stream, fragments of lignite were found, which have almost certainly been derived from some bed *in situ* in the upper part of its course.

Region of flexed beds.

Seven and a half miles north of the 49th parallel, a belt of blackish Cretaceous shales holding *Inocerami*, crosses the river. The shales are well exposed in a small coulée on the west side, and a little further down the river, are found to be interbedded with and overlain by sandstones, which dip N. 20° E. < 10°. Half a mile further down the river, greenish-grey clays and sandstones with a dip of N. 20° E. < 15°, are found in a couple of exposures. One reddish zone of beds was seen, but it is scarcely probable that these represent the Willow Creek series. They are likely beds of the St. Mary River subdivision, and follow the shales above referred to conformably. Where the rocks are again seen, eleven miles north of the 49th parallel, they dip S. 30° W. < 65°, and mark the south-western edge of a wide belt of crumpled, disturbed and overturned beds, the continuation of which to the south-eastward is shown by parallel ridges stretching towards Lee's Creek and the St. Mary River, but which appears to subside to a great extent before the Waterton River is reached in the opposite direction. The beds consist, at the point above referred to, of greenish shales, with yellowish-grey sandstones and are doubtless of the St. Mary River subdivision.

Two miles further northward, a second band of dark, sandy Cretaceous shales crosses the river, with the same direction of dip, and an angle of 40°. For some miles northward the only rocks seen are interbedded shales and sandstones resembling, on the whole, those of the St. Mary River subdivision. One thin bed of lignitic shale was observed, and one of red clay. The dips are S. 20° to 40° W. at angles of 15° to 20°. Following these, at a point seventeen miles north of the 49th parallel, a bank presents the subjoined section:—

Section with their coals.

	FEET.	INCHES.
1. Yellowish sandstone	1	6
2. Dark shales	3	0
3. Lignitic shales	1	0
4. *Lignite*	0	6
5. Lignitic shales	1	0
6. Grey sandstone	6	0
7. Dark shales	0	6
8. Lignitic shales	1	5
9. *Lignite-Coal*	1	2
10. Shales	4	0
11. Sandstone	1	0
12. Shaly sandstone	5	0
13. Dark shales	10	0
14. *Coal* (of good quality)	1	0
15. Dark shales	60	0
	97	1

Disturbed character of strata.

The last-noted shales much resemble those of the Cretaceous (Pierre) and may possibly belong to that system. Sandstone intercalations are so frequent and considerable in the Cretaceous shales of this district, however, that without a very great amount of work, and the discovery of many additional fossil-bearing localities, the complete separation of the Cretaceous and Laramie cannot be carried out.

Half a mile further down stream, a sharp synclinal which, however, is evidently of a local character, occurs. The lowest bed seen is a coarse massive sandstone fifty feet thick. It is followed by fifty feet of blackish shales resembling those of the Pierre, but holding Laramie fossils, and containing an oyster-bed of five feet in thickness. This is followed by about seventy-five feet of grey sandstones with lignite and shales of the usual character. Next follows about 200 feet of alternating sandstones and shales, then about fifty feet of soft greenish-grey argillaceous sandstone, alternating with hard reddish-brown sandstone in beds a foot thick; and then a thick series of greyish and reddish sandstones and greenish-grey shales, which hold a second oyster-bed about seven feet thick, and a thin bed of conglomerate, the pebbles of which are chiefly composed of Rocky Mountain limestone. The latter is an unusual feature, but clearly indicates the proximity of the beds in this region to the Palæozoic shore-line.

Limestone conglomerate.

Less than a mile further down the river, about 200 feet of blackish Cretaceous shales appear, evidently lower in the series than the last, with a dip of S. 30° W. < 30°. Interstratified with the shales are a number of sandstones about six inches in thickness, and one massive bed twenty feet thick. Overlying the shales in this section about one hundred and seventy-five feet thick of greyish and brownish sandstone occurs, which at one point, where the attitude is nearly vertical, becomes almost a quartzite. The sandstone includes an oyster-bed about three feet thick, and a second layer contains other marine shells, in association with some lignitic shales.

Fossiliferous beds.

The oyster-beds, besides *Ostrea* hold *Corbicula occidentalis* and other shells and evidently correspond with those seen at Rye-grass flat on the Old Man, and mark the passage from the marine conditions of the Pierre to the fresh-water fauna of the Laramie.

For about three miles down the river from the point last described, exposures are not infrequent, and show rocks—chiefly sandstones—which contain *Ostrea glabra*, var. *Wyomingensis*, *Corbicula occidentalis*, *C. pyriformis*, *Melania Wyomingensis* (?), &c., and resemble those above referred to as overlying the Pierre. A distinct anticlinal axis here, however, crosses the river, with a north-west and south-east strike, and the attitude of the beds would seem to indicate that they underlie the dark Cretaceous shales. The angles of dip are, however, very inconstant, and unobserved flexures, or possibly faults, may account for this appearance.

The south-western edge of the wide area of Willow Creek beds which occupies the southern extension of the Porcupine Hill synclinal, is supposed to cross the river three miles below this point, but no exposures occur in the banks to the mouth of the Waterton—a distance of twenty miles. Where scarped banks are found, they show only drift deposits, consisting for the most part of silty material containing a few boulders. Belly Butte.

The Belly Butte, which stands on the east side of the river near its junction with the Waterton, is a conspicuous feature and land-mark, especially from the west. The most elevated point lies back from the river, but high, scarped hillsides border the river-valley itself and these are entirely composed of beds referable to the Willow Creek subdivision. The following section was measured here by Mr. R. G. McConnell, and gives a good idea of the rocks composing this series. The beds appear to have a light south-westward dip. Small reniform calcareous nodules abound throughout the series, and together with flakes of calcite, similar to these previously referred to in several places, strew the surfaces of its weathered banks. No fossils were observed.

Section of Willow Creek beds.

	FEET.
Drift	20
Reddish clay	1
Coarse, grey sand	4
Dull red sand	4
Grey sand	3
Hard, grey sandstone	2
Grey sand	12
Dull red clay	5
Bright red clay	2
Grey sand	1
Yellowish clay	5
Grey arenaceous clay	2
Dull red clay	3
Grey sands and sandstone	5
Yellowish, reddish and greyish clays	20
Grey sandstone	1
Greyish sands	6
Yellowish, reddish and greyish clays	12
Arenaceous clays (nodular beds)	4
Reddish and greyish clays	4
Nodular bed	1
Red and grey clay	10
Yellowish, reddish and greyish clays, containing calcarerous nodules	20
Grey sand	2
Yellowish clay	3
Grey sandstone	1
Grey clays	35
Reddish and greyish clays	6
Grey sands and sandstone	6
Reddish and greyish clays	15
	214

At two points between the Belly Butte and crossing-place of the trail to MacLeod, exposures were seen showing grey and yellowish, soft sandstones, and dark-greenish or greyish and brownish clays. At one of these several specimens of *Unio* were collected. About a mile and a half below the trail-crossing, on the east bank, another exposure occurs, in which a massive yellowish-weathering sandstone, thirty feet thick, overlies greenish-grey shales, with lignitic shales and thinly-bedded sandstones. A few fossils were obtained. From this point to the confluence of the Old Man River, no sections were found, though the whole thickness of the St. Mary River beds, and a considerable portion of the upper part of the Pierre shales, must cross this part of the valley.

Waterton River.

Rocks near Waterton Lake.

The country about the lower or northern of the Waterton Lakes, from which the river of the same name issues, consists of low rolling hills, largely composed of morainic material, and no exposures of the underlying rocks occur. It is, however, from analogy supposed to be underlain by Cretaceous or Laramie strata. The first section examined near the Waterton River, is found on the brook which joins it nearly two miles below the lake. The rocks are very dark blackish-grey shales or sandy shales, and are somewhat irregular in attitude, those furthest down the brook dipping S. 18 E. $<$ 35°, while less than a quarter of a mile distant, where seen furthest up the stream, they dip S. 25 W. $<$ 30°–40°. The thickness exposed is at least one hundred feet. Layers of calcareous or ferruginous concretions occur, with some large *Inocerami*, one of which where cut across in the bank measured two feet in diameter, with a maximum thickness of an inch and three quarters. A specimen collected here appears to be *I. Umbonatus*, and is covered with values of *Ostrea congesta.*

This band of Cretaceous shales does not appear to be continuous with any of those seen on the Upper Belly, and has not been traced further.

Sections on upper part of river.

Between this point and the mouth of the North Fork of the Waterton, a ridge nearly three miles long occurs on the opposite, or east side of the river. On the summit of the southern end of this ridge, there are considerable exposures of brownish and grey sandstone composed of hard and soft layers interbedded, of which in all about thirty feet in thickness is seen. The dip is N. 48° E. $<$ 5°, and a small but unmistakable fragment of *Inoceramus* was found in one of the beds. East of the northern end of the ridge, on the river, bluish-grey beds, chiefly sandstone, were observed, with a dip N. 45° E. $<$ 30°. About a mile up the North Fork from the river, where the valley becomes cañon-like, rocks resembling the last again occur, with a dip N. 10° E. $<$ 25°. Taken in conjunction with the sections on the Upper Belly, it is probable that the sandstones of the south end of the ridge belong to an upper part of the Cretaceous, and that those of the north end and on the North Fork represent the lower part of the St. Mary River series. The belt of dark Cretaceous shales which appears on the Upper Belly about seven miles north of the 49th parallel, must lie immediately below the above-mentioned Cretaceous sandstones, and the strike of the beds would carry them through to the exposures of similar shales seen on the Drywood Fork nine miles west of the Waterton. No sections, however, occur on the North Fork where they might be expected to cross. The shales probably mark an anticlinal axis, and it is uncertain whether the overlying sandstones have been removed to a sufficient depth to expose them throughout the entire distance above indicated.

Cretaceous shales.

On the next westward bend of the Waterton, below the mouth of the North Fork, beds with the character of those of the Willow Creek subdivision appear, with a dip of N. 53° E. $<$ 30°. These doubtless occupy the trough of a synclinal, to the north of the anticlinal last described. The return or south-westward dip of those beds was not observed, but the centre of the synclinal is probably marked by a copious spring in the north bank of a wide depression about a mile further on.

Small synclinal.

From the last-mentioned exposure, the rocks were not again seen in the river-valley for some distance, till, immediately opposite a prominent rocky ridge which is situated about a mile and a half east of the river, large yellowish sandstone blocks indicate the outcrop of a bed of the same material. The crest of the ridge, which is bare and scarped, consists of rather hard flaggy sandstones, sometimes considerably charged with ferrous carbonate, and characteristically brown in colour, with a dip of S. 18° W. and very regular. The ridge is about half a mile long, and appears to form a north-western outlier of one which, commencing on the east side of the Upper Belly, runs across almost to the St. Mary River. It forms the north-eastern edge of the synclinal above described, and is probably near the base of the Laramie or at the top of the Cretaceous, as in a coulée some distance to the southward, extensive exposures of the generally bluish-grey beds of the typical St. Mary River series occur overlying it, with a similar strike and dip. The beds in the continuation of the ridge east of the Upper Belly, however, show an opposite dip, and are probably locally overturned.

Little Rocky Ridge.

To the mouth of the Drywood Fork, and for a mile further, no additional opportunities occur for an examination of the rocks. Thence for nearly four miles the valley was not examined. The rocks next observed were those of the St. Mary River series, at first rather dis-

St. Mary River and Willow Creek beds.

turbed by several undulations, and with a general tendency to a south-westward dip, which was at one place observed at an angle of nearly 60°. The rocks then turn over an anticlinal axis, and half a mile further north dip at an angle of 50° in the opposite direction, or N. 20° E. At this point, the stream makes a rather remarkable flexure to the westward between high cliffs, and then changes its general direction to north-east, entering, in about a mile, the wide area of Willow Creek beds. These beds continue to characterize it to its mouth.

At the bend of the river above alluded to, the circumstances appearing favourable, an attempt to measure the thickness of the beds was made, with the following result:—

Measurement of part of Laramie.

	FEET.
1. *St. Mary River beds.*—Exposures near the axis of the anticlinal, not continuous, but with general north-easterly dips (estimated)	500
2. *St. Mary River beds*, measured by pacing and triangulation (actually seen)	640
3. *St. Mary River and Willow Creek beds.*—Interval between the highest beds of last, and first seen of Willow Creek beds, at assumed minimum dip, least thickness	1,680
4. *Willow Creek beds.*—Thickness actually seen (estimated)	450
Total thickness of part of Laramie series	3,270

The above section is in ascending order, and differs in this respect from others in the report. By deducting the observed thickness of Willow Creek beds, an approximate thickness of 2,800 feet is obtained for the St. Mary River beds. This may include a portion of the Willow Creek beds at the top, but the base of the St. Mary River subdivision was not attained.

Willow Creek beds.

The Willow Creek beds first appear with a north-eastward dip at an angle of 30°, which flattens out a short distance further down the river, and is then followed by light (under 5°) westward and south-westward dips, alternating with sections in which the beds appear to be perfectly horizontal, and these conditions continue to the confluence with the Upper Belly. The rocks are of the character usually met with in this subdivision when unaffected by flexure and concurrent induration. They consist of reddish, purplish and brownish, hard crumbling clays, in which small reniform calcareous nodules are frequently found, and soft, generally grey, sandstones, which are often rather massive and without evident traces of bedding. Crushed fresh-water shells were observed in one locality. The length, without counting its flexures, of that part of the Waterton River flowing across these rocks, is eighteen miles.

Section on the Old Man and Belly Rivers.

The rocks east of the disturbed foot-hill belt, on the Old Man and its tributaries, have been examined in a few places, but possess no special interest. They consist of the Willow Creek and Porcupine Hill sub-divisions of the Laramie and form part of the wide Porcupine Hill synclinal. East of Fort MacLeod the section on the Old Man and Belly is one of the most interesting and important in the district, and is fully described below.

Rocks near Fort MacLeod.

The first scarped bank below Fort MacLeod is composed, to the water's edge, of drift clays, but at the mouth of Willow Creek, and thence for a distance of about four and a half miles down stream, frequent exposures occur of the Willow Creek sub-division of the Laramie. The beds are to all appearance horizontal or very nearly so, and consist of pale purplish, reddish, and greenish-grey clays or sandy clays, with soft sandstones and occasional bands of ironstone. The bedding is uniform and regular, and the whole series has a soft character, which causes it in some places to weather into miniature bad-land forms. In some clayey layers, peculiar whitish-weathering irregularly reniform, and generally small sized concretions, abound. Nodules of similar appearance frequently occur in the beds of this horizon elsewhere, and are rather characteristic. It was supposed that they might possibly be phosphatic, but they proved on chemical examination, to be merely calcareous. Organic remains are usually rare in the Willow Creek beds, and in these exposures none were observed, with the exception of the scattered fragments of a single large Chelonian, converted into ironstone. Owing to their nearly horizontal position, no estimate of the total volume of these beds can be made here, but in one section a thickness of one hundred and forty feet is actually shown.

Nodules.

Junction Willow Creek and St. Mary River beds.

At the north bend of the Old Man River, a light westerly dip is observed, and the older beds of the St. Mary River sub-division appear. There is no reason for the separation of this from the above series, but difference in colour, and to some extent in the composition of the beds, and the line of separation is in consequence only an approximate one, justified by the facility which it affords of recognizing a definite horizon in the extremely thick Laramie formation of this district. The beds here immediately below those of the Willow Creek series, have general brownish colours, but soon become more varied in aspect, and show persistent greyish and greenish-grey tints. They consist of sandy and shaly clays and shales, interbedded with sandstones, which sometimes show ripple-markings, and of which the bedding is often remarkably regular. The sandstones are often quite hard, and project in

St. Mary River series.

cornice-like forms from the bank. Ironstones also occur in nodules and layers, one of the latter being observed to be as much as 2 feet 6 inches in thickness. These beds are less massive and alternate more rapidly than those of the overlying series. They characterize the river for about eight miles, following its course, or to Rye-grass flat, and are affected by light undulating dips which seldom exceed ten degrees in amount. At least 200 feet in thickness of beds of this character are exposed, but no precise estimate of their total thickness could be made. They were found to contain in several places fresh-water molluscs, among which the following species are represented:—*Goniobasis* like *G. Nebrascensis ? Cassiopella* n. sp., *Viviparus Leai*, *Sphærium* n. sp., *Hyalina* or *Valvata*, *Acroloxus*, *Slenites*. They also hold a few obscure impressions of plants.

Fossils.

Upturned beds at Rye-grass flat.

Opposite Rye-grass flat, after an interval of nearly a mile without exposures, a small low point shows brownish and yellowish earthy sandstone, with a southwestward dip at an angle of 45°, and holding remains of *Ostrea*. This is followed on the same side of the river by a scarped bank composed of similar rocks, with about the same dip. Facing this, at the lower end of the wide flat, the same rocks are again well shown, and dip westward at angles of 40 to 45 degrees. These rocks are evidently of brackish-water or estuarine character throughout, and hold abundantly *Corbula*, n. sp. like *C. pyriformis*, with a large form of *Corbicula occidentalis* and valves of *Ostrea*.

Brackish-water fauna.

Some layers are almost composed of these shells in densely crowded and occasionally hard masses, but the rocks are as a rule quite soft in character, and may be described as sandstones and sandy clays of yellowish and brownish colours, with occasional carbonaceous shales. The total thickness of the brackish-water beds here, was not ascertained, but it must be very great, as the portion which could actually be measured, on the left bank, is about 840 feet thick. Occasional coaly streaks, apparently produced by compressed masses of drift wood, are found in the sandstones. The fauna is that characteristic of the transition beds between the Fox Hill series and the generally fresh-water Laramie above, but the Fox Hill sandstones themselves were not here clearly recognized, though at a distance of about twenty-one miles only, on the St. Mary River, they form a massive layer about eighty feet in thickness. The beds of Rye-grass flat, with similar appearance and molluscous fauna, re-appear at Scabby Butte a few miles to the north (page 79 c).

Fox Hill sandstones.

There is no apparent reason for the sudden interruption at this spot of the generally low dips, or nearly horizontal attitude, which the rocks elsewhere maintain east of the disturbed foot-hill belt, within the limit covered by the present report. On the east side of the point below the flat, these rocks still continue, but are somewhat irregularly folded and broken and in places become almost flat. They are seen to be followed in descending order by coffee-coloured clay shales, very regularly stratified, in beds each of which is a few inches in thickness. These constitute the upper part of the Pierre shales, and have at this place a thickness of about fifty feet. The beds now again become quite regular, and are to the eye horizontal, or affected by very light low undulating dips. Just below the point at which the Old Man enters the Belly River, the Pierre becomes well characterized, with its distinctive blackish clay-shales, and these continue thence to the mouth of the St. Mary River, a distance of twelve miles. Numerous specimens of *Cyprina ovata* var., with fragments of *Baculites* and *Ammonites* were obtained from this part of the Pierre. From about two miles above the mouth of the Belly River and thence to the St. Mary, the drift deposits are remarkably thick, a circumstance doubtless due to the great depth to which the surface of the Pierre shales had been worn away, in consequence of their soft character.

Summit of Pierre shales.

The base of the Pierre shales is reached at the mouth of the St. Mary River, and the angle between the two rivers to the east, shows, in a scarped bank, the greyish and yellowish-grey shales and sandstones of the next sub-division of the Cretaceous in descending order, with the associated coal, which is considered as forming the base of the Pierre group. The section in this bank, as measured by Mr. McConnell, is as follows, the order being descending :—

Confluence of St. Mary River.

Base of Pierre shales.

	FEET.	INCHES.
1. Dark shales		
2. Ironstone	0	6
3. Brownish, shaly sandstone	2	0
4. Finely laminated dark shales	3	0
5. Oyster bed	2	6
6. *Coal*	0	10
7. Carbonaceous shales	0	9
8. Laminated dark shales	9	0
9. *Coal*	0	9
10. Carbonaceous shales	0	9
11. Laminated dark shales	10	0
12. Carbonaceous shales	1	1
13. *Coal* (3 ft. to 3 ft. 6 in.)	3	6
14. Carbonaceous shales	3	0
15. Laminated dark shales	2	0
16. Yellowish-weathering sandy shales	30	0
17. (Concealed)	5	0
18. Lignitic shales	3	0
19. Laminated dark shales	6	0
20. Brownish sandstone	3	0
21. Hard, greyish sandstone, topped with ironstone	1	2
22. Lignitic shales	5	0
23. (Concealed)	15	0
24. Soft, greyish and yellowish sandstone	25	0
	132	10

St. Mary River to Coal Banks.

From the mouth of the St. Mary, the Belly runs three miles eastward, and then turning sharply at right angles flows northward for about the same distance to the point known as "Coal Banks" or the "Colliery." This part of the river-valley is entirely excavated in the sub-Pierre rocks, a portion of the upper part of which has just been described, and which, from the fine sections which occur here and at other points further down the river, I have designated in a previous report as the Belly River series. The rocks of the Belly River series, though at first sight resembling those of parts of the Laramie, and particularly that portion of it which has been described as the St. Mary River sub-division, are found, on closer examination, to differ considerably in the more massive and irregular character of the beds, and their generally softer and more earthy condition. There is a marked absence of the regular and often flaggy sandstones which occur so frequently in the younger series, the sandstones of the Belly River sub-division being generally thicker, and almost always more irregularly hardened, while ironstone is much more abundant and occurs in larger masses. The scarped banks of the river in this part of its course, are cut by numerous deep ravines or coulées, and frequently show bad-land weathering. In colour the beds are generally greyish, or yellowish- or greenish-grey, but nearly always quite pale in tint. The ironstone nodules are often very large in the sections now described, and generally septarian, the internal fissures being filled with calcite, or lined with that mineral in rhombohedral crystals. The only organic traces here met with were fragments of bones, doubtless reptilian, but so much broken as to yield very little information. In many cases the bones appear to have been rounded and water-worn before their inclusion. The beds are to all appearance flat, and the thickness exposed in the banks is about 200 feet.

Rocks of Belly River series.

Rocks of Coal Banks.

At the point known as Coal Banks, the outcrop of the coal marking the base of the Pierre shales, which has run northward west of the river, again appears on the left bank. From this point to Big Island,—a distance of twelve miles in a direct line,—the river, though with numerous minor flexures, pursues a general north-north-eastward course, and nearly follows the outcrop of the coal-bearing horizon and base of the Pierre. The line of outcrop is, however, somewhat sinuous in outline. It crosses the river just north of Coal Banks, and making a sweep, the exact outline of which is uncertain owing to the thickness of the drift deposits which here form the whole surface of the country, recrosses the river to the left or west bank, about six miles above Big Island. Thence, owing to the slight divergence of the line of strike and main course of the river-valley, the coal-bearing horizon may be observed gradually rising in the bank, till it is eventually cut off by the base of

Outcrop of coal seams.

the drift deposits near Big Island, and is not again seen on the river. In consequence of the above described eastern sinuosity of the outcrop of the base of the Pierre, a portion of the Belly Valley extending nearly five miles northward from the coal crops near Coal Banks, is entirely occupied by the Pierre shales. The light undulating character of the dips renders it impossible to estimate the exact depth below the bottom of the valley at which the coal would be found, but it is probably not over 500 feet midway between the northern and southern exposures. Besides the obvious method of working the visible outcrops of the coal seam on this part of the Belly River, it might thus also be reached with facility by shafts in the concealed interval, and the exact definition of the attitude of the beds becomes a matter of considerable importance.

Depth of coal seam north of Coal Banks

The Belly Valley, in that part of its course between Coal Banks and Big Island, is about 300 feet in depth, with an average width of nearly a mile, while the drift deposits underlie the surface of the plain to a depth of about 100 feet. The river-valley, therefore, cuts into the Cretaceous rocks to a depth of about 200 feet, and, with its ramifying coulées, presents remarkably fine sections of these.

Section in Belly Valley.

Having thus briefly described the general mode of occurrence of the coal on this part of the Belly River, the following more detailed notes on the outcrops which occur will serve to show the actual character of the seam.*

Details of coal seam.

The coal-bearing horizon embraces several associated seams, but only one of these is here of sufficient thickness to be worked. This, which is that opened at Coal Banks in "Sheran's mine," and subsequently in the North-Western Coal Company's mine, on the opposite or right bank of the river, may, for the sake of clearness, be referred to as the "main seam."

At Sheran's mine, the coal has been extracted chiefly by quarrying along the natural outcrop, though during the summer of 1882 a small level was begun. The outcrop is situated in the front of a steep scarped bank facing the river, and the seam, which at the southern end of the bank is about thirty feet above the water, dips away below the water at the northern. The following section shows the mode of occurrence and association of the coal in the bank, but does not extend upward to the base of the drift deposits :—

Character and position of seam at Coal Banks.

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*In the preliminary report on this district, proximate analyses of this and other coals were given. These were for the most part made by myself, and are not here repeated, as Mr. Hoffmann has since carried out a more complete series of analyses, which are reported on by him in connection with the work of the laboratory.

		Feet.	Inches.	
	1. Finely laminated grey shale	8	0	
	2. *Coal* (shaly below)	1	6	
	3. Grey, thin-bedded shale	12	0	
	4. Ironstone	0	3	
	5. Grey shale	1	9	
	6. *Coal*	0	8	
	7. Grey shale and nodular sandstone, carbonaceous below	7	0	
Main seam.	8. *Coal*	1	4	Coal, 5′ 4″
	9. Shaly parting (often almost absent)	0	4	
	10. *Coal*	4	0	
	11. Carbonaceous shale	2	0	
	12. Grey shale	2	0	
	13. Ironstone	0	4	
	14. Greyish and brownish shale	3	0	
	15. Carbonaceous shale	3	0	
	16. Coaly shale	0	8	
	17. Grey shale	2	0	
	18. *Coal*	0	4	
	19. Carbonaceous shale (to water)	1	4	

The dip at this place is about N. 60° W. (N. 83° W. mag., variation 22° 46′ E.), at an angle of five to eight degrees.

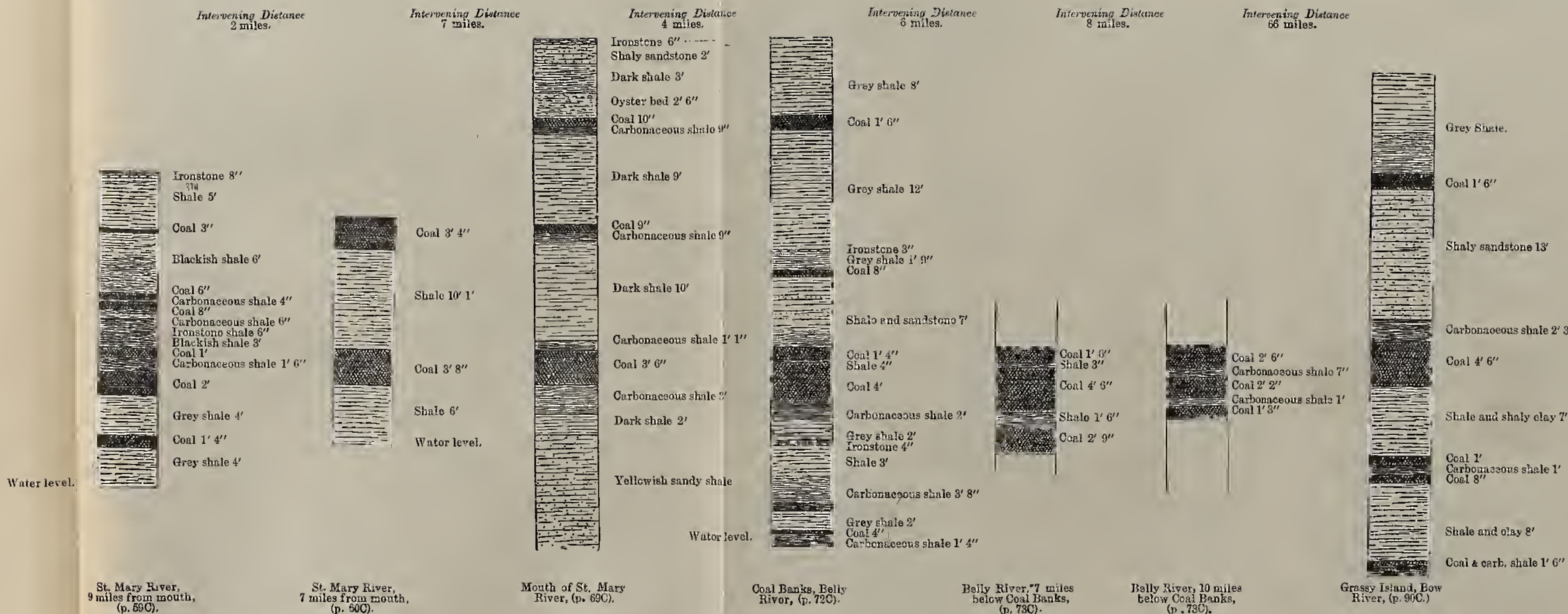
On the opposite side of the river, at its next bend, the coal seam is again well shown. It is slightly undulating, and dips gradually away below the water-level at the northern end of the bank. It is near this point that the N. W. C. Company's mine has since been opened. This consists of a level run in on the strike, and is already well situated for a large output. The part of the section designated above as the main seam is here as follows :—

	Feet.	Inches.
Coal	1	6
Shaly parting (1 to 3 inches)	0	2
Coal	3	3
Total coal	4	9

About four inches in thickness at the base of the seam is here laminated in texture, but appears nevertheless to be of good quality. The general dip is about N. 27° W., at an angle of less than five degrees.

Comparative sections of seam between Coal Banks and Big Island.

From this point, for a distance of five miles down the valley, as above stated, the dark shales overlying the coal are alone seen. When the main seam again appears, on the west bank of the river, it shows the following section :—



COMPARATIVE SECTIONS OF THE COAL-BEARING ZONE AT THE BASE OF THE PIERRE SHALES, REPRESENTING DIFFERENT POINTS ALONG ITS OUTCROP FOR A LENGTH OF 88 MILES.

	Feet.	Inches.
Coal	1	6
Shale	0	3
Coal	4	6
Shale	1	6
Coal	2	9
Total coal	8	9

The lowest division of the seam at this place, is apparently not represented in the sections previously described. The coal in it is somewhat laminated, but seems to be of good quality. The dip is here about N. 87°, W. at an angle of five degrees.

About three miles further north, extensive exposures of the coal are again found in the scarped bank or cliff facing the river, at a height of about one hundred feet above the water-level, the lower part of the bank being composed of the greyish and greenish-grey beds of the Belly River series. The dip is light and undulating, but on the whole westward, or away from the river. The main seam is here composed as follows :—

	Feet.	Inches.
Coal	2	6
Carbonaceous shale	0	7
Coal	2	2
Carbonaceous shale	1	0
Coal	1	3
Total coal	5	11

The coal here appears to be of good quality throughout.

North of this point, the coal-bearing horizon is not again found well exposed on the river, the outcrop running to the west of the valley. Opposite the lower end of Big Island, the drift deposits have a thickness of one hundred and sixty-five feet, and below them two coal-seams of a few inches each are seen. These occupy a horizon a little below the main seam, and have a gentle dip westward or away from the river.

Big Island. Coal outcrop leaves the valley.

At Big Island, the river resumes its eastward course, and the scarped banks continue for a distance of four and a half miles, in a direct line, to show fine exposures of the series underlying the Pierre. The banks generally show a thickness of about one hundred feet of these beds, which appear to be practically horizontal. At the first bend to the south beyond Big Island, a hard sandstone layer about fifty feet above the water, and in some layers charged with little greenish-grey rolled pellets of shaly clay, was observed to show also numerous casts of a large *Unio*, with rounded fragments of bone. The inclusion of rounded pieces of the nearly contemporaneous clays in the sandstones is else-

Exposures of Belly River series.

where found to be rather characteristic of the upper or pale part of the Belly River series, and taken in connection with the irregular bedding and scattered and broken character of the larger bones, would seem to show that the sheet of water in which the beds were laid down was a somewhat turbulent one. At this place a detached tooth was also collected, which Prof. Cope has been so kind as to examine, and pronounces to be that of a carnivorous Dinosaurian, which as it comes from below the Pierre shales may be a *Lælaps*, though it looks much like *Aublysodon* of the Laramie. At the next bend to the north, the scarped banks of the river are 275 feet in height. The upper one hundred feet consists of drift deposits, elsewhere described. Below there is a yellowish sandstone about twenty feet thick, irregularly hardened. This is followed to the water's edge by a series of bluish grey and greenish-grey clays and sandy beds, which occasionally become hard sandstones. Below this point a gap of about a mile and a half occurs in the section on the river, in which a few scarped banks show boulder-clay only, to the water's edge.

Dinosaurian remains.

Gap in section.

The next rocks seen occur at about six miles above the mouth of the Little Bow River, and are supposed to represent the summit of the lower or yellowish portion of the Belly River series. A rather massive yellowish sandstone here appears on the north bank. It forms a low cliff twenty to thirty feet high, at the edge of the water, and is overlain by greyish and yellowish sandy clays holding some selenite. Similar rocks, and apparently on almost exactly the same horizon, are seen in several places between this point and the Little Bow, the sections being, however, generally near the water's edge, and capped by a heavy covering of drift deposits. Coaly layers now begin to appear in the rocks in some places.

Massive sandstones.

From the mouth of the Little Bow to the confluence of the Belly and Bow, rocks similar in general character to those last mentioned, and probaly not far from the same horizon, continue to appear in numerous exposures. At seven and a half miles below the Little Bow, a well defined coal-seam, about eighteen inches in thickness, was first observed. It is here at a height of about twenty feet above the river. The sections not being absolutely continuous, and the character of the beds somewhat variable, it was impossible to arrive at certainty as to the equivalency of the beds, but it is probable that the coal-seam just mentioned is that which characterizes the banks nearly to the mouth of the river. It appears at a height above the river-level which varies in accordance with the light dips by which the beds are affected. The rocks associated with the coal are yellowish, brownish and grey, soft sandstones and shales, with occasional layers of ironstone. They show numerous alternations of colour, and produce a generally banded

Rocks from Little Bow eastward.

Coal-bearing horizon.

appearance in the banks when viewed from a distance. Near the coal-seam, and both above and below it, are several carbonaceous shales, which, however, are not very constant. The greatest thickness of beds of the character just described, seen below the coal-seam, was about one hundred feet. Some beds on this part of the river yield fresh- and brackish-water molluscs in great abundance, the following being among the most characteristic forms :—*Corbula subtrigonalis, Corbula perundata, Corbicula Nebrascensis? Velatella baptista? Cassiopella* n. sp. *Campeloma* like *C. producta;* also species of the genera *Goniobasis, Viviparus, Physa, Unio* and *Sphœrium,* as yet undetermined. From the close resemblance, lithologically and in fauna and accompaniments, of the beds in the vicinity of the coal in these sections on the Lower Belly, with those seen on the Milk River north of the East Butte (p. 44 c.), and again in 1874 nearer to the Butte.* I am inclined to suppose the almost absolute identity in horizon of the strata in these localities. Fossils.

At a mile and three-quarters below the point above referred to at which the coal was first recognized as a well-defined seam, it is found at a height of fifty feet above the river, still maintaining a thickness of about eighteen inches. Its greater height above the river is owing to a light northerly dip by which the measures are here affected, and in following the river in its next great bend to the south, at a further distance of about two miles, the coal is about one hundred feet up in the bank. Two miles further on, it is again seen on the opposite or right bank at a similar elevation.

From this point, the river turns abruptly north, making a great loop which may be called Drift-wood bend. Following this reach of the river to the north, in about a mile and three-quarters, the coal-seam comes down to the water's edge. It is here associated with yellowish sandstone, and has a thickness of three feet three inches. The seam here appears to be of good quality throughout, and this is the most favourable locality observed for working it. The coal contains 9·18 of hygroscopic water only, and is a very fair fuel. (See p. 26 M.) Drift-wood bend. Workable coal-seam.

The coal, for several miles to the north, undulates at low angles from the water's edge to about twenty feet above it. It varies in thickness from the maximum just given to about eighteen inches, and is again seen with the latter dimensions at the north-western point of Drift-wood bend. This coal was not again observed in anything like workable thickness on the Belly, and, indeed, from this point to near the mouth of the river, the sections of the Cretaceous rocks are comparitively inconsiderable, the banks being more rounded, and

*Geology and Resources of the 49th Parallel, p. 122.

the greater part of the depth of the valley being excavated in drift deposits, which here show interesting peculiarities elsewhere described.

Belly River series near confluence with Bow River.

A fine display of the beds of this series is, however, again found about the confluence of the Bow and Belly. At the first south bend on the Belly above the confluence, the following general section was examined :—

	Feet.	Inches.
1. Banded, sandy shales, some layers carbonaceous..	15	0
2. Nodular, yellowish sandstone.........(6 to 8 feet.)	8	0
3. Soft, laminated sandstone........................	4	0
4. Greyish, nodular sandstone........................	4	0
5. Sandy shales, in places slightly carbonaceous. Some ironstone nodules (Reptilian bones and teeth and scales of Ganoids about the middle)...	12	0
6. Nodular ironstone..............................	0	6
7. Grey, sandy clay................................	3	0
8. Carbonaceous shale, or impure lignite...........	0	10
9. Grey, sandy shale................................	8	0
10. Blackish carbonaceous layer, or very impure lignite.	1	6
11. Alternating greyish, yellowish and purplish sandy clays, with occasional soft, or nodularly-hardened sandstones to base of section. Bank presenting a general banded appearance, though beds poorly exposed in detail, about........................	90	0
	146	10

South Saskatchewan.

Confluence of Bow and Belly to Cherry Coulée.

From the confluence of the Bow and Belly to the mouth of Cherry Coulée,—eleven miles,—the South Saskatchewan flows in a narrow valley between high scarped banks. The rocks exposed are those illustrated in the last section, and continue flat or undulating at very low angles. Vegetation is almost absent from many of the slopes, and the sombre tints of the clays and sandstones give the valley a gloomy and forbidding appearance. Some of the beds yield fossils in abundance, embracing *Ostrea glabra*, *Anomia micronema*, *Corbula perundata*, *Velatella baptista ?* *Melania insculpta*, *Campeloma multiliniata*, *Viviparus*, *Physa Copei* var, *&c.**

The river from this point to the mouth of Swift Current Creek was examined, and a track-survey made of it by Mr. McConnell in the autumn of 1882. Only the upper part of this traverse is, however, included in the area of the present report.

Rocks north of Cherry Coulée.

For seventeen miles below Cherry Coulée, beds resembling those last described, and at about the same horizon, continue to appear in numerous sections. At the end of this reach, the beds include very little

* Mr. T. C. Weston has since made extensive collections here, which have not yet been examined.

hard sandstone, and the brownish, greyish and yellowish beds alternate with carbonaceous clays, which become impure lignite-coal in some instances. At this place the following section was noted :—

	FEET.	INCHES.
Greyish sands		
Lignite-coal, shaly	3	0
Black shales	5	0
Lignite-coal, shaly	5	0
Yellowish argillaceous sands		

Two sets of beds.

Below this point, for some miles, the river becomes cañon-like. The brownish earthy-looking beds which above have been exposed in the river banks for many miles, now occupy only one hundred to one hundred and twenty-five feet of the lower part of the scarps, the upper half being composed of light coloured greyish beds, between which and the former the carbonaceous zone intervenes. This arrangement is precisely that described on the Bow (p. 91 C.), and the horizon is undoubtedly the same.

Lignite-coals.

At a point twenty-two miles below Cherry Coulée, two seams of lignite-coal are exposed, the largest being about four feet in thickness. Three miles further down the following section was measured :—

	FEET.	INCHES.
Yellowish sandstone		
Shales	10	0
Lignite-coal (fair quality)	4	6
Shales	1	3
Sandstone	1	0
Lignite-coal (fair quality)	4	0
Shales	6	0
	26	9

The higher coal-seam is one hundred and twenty five feet above the water-level. Still higher in the section two more coal-seams occur, one of which is over four feet thick.

Extension of coal seams to Medicine Hat.

Beyond this locality, the South Saskatchewan passes out of the limit of the map accompanying this report. It may be added, however, that the coal-bearing zone above described continues in the river banks, and is that which yields the lignite-coal of the vicinity of Medicine Hat, which, since the date of the examination here referred to, have been opened and is already somewhat extensively worked. A slope has been constructed from the prairie level to the horizon of the seam, and levels run in on the coal. The screens and houses of the mine are situated at the head of the slope, and a branch line has been constructed to connect this point with the Canadian Pacific Railway. The seam worked here varies from four feet six inches to five feet four inches in thickness. It contains a clay parting, which in some places is as much as three inches thick. Preliminary openings have been made elsewhere along this part of the river, some of which show a seam somewhat thicker than the above. The quantity of fuel here available is practically inexhaustible, and the quality, though inferior to that of Coal Banks, is such as to fit it for all ordinary purposes. (See p. 12 M.)

Lower Part of Willow Creek, and the Trail from MacLeod to Calgary.

Willow Creek beds.

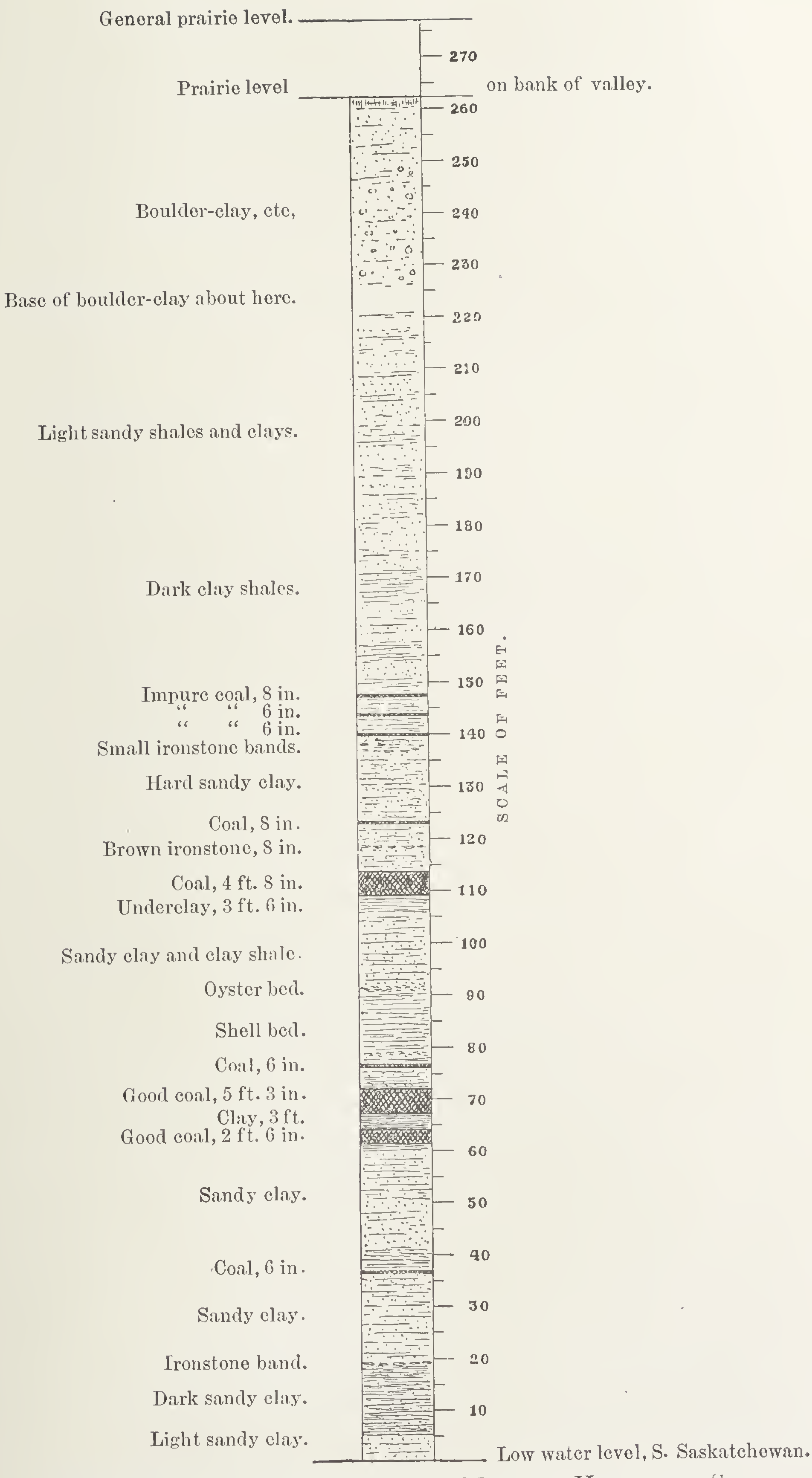
For about thirty-eight miles north-west of Fort MacLeod, the trail to Calgary follows the eastern base of the Porcupine Hills nearly parallel to the course of Willow Creek, the tributaries of which stream flow in at right angles from the hills to the west. Clays and sandstones of the Willow Creek sub-division, with their usual characters, appear near the mouth of the creek, immediately north of Fort MacLeod. Twelve miles north-west of MacLeod, at the "Cut Bank," scarps about twenty feet high show sandy clays, grey, lead-coloured and blackish, in beds which blend together. A few irregular layers of ferruginous sandstone, a foot to two feet thick, are also included, and fragments of crushed shells were found in one place. The characteristic reddish colour of the series is not here shown, and it is probably not far beyond this point that this dies out entirely, leaving the beds which may be so easily distinguished in the southern part of the region, indistinguishable from those of the remainder of the Laramie, on the Bow.

Sixteen miles further on, at the "Leavings," low exposures of greyish, sandy shales and sandstones occur, but offer nothing worthy of note. Still further north-westward some sandstone beds appear in the scarped banks. All these rocks are horizontal or nearly so.

It will be observed that the sections generally on Willow Creek are inconsiderable, and not so instructive as to the composition of the series of the same name, as those of Belly Butte and elsewhere. The beds so-called were, however, first recognized at the mouth of Willow Creek and on the neighbouring part of the Old Man River, and Willow Creek for a considerable part of its course follows their strike.

Northern part of MacLeod-Calgary trail.

The northern part of the trail from MacLeod to Calgary, does not fall strictly into the order adopted in this report, for notice here. No sections of any importance, however, occur in its vicinity, or in the banks of the several rivers in the neighbourhood of the crossing places. A few localities show sandstones, which are invariably horizontal or so nearly so that no inclination can be detected in small exposures. These belong to the Laramie. Shaly beds also, no doubt, occur, but are concealed by the sod.



Section including Lignite-coals near Medicine Hat on the South Saskatchewan River (p. 77 c), by J. P. Lawson, Esq.

Scabby Butte.

The prairie region between Willow Creek and the Little Bow River presents, in so far as known, but a single point at which the underlying rocks are well exposed. This is almost exactly on the 113th meridian, five and a half miles south of the 50th parallel, and is known as Scabby Butte. The edge of a low plateau has here been worn away, and shows, according to Mr. McConnell, the following section:—

Section at Scabby Butte.

	FEET.	INCHES.
1. Light yellowish sands	7	0
2. Brownish, lignitic shales	3	0
3. Greyish and yellowish sands	5	0
4. Brownish shales	8	0
5. Light greyish sands, lined in places with yellowish, and holding some thin ironstone layers.	20	0
6. *Lignite-coal*	1	3
7. Lignitic shales	2	0
8. Greyish sands	6	0
	52	3

Vertebrate remains.

The chief importance of this section lies in the fact that many bones, apparently of dinosaurian reptiles, are found strewing its weathered surface. Fossil shells also occur, and indicate the horizon to be the same with that shown at Rye-grass flat, on the Old Man, (already several times referred to), and to represent the transition beds between the Pierre or Fox Hill and Laramie. A *Corbula*, specifically the same with that of Rye-grass flat, is the most abundant mollusc. Mr. McConnell observed no scarped banks or outcrops in the parts of the Black Spring Ridge which he visited; though its occurrence is doubtless in connection with the superposition of the harder beds of the Laramie on the Pierre.

Mr. McConnell furnishes the following notes on Little Bow River, which he examined:—

Rocks on Little Bow River.

"Little Bow River heads in some springs near the crossing of Highwood River by the MacLeod and Calgary trail, and running in a south-easterly direction, empties into the Belly about twenty miles below Coal Banks. The valley of the Little Bow above the Blackfoot Crossing trail is wide and shallow, and exposures of rock are very infrequent. Below the trail, good sections occur opposite the Black Spring Ridge. Little Bow River cuts through the Pierrre shales and partly through the Belly River and St. Mary River series. Exposures of the Pierre shales commence about three miles below the mouth of Snake Valley, and continue down the river for several miles.

The rocks are of the usual character, consisting of blackish shales below and brownish and chocolate-coloured sandy shales above, and include occasional interstratified beds of greyish sands. Near the base of the formation a small coal-seam about six inches thick was seen, the main Coal Banks seam being concealed. Good sections of the rocks below the Pierre occur about ten miles above the confluence of the Little Bow and the Belly Rivers, consisting mainly of greyish and yellowish sands, sandy clays and sandstone, interstratified with thin beds of ironstone. Near the mouth of the Little Bow the rocks become concealed."

Horizon of Coal Banks seam.

"The rocks of the St. Mary River series are well exposed at all the larger bends of the river between the Blackfoot Crossing trail and the mouth of Snake Valley."

"Near the mouth of Snake Valley a very conspicuous band of argillaceous sands, bleached almost pure white, appears in this formation. These sands alternate with and pass into, in a short distance along their strike, beds stained different shades of yellow and brown. In addition to the sands the section contains thick beds of carbonaceous shales, and beds of greyish, bluish and yellowish sandstones. A small coal-seam, about fifteen inches thick, occurs a short distance above the mouth of Snake Valley. This seam is probably a continuation of that at the Blackfoot Crossing. Above the Blackfoot Crossing trail only a few small exposures were seen. These consist principally of greyish and yellowish sandstones and dark clays. A few very small exposures of Laramie beds occur in the Snake Valley."

Continuation of Blackfoot Crossing seam.

Section on Bow River Eastward from the Edge of the Disturbed Belt.

Beds near Coal Creek.

The belt of flexed and disturbed Cretaceous and Laramie rocks on the Bow River extends from the mountains eastward to Coal Creek, a distance of twenty-five miles. On the west side of Coal Creek several abrupt anticlinals and synclinals of Laramie rocks are found within the length of a mile, and the course of the creek for some distance at least from its mouth coincides with the last of these, and the point at which the beds assume a general eastward inclination. The horizon of the beds is supposed to be near the base of the Laramie. In the scarped bank on the east side of the creek, near its mouth, associated with sandstones and sandy shales, a seam of good coal, rather variable in character, occurs. It is here, from eight inches to a foot in thickness, and may be traced round the angle of the bank to that bordering the Bow River, and in the opposite direction, for about quarter of a mile from the mouth of the creek, when the dip carries it to the water level of

Coal seam.

the stream. It might doubtless be uncovered without much labour on the south side of the Bow, in the strike of the beds. Since my visit it has been opened at another locality, a short distance farther up the creek to the westward, and here exhibits, according to Mr. McConnell, a thickness of about three feet of good coal, with several feet of coaly shales. It is much less at a short distance on the strike in each direction, but though evidently very variable, may, in some parts of its extent, constitute a valuable source of fuel. The beds at the mouth of the creek dip N. 47°, E. < 30°.

Rocks near mouth of Jumping Pound River.

By reference to Mr. Hoffmann's analyses (p. 32 M.) it will be seen that this is a fuel of very fair quality, containing 4·93 per cent. of hygroscopic water, but a large proportion of ash. The horizon of the seam probably crosses Jumping Pound River, three or four miles south of the Bow, and this locality is therefore one worth examination.* This coal may occupy the same position in the Laramie as that of the Indian Farm near Pincher Creek, and that elsewhere found near the base of this formation. For about three and a half miles down the Bow, or to the mouth of the Jumping Pound River, similar sandstones, shales and sandy clays appear in a number of places, the sandstones being somewhat more massive and roughly bedded than those before seen, and the whole overlying the coal bed with light eastward dips, averaging a little more than ten degrees. The minimum thickness of beds thus displayed on this part of this river may be stated as about 3,300 feet.

Thickness.

East of the Jumping Pound, within a distance of less than three miles, the river makes a wide bend to the south, and an abrupt northward flexure. The prevalent dips are here westward, implying the existence of a synclinal about the mouth of the Jumping Pound, but the angles observed were very low (5° to 10°), and are probably not constant, and do not result in bringing more than a small part of the rock series above described again to the surface.

Comparative thickness of Laramie.

It will be observed that the thickness above given considerably exceeds that determined for the St. Mary River sub-division (p. 66 c), in the southern part of the district, and might be expected to bring the Willow Creek beds to view. As elsewhere explained, however, the subdivision of the Laramie applicable in the southern part of the district cannot be carried out in the Bow River region. It is probable, however, that the rocks exposed in a bank about two miles below the Jumping Pound, may represent those of Willow Creek, though wanting the characteristic reddish tint. These consist of sandstones and shales, with some ironstone bands, and are much softer in

* Since writing the above, I have been informed that the seam has been found here, but apparently in inconsiderable thickness.

general character than those above described. They have general brownish and olive colours, and hold, *Goniobasis tenuicarinata*, *Limnæa tenuicostata*, *Unio Aldrichi* or *senectus*, and *Viviparus*. These beds, though not identified, must recur above the Jumping Pound, and might probably reduce the thickness of the representatives of the underlying St. Mary River series to nearly that before given.

Porcupine Hill series west of Calgary.

From the point to which the description has been carried above, to Calgary—twenty miles—the rocks are seen in the scarped banks of the river in a number of places, and are generally horizontal, or very nearly so. They consist, for the most part, of sandstones, which are often quite massive, and generally differ from those of the lower part of the formation in colour, being yellowish-grey instead of greenish-grey. One cliff on the south side of the river exhibits about one hundred feet in thickness of soft sandstone, and the edge of the plateau, in the immediate vicinity of the river, rises from 250 to about 500 feet above it, indicating a considerable additional thickness of Laramie rocks. Olive-green and blackish-grey shaly beds, often almost clays, also, however, occur in some places, and occasionally hold crushed shells resembling those last referred to. A small cliff, composed of sandstone of the character above noted, appears on the east side of the Elbow River at Calgary. The rocks on this part of the Bow, with little doubt, represent those of the Porcupine Hills subdivision of the Laramie, and closely resemble them in lithological character.

Boulder-clay.

At several places between the Jumping Pound and Calgary, sections of boulder-clay occur. In one bank, six miles above Calgary on the north side of the river, blocks of sandstone from the Cretaceous or Laramie, in some cases eight feet in diameter, were observed to be strongly glaciated. These are associated with boulders from the Rocky Mountains, and the whole imbedded in a rudely stratified sandy clay. No Laurentian fragments occur, nor were any observed in the gravels of the river west of Calgary, though a few were found at that place.

Calgary to mouth of Highwood.

From Calgary to the mouth of the Highwood River,—a distance of twenty-four miles by the course of the stream,—the rocks maintain so great a general similarity in character that it is unnecessary to note in any detail the composition of the numerous exposures examined. The beds are, as a rule, nearly horizontal, but the dips, so far as observed, are westerly or north-westerly at very low angles, and this, with the eastward slope of the river bed, appears to render the section in the main a descending one. The rocks are still for the most part sandstones of general yellowish and grey tints, and seldom much indurated. Shaly beds of olive, brownish and grey colours also, however, occur, and appear to be most abundant on that part of the river which runs southward between Calgary and Fish Creek. They were also observed in a bank about three miles above the mouth of the Highwood. The beds on this southward-flowing reach of the river, it is presumed, represent those above referred to as probably the equivalents of the Willow Creek series. Traces of carbonaceous matter and obscure fragments of plants also occur, but none of a determinable character were found. Boulder-clay is frequently exposed and sometimes in considerable thickness. Laurentian fragments were again found on the river at about four miles above the Highwood, but none are of large size. The boulder-clay was here also observed, for the first time in the section on this river, to rest on a shingly deposit of quartzite gravel, like that elsewhere described as intervening between it and the underlying rocks.

Thin coal seams.

In a bank about one-fourth of a mile up the Highwood, on the east side, associated with sandstones, sandy shales and shales like those above described, at a height of thirty feet above the water, a seam of lignite-coal three inches in thickness occurs. It appears also in the north bank of the Bow immediately below Highwood River, about fifty feet up in the bank, and at about a mile further down the river, is again seen in a scarped bank one hundred feet high, at a height of seventy feet above the water. It is, wherever observed, quite too thin to be of economic importance. The beds at the last mentioned locality have a light dip westward, at an angle of about 5°, and a few feet below the horizon of the seam there is evidence of contemporaneous local erosion, hollows having been produced which cut across the edges of some of the beds. In these a coaly layer occurs which has, locally, a thickness greater than that of the overlying seam. This seam is possibly represented by that which occurs at the junction of Sheep Creek with the Highwood. The seam is there about nine inches thick, and the quality poor. The beds appear to be horizontal.

Pine Canon.

For six miles below the Highwood, the Bow is hemmed in closely by banks one hundred and fifty feet high, which are scarped on alternating sides of the river, and present an almost continuous exposure of beds which show locally light undulating dips, but probably on the whole maintain a very gentle inclination westward. The rocks are sandstones of general dull greenish-grey colours, sometimes rather massive, but more often well bedded, and alternating with greenish-grey or brownish, and occasionally somewhat rusty, shaly clays; the whole, from a distance, when prominent sandstones are absent, often presenting a brown colour and earthy appearance. Some very obscure vegetable impressions were seen, and in an exposure immediately below the cañon, specimens of *Unio* and *Viviparus* were obtained. These

Equivalency of beds.

beds may be supposed, in a general way, to represent those which occur immediately to the east of the Willow Creek series on the Old Man River, and those which form Gooseberry Cañon on the St. Mary.

From this point, for about twenty-six miles, the rocks shown in occasional sections in the banks possess no special interest. They are chiefly sandstones which are often somewhat massive, but are occasionally associated with shales. They are horizontal, or very nearly so, and the section is not sufficiently continuous or provided with sufficiently well marked zones to enable one to determine whether the beds have any general direction of inclination. Boulder-clay, generally brownish and earthy, is seen in a number of places, and invariably caps the sections in greater or less thickness.

Sections near Arrow-wood.

At the point now reached, however, near the south-western angle of a wide southerly flexure of the river, a low bank shows about twenty feet of sandstone and shaly clays, among which a coal-seam one inch in thickness is included. Obscure impressions of plants also occur, and in a grey soft sandstone at the water's edge *Unio Aldrichi* or *senectus*, *Goniobasis tenuicarinata*, *Viviparus*, *Cassopella* and *Sphærium*, with fragments of reptilian bones. Above the whole lies fifteen to twenty feet of the shingly drift, and over this ten feet or more of hard boulder-clay.

Mingling of brackish and fresh-water forms.

About two miles further down the river, on the east side of the mouth of the eastern Arrow-wood Creek, a very interesting section occurs, in which beds of marine or brackish origin are found immediately underlying, and passing up without the least unconformity or break of any kind into those which are shown by their fossils to be fresh-water. The section in the bank is as follows, in descending order. The beds appear horizontal, but their relation to those last described above, shows that there must be a general light westward dip. The measurements given are approximate only:—

	FEET.
1. Soil and subsoil	6
2. Gravel	6
3. Soft sandstones with two zones of large ironstone concretions	16
4. Harder sandstones	15
5. Small hard ironstone balls, irregularly scattered	..
6. Soft laminated sandstones	8
7. Carbonaceous clay, with thin streak of coal	4
8. Soft sandstones, shaly beds	15
9. Thin irregular ironstone layer	..
10. Somewhat harder sandstones, with *Unio*, *Viviparus*, etc.	20
11. Ironstone and ferruginous sandstone filled with *Unio Danæ*, *Viviparus*, etc	3
12. Soft sandstone, with some sandy shales	10
13. Somewhat harder sandstone, charged with *Corbicula occidentalis*, *Unio Danæ* and *Ostrea*	30

The general colour of the rocks here shown is yellowish-grey, but when unaffected by the weather they have no yellow tint.

Two miles below Arrow-wood Creek, on the south side of the river, rocks similar in appearance to the last, and horizontal or nearly so, appear. In a layer of ironstone a foot thick, at the water's edge, abundance of marine or brackish-water and fresh-water shells were found, including *Corbula*, n. sp., like *C. pyriformis*, *Corbicula* like *C. Durkei*, *Physa Copei* var., *Unio*, *Viviparus* and *Goniobasis*. For about five miles further similar beds, still horizontal, continue and are seen in a number of places, till at the point at which the river again turns northward (four miles south-east of Blackfoot Crossing) a section, still nearly in the same horizon, shows seams of lignite-coal. A narrow tongue of land from the north here forms a peninsula, and the best exposure is in the lower end of the scarped bank on its west side. The beds here present the following arrangement, in descending order:— Sections near Blackfoot Crossing.

		Feet.	Inches.
1.	Soft, greyish sandstones	10	0
2.	*Lignite-coal* (8 in. to 1 ft.)	1	0
3.	Dark grey clay	0	8
4.	Pale grey, sandy clay, with roots	1	0
5.	Dark grey, somewhat carbonaceous clay	2	6
6.	Grey banded sandstone, ironstone balls	3	0
7.	*Lignite-coal*	0	3
8.	Irregular layer of sandstone (0 to 4 inches)	0	4
9.	Carbonaceous sandstone, with thin coaly layers	1	9
10.	Grey soft sandstone, with some shaly layers, and ironstone balls (partly concealed)	10	0
11.	*Lignite-coal* (irregular) at water level	0	6
		31	0

The ironstones hold in some places a great profusion of well preserved and large shells of *Viviparus Leai ?* with *Unio Danæ*. The lignite-coals are not here sufficiently thick to possess economic value, but are of interest, as they with little doubt represent those which immediately below the Blackfoot Crossing assume considerable dimensions.

From this point, the river turns abruptly northward, and then making an eastward bend, in six miles reaches the Blackfoot Crossing. No sections of the underlying rocks were observed in this part of the river, but in two places the banks showed shingly quartzite drift overlain by boulder-clay, and the whole covered by a thick coating of sand similar to that which forms a series of sand hills at a short distance from the valley. Drift deposits.

Immediately below the Blackfoot Crossing the banks show small sections of sandstones and shales, with traces of lignite-coal, but Sections below Blackfoot Crossing.

disturbed by slides. Four and a half miles below the Crossing, however, on the north side of the river, an excellent section which presents the lignite-coal seams of this locality in their best known development, occurs. The coal is here favourably situated for working, the lowest seam being about thirty feet above the water's edge and nearly horizontal. The underlying rock is a somewhat hard whitish sandstone. The section is as follows:—

Lignite-coal.

	FEET.	INCHES.
Coal	1	8
Black carbonaceous shale	1	4
Coal	1	8
Shale	0	3
Coal	0	9
Shale	0	3
Coal	2	0
Shale	1	0
Coal	1	10
Total	11	10
Total coal	8	11

Nearly opposite, on the south side of the river, the coal with a similar development, appears at intervals in the scarped bank for at least a quarter of a mile. Though practically horizontal in the main, it is affected by a number of light undulations. Below this scarped bank a wide, flat-bottomed valley, which has evidently been at a former period occupied by the river, opens, and after making a circuit to the south rejoins the river some miles lower down. In the eastern arm of the old valley a small brook flows, which at about a mile back from the river enters the old river-course by a narrow, steep-sided coulée. In the latter, numerous exposures of the same coal-bearing horizon are found. In the south side of the wide old valley, for some distance east of the point at which the brook joins it, the position of the coal is also marked by shales reddened by its combustion along the outcrop.

Outcrops of coal south of river.

The coal is last seen to the south, two miles up the brook valley from the river, at a point six and a half miles south-east of the Blackfoot Crossing. At this place a small quantity of coal was extracted for use at the Blackfoot Agency. The deposit here consists of two seams, separated by about a foot of carbonaceous shale, the upper averaging 1 foot 8 inches in thickness, the lower 3 feet. The bed may be traced here for about 500 feet in the natural exposures, and is affected by variable dips which do not exceed 5° in amount. The seams pass below the level of the bottom of the coulée at the upper end of the exposures. Their thickness is nearly uniform, and they would afford, say, 4 feet 6 inches of clear coal, the whole of which might be worked at once. The immediate banks of the coulée at this place are about eighty feet high, the upper two-thirds being composed of drift deposits which rest on a worn undulating surface of the rocks below. The general surface of the prairie is over one hundred feet above the level of the coal.

In following the coulée northward from the spot just described, the coal is frequently seen in the right, or east bank, for about a mile, or to the wide old valley previously mentioned. Owing to the slope of the bottom of the coulée towards the river, the beds are cut into more deeply near its mouth, and at the last exposure the coal is about thirty feet up in the bank. The upper seam is here not well exposed, but the lower exhibits a few inches over four feet of good coal. In an exposure intermediate between this and the first, the upper seam is 8 inches thick, the shales 1 foot, and the lower seams 4 feet 4 inches. The seams are underlain by at least twenty feet of soft whitish sandstone.

Proved coal-bearing area.

The natural exposures thus serve to prove the continuity, in good workable thickness, of this coal deposit over a tract of country at least several square miles in extent. Its moderate depth below the surface of the plains, and nearly horizontal attitude, would enable it to be proved by boring, at a small expense over any desired area, and before undertaking any mining operations away from the visable outcrops, it would be advisable to test it in this way, owing to the knowledge of its variability already obtained.

Borings made by C. P. Ry. Co.

On Crowfoot Creek, about six miles north-east of the Blackfoot Crossing, Mr. McConnell observed a seam of coal about eighteen inches in thickness, which he describes in a succeeding page. This at the time was supposed to represent one of the closely associated groups above described on the Bow River. Since the railway has traversed this part of the country, however, several borings have been carried out in the vicinity of the line in townships 21 and 22, ranges xx. and xxi., by Mr. Ducker, working under the direction of the Canadian Pacific Railway Company. Mr. J. H. McTavish has kindly furnished me with details of these borings, which show that the seam observed in the natural exposures on Crowfoot Creek is more than sixty feet above the horizon of the main seam shown on the river, and that the main seam retains much the same thickness as on the river exposures, but is at a lower level, in consequence of the persistence of the light north-westerly dip which here affects the beds. It will therefore be very easy to open this seam by a shaft sunk to a moderate depth beside the railway line.

Of Mr. Hoffmann's analyses (pp. 19–21 M.) Nos. 12, 13 and 14 refer to specimens collected from different outcrops of the seam above described. No. 15 is from the seam on Crowfoot Creek, mentioned in the preceding paragraph. This fuel contains considerably less hygroscopic water than that of the Medicine Hat mine, though less like a true coal in physical character.

Great depth of boulder-clay. Immediately below the mouth of the small stream on which the above described exposures of the coal are found, a bank showing an imperfect section, which may have been disturbed by a slide, occurs. Below this point, for a length of about seven miles in a straight direction, the river's course continues extremely tortuous, and though high scarped banks characterize almost every bend, they are composed exclusively of boulder-clay, which forms the whole height of the bank, often one hundred feet. If the underlying shingly deposit occurs, it is below the present river-level, and we evidently have here a wide pre-glacial hollow, which has been filled by the drift deposits.

The underlying rocks again appear four miles below the mouth of Crowfoot Creek, on the south bank, and are still referable to the Laramie series. Small broken hills, remnants of the elevated edge of the plateau, fringe the river. They are composed of sands and sandy clay, in places reddened by the combustion of lignite-coal seams. Horse-shoe bend. From this point, the river flows three miles due east, and then turning abruptly back on its former course, produces a sharp flexure, which, for want of a better name, I have called Horse-shoe bend. The bank at the outer side of this bend is again composed of boulder-clay, but to the south of it, fine exposures occur on the right bank of the river of the rocks already imperfectly seen in the hills above alluded to. The river-bank here assumes the broken hummocky character with bare hills and deep intervening ravines which is generally designated badlands in the west. The banks rise irregularly from the river to a height of about two hundred feet, and are composed at the base of brownish and fawn-coloured sandy clays, and grey or yellowish-grey sands, or very soft sandstones, with thin ironstone layers. Towards the top, whitish and pale-grey soft sandstones predominate, and there again show marks of the combustion of lignite-coal.

Coal seams near Horse-shoe bend. A short distance further on, three miles nearly due south of Horse-shoe Bend, a high scarped bank affording a fine section occurs on the same side of the river. The beds in this region must have a pronounced general westerly dip, and those above described be near the base of the Laramie, for, capping the cliff at this place, at a height of one hundred and thirty-five feet above the river, is a bed of lignite-coal, and below it to the water's edge are the Pierre shales. This coal seam must underlie the whole of the rocks seen in the bad-land exposures, and is not the same with that the combustion of which has produced the reddening above alluded to. The latter must occupy a place in the series about two hundred feet higher, and was not any where found well exposed, so that its thickness or character might be determined. The discontinuity of the exposures and variability of the dip, further renders it uncertain whether the upper seam is the same with that occuring about the Blackfoot Crossing, or yet another intermediate between it and the base of the Laramie. The question can probably only be solved by a boring carried at least two hundred feet below the Blackfoot Crossing seam in the region where it is well defined.

Coal at summit of Pierre shales.

The coal-seams capping the cliff above described, may either be regarded as forming the base of the Laramie, or summit of the Pierre. The Fox Hill sandstones, elsewhere well defined, are here either wanting or inseparably blended with the Laramie. The coal seam appears again on the opposite bank, a short distance down the river, making a total length of outcrop here seen of half a mile or more. It is four feet four inches in thickness, compact and hard when not long weathered, and differs considerably in physical character from that of the Blackfoot Crossing, being divided by vertical cleat planes in such a way as to break into cuboidal blocks, which resist the action of the weather better than the irregular fragments derived from the conchoidal-fracturing or shaly fuels. This seam was, however, not recognized either on the Red Deer River to the north, or in the southern part of the district, and is therefore local in character.

This seam is represented by No. 16 of Mr. Hoffmann's analyses (p. 22 M.) It contains 11·13 of hygroscopic water and 9·19 of ash.

The beds here underlying the coal to the water's edge do not present the ordinary blackish color of the Pierre shales, but represent the upper portion previously described on the Old Man River (p. 69 C). They are rather soft sandy clays or shales of general rich brown tints and banded aspect, with occasional grey, red-weathering ferruginous and calcareous layers, which are usually hard.

Wide belt of Pierre shales.

From this point, the Pierre shales characterize the banks for a distance of about thirty miles by the course of the river, or twenty miles at right angles to the strike. The general westward dip no doubt continues, but it is so light that it can scarcely be observed. For some miles below the cliff-section above described, brownish colours are characteristic of the rocks, and the thickness of this part of the Pierre must here be considerably over one hundred feet. The drift deposits are almost absent in the section above described, for several miles, and further down seldom exceed fifty feet in thickness. As lower beds are gradually reached, the ordinary slaty-grey or blackish colour of the Pierre appears. Fossils are moderately abundant in a few places, and layers of ironstone concretions also occur. At about twelve miles down the river a zone of very soft sandstone of a pale grey tint, and including some ironstone layers, appears at the water's edge. A few fragments of marine fossils were found in this, but very badly preserved. This intercalation in the Pierre must have a thickness of about fifty feet, and though the exposures are not extensive in this part of the valley, it may be seen gradually rising in the bank for several miles, till it eventually passes above the top of the section. The beds underlying it have the usual character and colour of the Pierre shales, and in a cliff a mile above Grassy Island have a thickness of at least one hundred feet. The sandy intercalation in the Pierre is again found even more largely developed on the Red Deer River to the north. The portion of the river-valley occupied by the Pierre rocks is sombre and forbidding in appearance. The banks, though not so high and steep as in some other places, are frequently almost destitute of vegetation, and very extensive land-slips have occurred in many places, giving them a ruined and desolate aspect.

Sandy intercalation in Pierre.

Grassy Island coal seam.

At Grassy Island, the base of the Pierre, with the coal-bearing horizon elsewhere characterizing it, is found; the first outcrop of the coal and harder beds associated with it, at the water level, producing a little rapid about a mile and a half above Grassy Island. The best exposures occur in the scarped banks on the south side, near the island, the north bank being quite low near the river, and rising gradually in grassy slopes. In their general arrangement, appearance and thickness, the seams here exposed correspond closely with those about Coal Banks on the Belly River, fifty-seven miles distant, and show the remarkably constant character of this coal-bearing zone. The beds at Grassy Island have a general westward or north-westward dip at an angle of about 5°. The section including the coal-seams, as constructed from several exposures in this vicinity, is as follows:—

	FEET.	INCHES.
Lead-grey shale	25	0
Coal	1	6
Soft, grey and yellowish-grey shaly sandstone	13	0
Carbonaceous shale, coaly streaks	2	3
Coal (good and sound throughout)	4	6
Dark grey shale and shaly clay	7	0
Coal	1	0
Carbonaceous shale	1	0
Coal	0	6
Soft shale and clay	8	0
Coal and carbonaceous shale (to water)	1	6

The seam of 4 feet 6 inches in thickness may be assumed to be the representative of the "main seam" at Coal Banks. It is superior in quality to that of the Blackfoot Crossing, differing from it in physical character in the manner above described in connection with the Horse-shoe bend seam, but it is inferior in composition to that at Coal Banks. (See analysis No. 11, p. 18 M.)

Rocks of Belly River series.

Below Grassy Island the inclination of the beds must become very light, for at a distance of about two miles to the east, in a low exposure on the north bank of the river, at the water's edge, one of the coal seams was again imperfectly seen. Thence for a distance of ten miles,—the river flowing almost due south,—occasional low exposures near the river show from ten to thirty feet of pale greyish and greenish-grey sandstones, generally soft, covered above by boulder-clay to the top of the scarped banks which are here less than sixty feet in height. These beds show occasional coaly streaks, and in one place *Unio* and fragments of bone were observed. For the next ten miles the river still flows southward, but with more easting, the banks seldom exceed fifty feet and boulder-clay only was seen in the few scarps which occur.

Exposures near 112th meridian.

Two and a half miles west of the 112th meridian, the river makes a right angle, turning abruptly to the east. Here greyish and ferruginous sandstones occur, somewhat irregularly hardened and bedded, and including some ironstone, but in low poor exposures. Similar small exposures appear here and there for about five miles further, but show no marked peculiarities. At two and a half miles east of the 112th meridian, the country on both sides of the river rises suddenly to a considerably greater elevation, probably over one hundred and fifty feet above the water-level, and in a broken scarped bank one hundred feet in height, fifty feet of similar rocks, to all appearance quite horizontal, and overlain by boulder-clay, are exposed. Smaller exposures of beds of the same series are found for nine miles beyond. The bedding is usually rude and massive, with harder sandstones, which are usually ferruginous, forming projecting layers. Large ironstone concretions, often several tons in weight, are included in the sandstones in numbers so considerable that they may eventually prove of economic value. They are often, however, solid ironstone in the centre only, and pass gradually outward into ordinary ferruginous sandstone with a comparatively small percentage of iron.

Large ironstone concretions.

Thin coal seams.

At the point last defined, nine miles east of the 112th meridian, an impure lignite-coal or carbonaceous shale was for the first time seen in this series on the Bow, at a height of twenty feet above the water. In several places within the next few miles carbonaceous zones recur, varying from three to five in number, and occasionally becoming lignite-coal, but too impure and thin to possess any importance. The beds undulate slightly, and in one bank were noticed to have a distinct north-eastward dip at a very low angle. Twelve and a half miles east of the meridian the river becomes fringed on the south side, for a short distance, by broken bad-lands which exhibit fine sections. The coaly zone is here seen in places nearly fifty feet above the river, overlain by about a hundred feet of the pale grey sandstones which contain ironstone concretions in great abundance These have been described as occurring at the water-level further up the river. For four miles eastward the undulations of the beds become more marked than before, and the general north-westward inclination must here be locally reversed, for the coal-bearing zone descends to and in places passes below the water-level. At the point now reached,—fourteen miles north of the mouth of the Bow,—this zone includes, at the edge of the water, a seam of fair lignite-coal eighteen inches in thickness. The coal is separated into two parts by a shaly layer of three inches, not included in the measurement. This seam is without doubt the continuation of that described on page 75 C.

Sections near mouth of Bow.

Two miles below, the river again turns definitely to the south, but shows nothing but boulder-clay in its banks for about nine miles, or to within six miles of its mouth. A low bank of dark shaly beds with flaggy sandstones and ironstone here occurs, holding numerous specimens of *Corbula perundata*, *Ostrea*, etc. One more similar exposure was noted between this place and the mouth of the river, where beds of the same series, previously described, are again found displayed on a much grander scale.

Rocks between Bow and Red Deer Rivers, and on the Red Deer River.

The following notes on the country north of the Bow and the Red Deer Rivers, with the ensuing section on the Porcupine Hills, are by Mr. McConnell, who conducted the examination of these portions of the field.

Crowfoot Creek

"Between the Blackfoot Crossing and the mouth of the Rosebud or Arrow-wood River, exposures of rock along the route passed over are very infrequent. In Crowfoot Creek, about six miles from the Blackfoot Crossing, and near the place at which the Lord Lorne trail enters its valley, a small coal-seam about eighteen inches thick was seen. The same seam, but with somewhat increased thickness, is exposed again about a mile farther down the stream, and is then seen to be associated above with rather hard, grey sandstone, and beneath with a small bed of clay. After leaving Crowfoot Creek, no further indications as to the character of the rocks lying beneath the surface were met with, until the Wintering Hills were reached.

Wintering Hills.

"The Wintering Hills form a wide, rough ridge, running in a south-easterly direction from Rosebud River and presenting a steep escarpment to the north-east, from the base of which a rough, hilly plain slopes gently down to the valley of the Red Deer River. The slope of the ridge to the south-west is very gradual, and may not exceed the dip of the strata. The summit of this ridge where crossed by our trail is about 460 feet above the level of Bow River at the Blackfoot Crossing, and about 800 feet above the level of the Red Deer River at the mouth of the Rosebud.

Rocks in Wintering Hills.

"Both flanks of the ridge near its summit afford good exposures of sandstone. These sandstones are greyish and yellowish in colour, rather coarse in texture, and very hard, and to their protecting influence the existence of the hills is undoubtedly due. They are underlain by a softer and more friable variety of the same rock, alternating with more argillaceous beds, and these are followed by about sixty feet of dark plastic clays, which are well exposed near the base of the escarpment, and greatly resemble in appearance the Pierre shales. The clays are succeeded by light-coloured argillaceous sands, very slightly indurated and streaked at intervals with thin, reddish, clay-ironstone beds. No fossils were found in any of these rocks, although they were carefully searched.

Anticlinal of Wintering and Hand Hills.

"The sequence of the beds in these hills is almost identical with that described by Dr. Hector, as occurring on the other side of the Red Deer River in the Hand Hills, in which, reversing the order south of the river, the principal escarpment faces to the south-west, while to the north-east the hills slope gently away with the dip of the strata, and judging from the relative position of these two series of hills, and from the dip of the rocks which compose them, there seems little reason to doubt that at one time they formed part of a wide low anticlinal, the axis of which is now occupied by the deep, gorge-like valley of the Red Deer River. The river is now about 1,300 feet beneath the highest part of the fragments of the anticlinal yet remaining.

Red Deer River

"The Red Deer River varies in width from 150 to 300 yards; its bed is usually sandy, and sand-bars and sandy islands occur at intervals, all the way down. The current, at the beginning of July, ran at an average rate of about $1\frac{3}{4}$ miles per hour.

Rocks near mouth of Rosebud.

"Near the mouth of Rosebud River, the rocks forming the river-valley are composed principally of pure and arenaceous clays, alternating with some beds of indurated sands, and with a few seams of clay-ironstone. These rocks, being very soft, are greatly cut up by deep coulées running back from the river, the ramifications of which, uniting, gradually detach small portions of the plateau, and leave these an easy prey to the degrading influence of sub-aërial erosion, by the agency of which they have been sculptured into dome and pyramid, scarp and terrace, and all the endless variety of form characteristic of the "bad-

Bad-lands.

lands" of the West. The effect in this instance is intensified by the brightness and rapid alternation of the colouring, thin beds of red, yellow, brown, grey and white, extending along the banks with ribbon-like regularity for miles.

Silicified wood.

"About half a mile below the mouth of Rosebud River, and near the base of the section, a bed of silicified wood was observed. This bed, which is about one foot thick, is, on a fresh fracture, of a deep brown-black color, but on exposure to the atmosphere weathers to a light cream colour. The same bed is mentioned by Dr. Hector as occurring near the mouth of Shell Creek, about three miles and a half further down the river. The section including it is given by him as follows, in descending order:—*

Section by Dr. Hector.

	FEET.	INCHES.
Buff, unstratified earthy clays	12	0
Ash-grey and cream-coloured sandy clays in bands, with seams of clay-ironstone and carbonaceous layers	30	0
Seam of pure lignite	3	0
Banded clays, sandy in places	..	..
Silicified wood, composed of stems, trunks and roots of large trees	1	0
Brown coal	1	6
Sandy clays, varying from grey to light cream colour	100	6

"The coal seam included in the above section can be traced by numerous exposures from the mouth of Rosebud River down the stream for a distance of about eleven miles, at which point it reaches the surface and is cut off at a height above the river of about 275 feet. It is seen again for a short distance about eight miles further down, near the mouth of a large coulée, its re-appearance being due to the greatly increased height of the plateau above the river. The side of the valley south of the river at this point is 550 feet high, and the coal appears in the bank about 440 feet above the river-level.

Coal-seam in Laramie.

"This seam belongs to the same geological horizon as the coal at the Blackfoot Crossing, and it is quite possible that the two seams may be identical and so underlie the whole country between this part of the Red Deer River and the Bow River.

"On the Red Deer River this seam is seen at its best in a small coulée about four miles below the mouth of the Rosebud River, where it is over six feet thick. Three miles further up the stream it measures four feet, while down the stream it shrinks in some places to two feet, but enlarges again considerably before it finally disappears. The coal is usually associated, both above and below, with a varying quantity of carbonaceous shales, but these are not constant, and die out occasionally, when the coal comes in direct contact with the sandy clays beneath. In many places this seam has been entirely burnt away, and the red cliffs

* Quart. Journ. Geol. Soc., Vol. XVII, p. 425.

seen at intervals along the valley are due to its combustion. The height of the coal-seam above the top of the Pierre is about one hundred and sixty feet.

"The total thickness of the rocks exposed in the sections along this part of the river and in the Wintering Hills, measuring from the top of the Pierre up, is about 990 feet, of which the greater part is composed of pure and arenaceous clays, and differs greatly in lithological character from the Fox Hill proper which occupies the same relative position farther south, and which is distinctively a sandstone formation.

Thickness of rocks.

No Fox Hill sandstones West edge of Pierre shales.

"About two miles below Shell Creek, the Pierre shales appear at the water-level, the slight dip they have to the north-west bringing them to the top of the bank about seven miles further down. The rocks forming the upper part of this formation consist here of sandy clays, containing in places thick beds of greyish sands, the sands never being persistent for any great distance.

"The clays vary from a light yellow to a deep coffee colour, the different shades alternating with one another in layers only two or three inches thick. About 500 feet of these clays is seen. They are underlain by about 250 feet of darker shaly clays, which have a much greater resemblance than the preceding to the typical Pierre shales. About two miles below Snake Creek, and near the base of the Pierre shales, a small coal-seam about eighteen inches thick was observed. This seam is probably an extension of the seam at Grassy Island on Bow River, and of the Coal Banks seam on Belly River.

Upper beds of Pierre.

"The Pierre shales are seen along the valley of the Red Deer River for about thirty miles, and are well exposed in the scarped faces of many of the rolling hills forming its banks, as well as at all the principal bends of the river. They are underlain by the Belly River series, which first appears near the water-level, about four miles below Snake Creek, but soon rises to the top of the banks, and shows nearly continuous sections for a distance of almost fifty miles. These rocks consist mainly of greyish argillaceous sands, alternating with greyish sands and greyish and yellowish sandstone. In places also thick beds of greyish and dark clays, and thin beds of ironstone, were seen. About ten miles below Snake Creek, a couple of coal seams appear on the bank, the larger of which is about three feet thick, but the coal is of inferior quality. Around Dead Lodge Cañon a large area of these rocks has been worn into bad-lands.

Width of Pierre belt.

Belly River series.

Coal-seams.

"Opposite the Rainy Hills, the Pierre shales re-appear capping the scarped banks of the valley. Here, near the centre of the shallow synclinal which they form, they have a thickness of about 250 feet. As generally found elsewhere a small coal-seam occurs near their base.

Synclinal of Pierre shales.

"Although no sections of Pierre were seen between Hunting Hill and

Dead Lodge Cañon, it is probably continuous along this part of the river a short distance back from the edge of the valley.

Edge of Pierre shales.

"The Pierre shales disappear about five miles west of the 111th meridian, and are followed in the course of three or four miles by the Belly River series. In the next ten or twelve miles no rocks of any kind were seen, the sides of the valley being low and covered with grass. The absence of exposures in this distance is probably due to the occurrence of a drift-filled depression in the Cretaceous rocks. Twenty-five miles west of the Forks the plateau again rises, and has forced the river to make a sharp bend to the north-west. Around this bend, and above it for a few miles, exposures occur which probably belong to the lower part of the Belly River series. The rocks seem to be more compact than those last seen, and contain a larger proportion of yellowish sands and sandstone. They also hold a small coal-seam. East of the bend the valley widens out, and its banks become grass covered, and show nothing but drift all the rest of the way down to the Forks or confluence with the South Saskatchewan."

Rocks on lower part of Red Deer.

The Porcupine Hills.

"The geological structure of the Porcupine Hills is very simple. They consist princinally of sandstones belonging to the upper part of the Laramie, which has been designated as the Porcupine Hill subdivision. These rocks have been thrown into a gentle synclinal form, the highest dip observed not exceeding ten degrees.

Character of rocks.

"Numerous small exposures of sandstone are found scattered over the hills, but these represent only the harder varieties of the rock of which they are composed. This sandstone is soft, coarse-grained, and usually of a greyish or light brownish colour, the more massive varieties often showing false-bedding, the laminæ being about an inch to an inch and a half thick.

Sections in Willow Creek.

"More instructive sections are found in the valley of Willow Creek, one branch of which cuts through the hills transversely. These show fine- and coarse-grained sandstone, often weathering to a light yellow, and alternating with bands of more thinly bedded sandstones, clays and shales.

"The only fossils found in these rocks were fragments of *Unio Limnaea*, and a few other fresh-water shells.

Thickness.

"The total thickness of the beds forming the Porcupine Hills cannot be less than 2,500 feet."

Pincher Creek, Mill Creek, South, Middle and North Forks of Old Man River.

As already stated, the foot-hill belt is characterized geologically by Cretaceous and Laramie beds, with a strike generally parallel to the base of the mountains, sharply folded, and resting at all angles up to vertical. With the exception of a single gap through which the South Fork of the Old Man issues, it is everywhere sharply bounded to the west by the Palæozoic rocks of the mountains. The line of junction appears usually to be a faulted one, with extensive down-throw eastward, and the Cretaceous or Laramie rocks near the line of contact, generally dip westward, or toward the mountains. It is, however probable that in some cases, owing to overturned folds, the Palæozoic rocks actually overlie the Mezozoic along the line of junction. Foot-hill belt.

The portions of the St. Mary, Upper Belly and Waterton Rivers which traverse this belt, have been described on a previous page. North of the North Fork of the Old Man, the streams which cross the foot-hills to and including the Elbow River, are noticed in the sequel by Mr. McConnell, and the arrangement of the beds in their banks clearly shown in his sections. A few notes will here be given of the sections afforded by the streams enumerated at the head of this chapter.

Pincher Creek, after leaving the Palæozoic rocks, flows north-eastward for a few miles in a comparatively low country. It then cuts through some prominent and partly wooded hills, which constitute the southernmost of the well marked foot-hill ridges, after which it flows northward for some miles before resuming its eastward direction. On the upper part of Pincher Creek the dips are generally south-westward, and the rocks exposed are for the most part sandstones, though where good sections occur shales are also seen. Two important bands of dark Pierre-like shales were, however, observed to cross the valley, one immediately west of the hills above alluded to, the other in a minor hollow in these. The first of these bands was again seen on the north branch of the Drywood Fork of the Waterton, and probably also runs through to Mill Creek. From Nelson's house, for about a mile down stream or to the road-crossing, strata composed of alternating grey, yellowish and greenish-grey sandstones and shales are almost continuously exposed, with a north-eastward dip of about 25°. These rocks evidently represent the St. Mary River sub-division of the Laramie, and extensive collections of well-preserved Laramie fossils have been made in them by Messrs. McConnell and Weston. Almost exactly at the road-crossing these are followed in ascending order by the reddish and purplish-grey beds of the Willow Creek sub-division, with their char- Sections on Pincher Creek. Shale bands. West edge Willow Creek series.

acteristically soft and massive appearance. A short distance below the road-crossing, they are found dipping in the same direction at an angle of about 15°, and gradually flattening out.

Sections at Indian farm.

The upper beds of the St. Mary River sub-division here form the front of a wide low ridge or plateau which runs south-eastward, while the wide valley to the north-east of it is based on the soft Willow Creek beds. Seven miles south-eastward, at the Indian Farm, the edge of this plateau is cut into by a small brook which displays fine sections of the St. Mary River sub-division, extending downward from near the base of the Willow Creek beds. At the farm building the dip is N. 50° E. $<$ 20°, but gradually and pretty regularly increases, till at about a mile up the stream it reaches an angle of 54°. About one hundred feet beyond this point, a seam of coal occurs, and the beds become absolutely vertical, but this disturbance is shown to be local by the fact that at about an equal distance still further up the valley the beds resume their former direction of dip at an angle of 60°. This coal, where exposed, is excellent in quality, though much broken and slickensided, so as to crumble easily on handling. (See p. 29 M.) The seam where examined was two feet in thickness. The opening made on it had, however, fallen in at the time of my visit, but the seam was said to be considerably thicker a few feet into the bank. The coal is seen to be underlain by one hundred feet of yellowish beds, chiefly sandstones, and overlain by grey sandy shales and sandstones. It must occupy a position very near the base of the lower or St. Mary River sub-division of the Laramie, and the rocks of this sub-division here shown have an approximate minimum thickness of 2,700 feet.

Coal-seam.

Continuation of seam.

As stated in the preliminary report before referred to, this seam should outcrop about a mile above the road-crossing on Pincher Creek, or near Nelson's house. The rocks at this place are, however, for the most part concealed. It is very probably the continuation of this seam, which has since (1883) been discovered in a coulée which opens into Pincher Creek, in the vicinity of the road-crossing.

Mill Creek.

On the upper part of Mill Creek, the beds, so far as examined, resemble those above described on the corresponding portion of Pincher Creek, and show general south-westward dips. About four miles above the mill, an excellent coal-seam occurs, of which, owing to the disturbed character of the rocks, the horizon has not been precisely fixed. It contains, according to Mr. Hoffmann's analysis (p. 40 M.) 1·63 per cent. of hygroscopic water and 12·37 of ash. The following sections of the seam, on opposite sides of a break or fault which here traverses the measures, are quoted from the preliminary report:—

Coal-seam.

	FEET.	INCHES.
Coal (rather shaly)	3	1
Coal	2	0
Shale	1	4
Coal	2	0
Shale	1	4
Coal	2	0
Total coal	9	1

	FEET.	INCHES.
Coal (rather shaly)	2	0
Shale	1	0
Coal (apparently good throughout, with the exception of a few shaly partings not equalling four inches in all	6	0
Total coal	8	0

At the mill, several hundred feet of hard blackish shales appear, dipping S. 20° W. < 50°. These are probably Pierre, and are overlain by a series of grey and brownish-grey sandstones, and greenish- and bluish-grey shales which are nearly vertical. These, with little doubt, belong to the St. Mary River sub-division, and have yielded a number of species of fossil plants which have not yet been examined. Shales at mill.

The South Fork of the Old Man, issues from the mountains at a point at which the continuity of the outer limestone range is broken. A few notes on the Cretaceous and Laramie rocks which here occupy a considerable area in the mountain country, are given on a succeeding page. The point which may be called the entrance to the North Kootanie Pass is at about two miles and a half south-west of Garnett's house. A small stream from the north (locally known as Kootanie Brook) here enters the South Fork. In its banks two coal-seams are exposed, the upper, overlain by about twenty feet of massive sandstone, is two feet ten inches thick. Below it is about thirty feet of shales and sandstones of general dark colour, and then a second seam one foot five inches thick. The dip is S. 45° W. < 20°. The coal appears to be of very fair quality, and may prove of some local value. On the main stream, for a distance of two or three miles below this point, dark shales resembling those of the Pierre group characterize the banks, and appear to underlie the beds containing the coals. The shales are, however, evidently repeated by folding, and it is possible that the rocks are in some places overturned. Just above the junction of the South Fork with Mill Creek, the stream is hemmed in by cliffs composed chiefly of greenish-grey sandstones with some shales.

South Fork of Old Man.

Coal-seams.

Wide shale band.

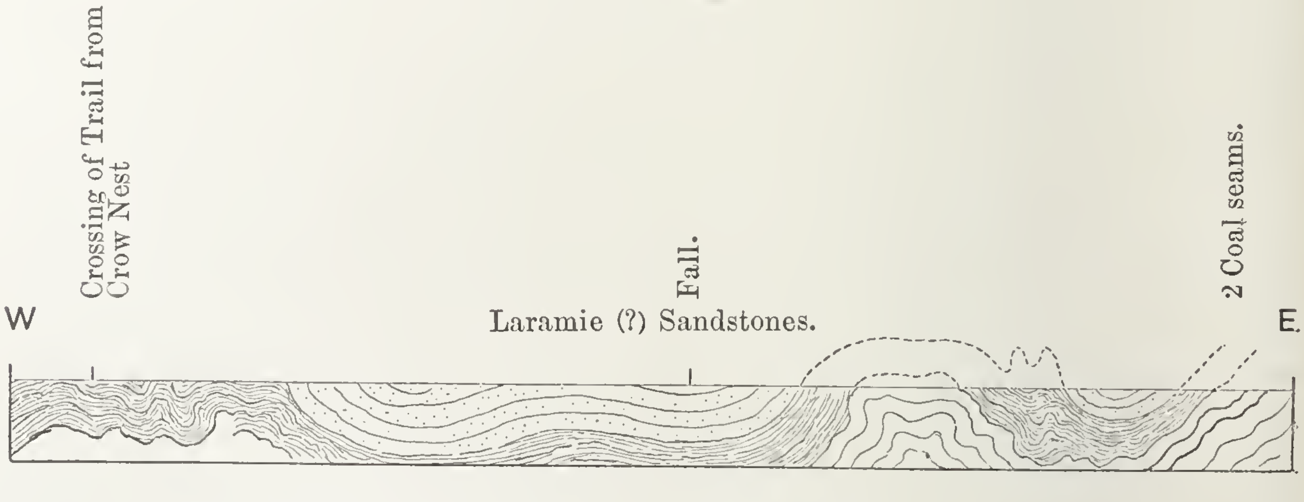
West edge of wide synclinal.

Between the point last described and that at which the base of the Willow Creek sub-division crosses the South Fork—about four miles eastward—a thin seam of coal is reported to outcrop in the bank, but was not visited. The appearance of the Willow Creek beds above referred to, may be regarded as constituting the western edge of the Porcupine Hill synclinal.

Middle Fork of Old Man. Gap in Palæozoic range.

The gap through which the Middle Fork of the Old Man, or Crow Nest River, leaves the limestone ranges, appears to be connected with a remarkable change in the strike of the limestones, which amounts to about 40° in direction. The limestones on the south side of the gap dip nearly south-westward, while those to the north dip more nearly west. The inclination in both cases is from 40° to 45°. The eastern junction of the limestones with the Cretaceous rocks is probably a faulted one, and is accompanied by considerable disturbance. The dip of some of the beds of the latter formation nearest the limestones is nearly in the same direction with that of the limestones, but at a lower angle. From this point south-eastward to the crossing place of the Middle Fork by the Crow Nest Pass trail, the valley crosses the strike of the Cretaceous or Laramie rocks obliquely. The south-westward dips continue, and the rocks observed are chiefly greenish-grey sandstones, which often weather brown, and are occasionally shaly. Near the first large tributary from the north which is crossed after leaving the limestones, the sandstones become for a considerable thickness conglomeritic. The pebbles are largely cherty materials from the limestone series, but also include many quartzite rocks probably derived from an underlying series not now seen in the mountains in this vicinity, together with a few porphyritic pebbles of a kind not yet observed in place in any part of the range.

Conglomerates.



Horizontal scale 2 miles to 1 inch.

GENERAL SECTION ON MIDDLE FORK OF OLD MAN RIVER EAST OF CROSSING OF TRAIL FROM CROW NEST PASS.

Near the trail-crossing above referred to, dark shales begin to occupy the banks of the valley, and continue with little interruption for a distance of nearly two miles. These shales are probably of Pierre age, and are many times folded together. Their position corresponds with that of a low tract of country which here stretches across to the South Fork. Eastward they are followed, apparently in ascending order, by a series of rocks which are chiefly sandstones, and may probably be Laramie. These extend, with undulating dips at low angles, for about three miles along the stream, or to a point about half a mile below the fall. The fall is about thirty feet in height, and occurs over massive grey sandstone beds, which are at this place nearly horizontal. These sandstones are interrupted to the east by a narrow band of black shales, which appears to fold over a compressed anticlinal of sandstone beds to the east, where the shales are again found, but with a thickness apparently much greater than before. This appearance is doubtless due to a series of repetitions by folding. They eventually take an eastward dip and form a small synclinal, the axis of which is occupied by yellowish and pale beds chiefly sandstones. On the east side of the synclinal the rocks above described as forming a compressed anticlinal, reappear, and at this point,—about four miles above the junction of the Middle and North Forks,—contain two good coal-seams. The following section, which extends downward from the base of the dark shales, was in part given in the preliminary report:—

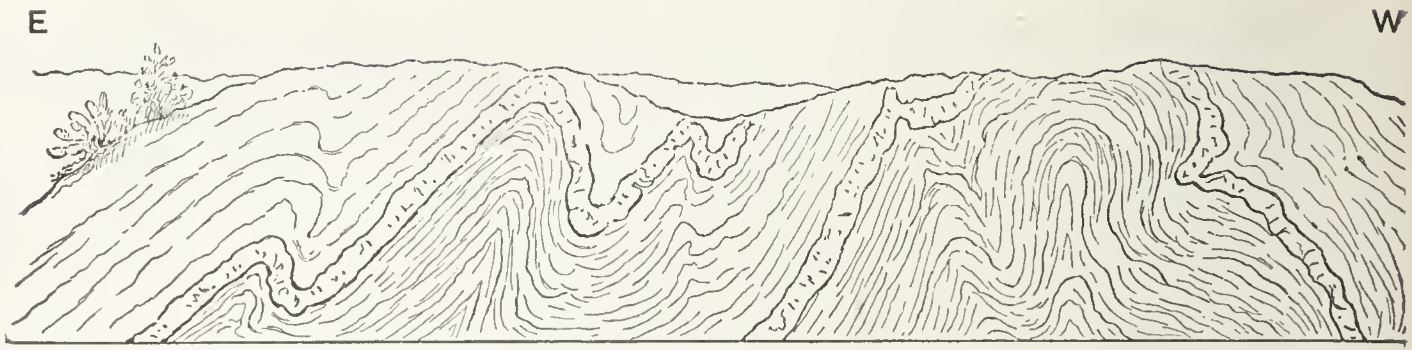
Pierre shales.

Rocks at fall.

Flexures below fall.

Coal-seams.

	Feet.	Inches.
1. Yellow-weathering sandstones and sandy shales	860	0
2. Dark shales, with a few thin sandstone layers	380	0
3. Grey to black, very fine shale, with occasional small fish scales and bones, becoming sandy and yellowish at base	6	0
4. Ferruginous sandstone	0	6
5. Greyish, soft sandstone or arenaceous clay, with some thin ironstone layers	10	0
6. Harder, greyish and ferruginous sandstone, with some obscure plant fragments	6	0
7. Hard, flaggy, yellowish sandstone	2	0
8. Grey, sandy shale and shaly sandstone	3	0
9. *Coal*	3	0
10. Soft, black carbonaceous shale	0	9
11. Grey, sandy shale	3	6
12. Grey, sandy shale and sandstone	4	6
13. Grey, flaggy sandstone, weathering rusty	2	6
14. Grey, sandy shale and shaly sandstone	5	0
15. *Coal.* Imperfectly seen, but at least 3 ft. of good quality	3	6
16. Carbonaceous shale	1	0
17. Grey, sandy shale	4	0
18. Ferruginous sandstone	0	6
19. Greenish-grey sandstone	10	0
20. Grey and blackish carbonaceous shale	4	0
21. Greenish-grey, soft-sandstone	6	0
22. Sandstone and arenaceous and carbonaceous shale, general greenish-grey tints, (about)	80	0
	1395	9



CONTORTED SHALES AND SANDSTONES IN BANK OF MIDDLE FORK OF OLD MAN RIVER.

Wildly contorted rocks.

For some distance below this point the beds shown on the Middle Fork are so much disturbed and contorted that no attempt was made to work out their structure in detail. The accompanying sketch-section of some of the beds in this vicinity, illustrates the extent to which flexure has been carried in some parts of the foot-hill belt. At the last stream which joins from the north before the North Fork is reached, the Willow Creek beds appear in a nearly vertical attitude, and are followed eastward by beds which probably belong to the next overlying, or Porcupine Hill sub-division, and which on the lower part of the North Fork are found dipping regularly eastward into the high land of the Porcupine Hills.

Rocks between Middle and North Forks.

An attempt was made to trace out the belts of dark shales and those characterized by sandstones, in the foot-hills between the Middle and North Forks, and though this might doubtless be accomplished by the expenditure of sufficient time, it has not yet been fully effected. The shaly belts generally exist as anticlinal or synclinal folds more or less complex, which in some instances disappear by running beneath the sandstones of the highest tracts or slope up till they pass above the plane of the surface.

Remarkable valleys.

The most remarkable feature of this part of the foot-hills, is the existence of several wide valleys occupied by very inconsiderable streams, which nevertheless cut across the ridges at right angles to their strike. These can scarcely be explained except on the supposition of the occurrence of a number of parallel lines of fracture.

North Fork of Old Man.

The North Fork of the Old Man River, leaves the mountains near Lat. 49° 52′, and after running a little south of east about thirteen miles, bends more to the south, and runs parallel with the western flank of the Porcupine Hills.

West Edge Porcupine Hill synclinal.

Near the bend, good sections of the Willow Creek series occur, the beds dipping to the east at an angle of 12°. Half a mile further up the stream, they are underlain by the more massive and harder sandstones and shales of the St. Mary River sub-division, which dip at first to the east at an angle of about 15°, but soon become vertical and even slightly overturned in places.

Near the centre of this band, which is about one mile and three-quarters wide, nine hundred feet of clays and sandstones resembling the Willow Creek series occur. The next rocks seen are shales belonging to the Pierre formation. These shales are somewhat sandy, and alternate at intervals with a thick bed of bluish sandstone. The dip is nearly vertical. They are succeeded by a great series of thickly bedded bluish and grayish sandstone, alternating with more thinly bedded sandstones and with greenish and dark shales, the whole forming a band about a mile and a half wide.

The remainder of the section is occupied by alternating bands of sandstones and shales almost exactly similar to the two just described, the dip is usually to the west at angles varying from 60° to vertical and the strike about N. 25° W.

Near the mountains the sandstones lie at lower angles and enclose a few beds of conglomerate and a coal-seam four feet thick and of excellent quality. (See p. 33 M.) Coal-seam.

The band of dark shales next the mountains on this section, is very much flexed and crumpled, and is underlain by about forty feet of greenish and bluish sandstones and whitish quartzites, and these overlie, apparently quite conformably, the Palæozoic limestone. The dip of the limestone is, in this instance, at first eastward at an angle of about 30°, but in about seventy-five yards, it folds over an anticlinal and dips in toward the mountains. East edge of limestones.

Highwood River, Sheep Creek, Elbow River.

The following descriptions of the rocks on the Highwood River, Sheep Creek and the Elbow River are by Mr. McConnell, and are illustrated by the accompanying sheet of sections.

"Highwood River affords the best section through the foot-hills of any of the streams flowing from the mountains between Bow River and the 49th parallel. Highwood River.

"From the mouth of a coulée running into it, about eight miles west of the fifth principal meridian, where the disturbance of the beds first becomes well marked, on to within a short distance of the mountains, it flows in a deep cañon-like channel, the sides of which afford almost continuous sections of the nearly vertical sandstones and shales characteristic of this region. The width of the disturbed area on Highwood River is about eighteen miles, though the rocks undulate slightly for seven or eight miles more.

"Going up Highwood River from the crossing of the Calgary trail, good sections of rock appear at all the principal bends of the stream. These are of the usual character of the rocks belonging to the St. Mary River sub-division, consisting of sandstones and clays. A thick band of yellowish-weathering sandstone is a prominent feature in many of the Laramie rocks.

sections. Highwood River forks about six miles west of the fifth principal meridian, after which the valley of the main stream bends to the north, and gradually assumes the character of a cañon.

"The Southern Fork branches again about two miles further west, and one of the streams bending to the south runs parallel with the Porcupine Hills, while the other continues westward to the mountains. Neither of these streams have valleys at all comparable in size or geological interest with the valley of the North Fork, and exposures of rock in them are very infrequent. In one place the valley of the Middle Fork almost disappears, the stream being depressed but very little below the general surface of the country.

Sections near lower forks.

"Near the lower forks, good sections of sandstones and clays occur, the rocks dipping westward at a low angle, which gradually increases further up the stream. Three miles further on, some carbonaceous seams appear in the section, and near them some fresh-water shells were found. A mile and a half up stream from this point, the rocks become for the first time suddenly and violently disturbed. They are thrown into an almost vertical position, and for a short distance resemble in the complexity and sharp plications of the subordinate folds the gneisses of the Laurentian system. The strike of these rocks is about N. 18° W., and following this direction northward the next transverse section that is met with is that of the South Fork of Sheep Creek, distant about twelve miles, but the rocks appearing in it do not belong to the same horizon, but to the underlying Pierre shales, showing that the disturbed rocks on Highwood River must mark the axis of an uplift which a little farther north has broken apart the rocks of the St. Mary River sub-division, and brought the Pierre shales to the surface. The contorted rocks on Highwood River consist of sandstones and shales, and include three small coal seams, all so crumpled as to be almost worthless. They also include an oyster bed composed of shells of an *Ostrea*, which is probably *O. glabra.*

Crumpled coal seams.

"From this point the river runs in the strike of the rocks about three miles, then bending more to the west, cuts across them.

"The rocks continue highly disturbed for several hundred feet across their strike, then the contortions gradually die away, and the strata dip regularly eastward at a high angle, until they are replaced by the Pierre shales. The rocks appearing in the section above the disturbed area consist of sandstones, in beds varying in thickness from six to thirty, and even fifty feet. The softer beds are usually of bluish and greenish colours, and the harder, yellowish or brownish, the different beds being separated by greenish and dark-colored shales and clays.

"Succeeding, and underlying the rocks just described, is a great thickness of dark shales. These at first dip to the east at an angle of about 50°, but soon become vertical, and dip westward before being replaced by sandstone. This series has the form of a simple sharp anticlinal, and measures about a mile across its strike, which would give it, if uninfluenced by local folds or by faults, a thickness of at least 2,000 feet. A section measured at the eastern outcrop of these rocks gives:

Thick shale band.

	FEET.
Sandstone	..
Black shales	75
Sandstone, weathering bright yellow	30
Alternating sandstone and shale	75
Black shale	..

"The sandstone bed appearing in this section, although traceable along its strike for over a mile, does not appear at the other side of the anticlinal, nor at any intermediate point, which seems to show that the great thickness of these beds is not due to repeated folding.

"The next rocks in the general section are heavily bedded sandstones lying on top of the shales, and dipping westward at a high angle. These sandstones differ greatly in every respect from the rocks east of the shales, they are harder and firmer in texture, much more heavily bedded, and the colors are green, red and brown in place of bluish and yellowish. These beds undulate a couple of times without bringing any other rocks up, and are then followed by a series of thinner and more argillaceous beds, alternating with beds from ten to twenty feet thick and with a thin band of shale about one hundred feet thick, the whole undulating in a succession of sharp folds for several miles. A thick bed of greenish sandstone underlying the shales can be traced through several of these folds. North of Highwood River, on Sheep Creek, in the exact strike of this series of alternating sandstones and shales, scarcely any sandstone is found, the shales occupying the entire section. West of the rocks just described, the valley of the river is occupied for several miles by an immense thickness of almost vertical shales. These shales are hard, in some places almost passing into slates, and are very dark in color. They are interstratified in places with thin bands of rather hard flaggy sandstone, but none of these bands could be identified a second time.

Alternations of shale and sandstone.

"This band of shales was traced northward across Sheep Creek and Fish Creek to the Elbow River, and southward to Willow Creek, a distance of over fifty miles. In some parts of its course its direction is marked by a wide valley, but more frequently the harder sandstone bands included in it project above the surface, forming hills and ridges.

"Between the band just described and the mountains, the shales re-appear six times in bands varying from one-fifth of a mile to a mile and a quarter in width, their general character being much the same in all. They dip to the west at a very high angle, being often vertical, and occasionally even overturned.

Character of sandstones.

"The sandstones alternating with the shales vary greatly both in texture and colour, but they may be generally described as consisting of thick beds, greyish or bluish on a fresh fracture, but often weathering yellowish or brownish. These alternate with bands consisting of more thinly bedded sandstones, and greenish or reddish, and reddish and dark shales, the thick beds of sandstone standing prominently out on the sides of the valley, and the softer rocks separating them being concealed. Near the mountains these sandstones form hills which rise 2,000 feet above the valley.

Coal-seam.

"In the last appearance of the shales near the mountains they hold a coal seam about two feet thick.

"A small stream falling into Highwood River about eight miles from the mountains, gives a very good section of rocks parallel with the section on Highwood River, and distant from it from four to five miles, the only noticeable difference between the two sections being the division on the creek of one of the bands of shales, and the appearance of an additional band of sandstone. Near the mountains, the sandstones lie at lower angles than on Highwood River further east, and several beds of conglomerate appear.

Sheep Creek

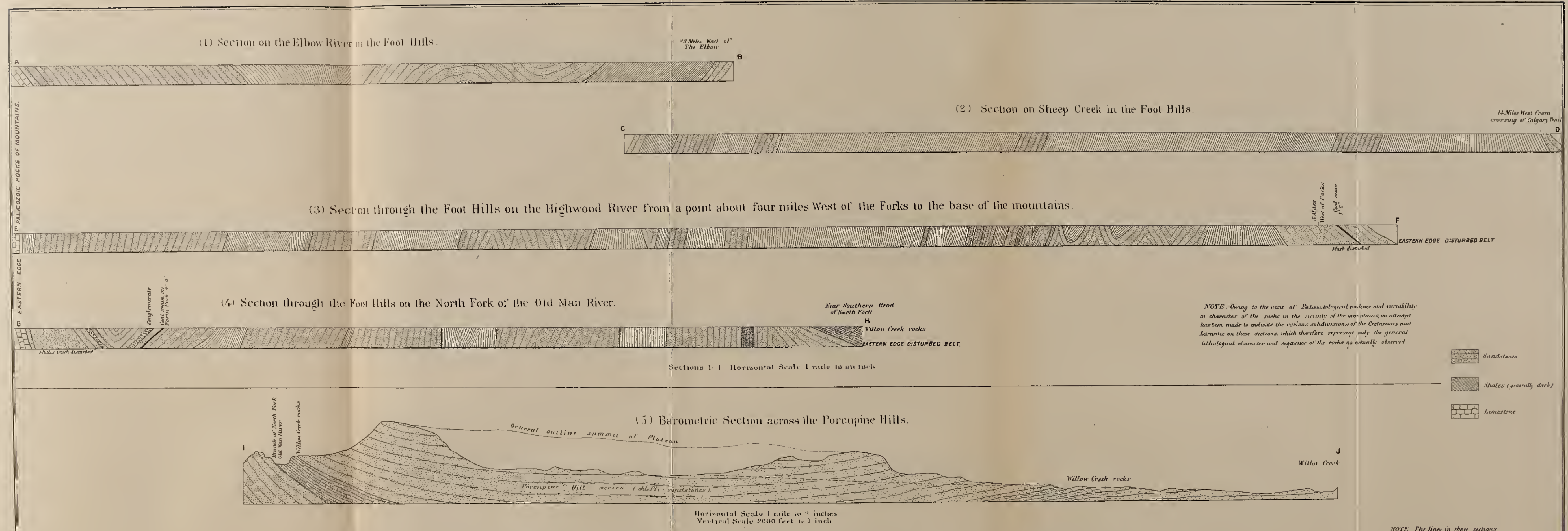
"On Sheep Creek the disturbed rocks are about twenty-five miles wide, and are remarkable for the large proportion of shales which they contain.

"These shales first appear about ten miles west of the fifth principal meridian, forming a sharp anticlinal, the dip at both edges being about 50°. They are succeeded by about half a mile of sandstone, dipping west at a high angle, and then the shales again come in and occupy fully nine miles out of the next ten of the section, the dip being to the west at angles varying from 50° to vertical. These shales resemble in every respect, except in width, the shales seen on Highwood River. They are succeeded by several smaller bands, which alternate with bands of sandstone of about an equal size.

"Near the mountains the sections on Sheep Creek, owing to the almost impassable character of the country, were not examined.

Elbow River.

"The Elbow River affords in its upper part a good section of the rocks near the mountains which there as elsewhere consist of alternating bands of sandstone and shales, the sandstones however being more



SECTIONS ILLUSTRATING THE CRETACEOUS AND LARAMIE ROCKS OF THE DISTURBED BELT AT THE BASE OF THE MOUNTAINS, AND THE PORCUPINE HILL SYNCLINAL.

From measurements by R. G. McConnell, B. A.

THE BURLAND LITHOGRAPHIC CO MONTREAL

nearly horizontal than is usually the case. The limestones where first met with dip eastward at an angle of about 30 degrees." *

Sections on the Bow River in the Foot-hills.

The foot-hills west of Morley, in the vicinity of the Bow, cease to present the narrow ridge-like and parallel forms generally characteristic of them, and become broad-topped and rounded. This is in connection with a change in the attitudes of the Cretaceous and Laramie beds of which they are composed, which here depart from the parallelism in strike to the base of the mountains which they usually maintain, and in some cases—as immediately below the fall—turn at right angles to their former direction and become occasionally nearly horizontal. West of the fall, (which is nearly in a line with the general direction of the edge of the Palæozoic) the Cretaceous or Laramie rocks form a bay in the edge of the limestones, of which the river occupies the centre. The dips are quite low, and as usual toward the mountains, and it would appear that the limestones are folded back over the newer rocks. Peculiar character of foot-hill region on Bow.

On the Kananaskis, a short distance above its mouth, dark Pierre-like shales with numerous bands of red-weathering ironstone, are well exposed. Immediately below the confluence of the Kananaskis the fall above referred to occurs, the beds producing it being a series of massive sandstones with light westward dip. These are followed and apparently underlain by, a considerable thickness of shales. Rocks near fall.

From this place, following the Bow to a point three and a half miles below the Ghost River, there are numerous fine exposures in the banks, but as these have not been examined in detail or measured, no connected description of them need here be attempted. As a whole, the rocks appear to consist of a very thick series of dark shales with some sandstone intercalations and a few beds which become conglomeritic. The shales appear to lie between two series of rocks characterized by pale tints and a predominance of sandstones, one of which doubtless represents the Laramie. At the point above defined, below Ghost River, the shales are seen for the last time, and are followed by sandstones Shale and sandstone bands.

* The above paragraph, by Mr. McConnell, refers to the first section of the folding sheet, and carries the description westward to a point about thirty-seven miles above "The Elbow." Beyond this point lies a region of broken and very rugged hills which has since (in 1884) been partly explored, and regarding which the following preliminary note may be added.—It would appear that the limestone above mentioned constitutes merely an outlying ridge, and that before the limestone ranges are finally reached at a further distance of about ten miles, several anticlinal and synclinal folds are crossed—the former constituting limestone ridges, the latter troughs of Cretaceous. The arrangement of these, so far as determined, is shown on the map, and it is even possible that the western trough may connect north-westward with the continuation of that on which the anthracite deposits of Cascade and Bow River are situated. The surface of the country is here, however, near the base-level of the Cretaceous formation and the plication has given rise in consequence to an intricacy of outline which has not yet been thoroughly worked out.

and sandy shales which, with little doubt, represent the base of the Laramie, though much disturbed and sharply folded. At the mouth of Coal Creek these beds assume a regular eastward dip, and this may be regarded as the western edge of the wide Porcupine Hill synclinal. The rocks occurring on the Bow River below this point have been noticed on a previous page. (p. 80 c).

Cretaceous and Laramie Rocks in the Mountains.

That portion of the Rocky Mountains near the 49th parallel, which was examined in connection with the Boundary Commission expedition in 1874, is composed entirely (with the exception of remnants of Triassic rocks) of Palæozoic strata, and the line between these and the newer formations of the plains is there perfectly distinct. It was, however, discovered, in the autumn of 1881, that a considerable area of the newer rocks occurs on the North Kootanie and Crow Nest Passes within the line of the eastern limestone range. Some time was devoted to the examination and outlining of this area in 1883,* and much information regarding it obtained. This will properly form a part of a succeeding report on the Rocky Mountains, it is thought well to give here a few notes on this area, which, on account of the occurrence of several good coal-seams, and the fact that the lower hills characterizing it bear a much more considerable quantity of good timber than other portions of the mountains, appears to possess considerable economic importance. The outlines of this area are also in part shown on the accompanying geological map.

Notes here given preliminary.

The notes here given with regard to this area are, however, merely of a preliminary character, and refer chiefly to the position of the coal-seams. These, though rather inaccessible as sources of supply for the country in general, will in event of the discovery of metalliferous deposits, assume immediate importance for smelting purposes, particularly as they are generally of excellent quality.

Extent of trough.

The area of Cretaceous and Laramie rocks extends from the Little South Fork, or south branch of the South Fork, to the sources of the North and North-west branches of the North Fork, and thence (according to the exploration of 1884) to the head-waters of the Highwood River and Sheep Creek.

The country underlain by this trough of Cretaceous and Laramie rocks, resembles orographically and geologically the rougher portions of the foot-hill belt, already described. It is over ninety miles in extreme length, and in its southern part averages about ten miles in width, with a total area probably exceeding 750 square miles. It is

* The explorations of 1884 havs since added largely to our knowledge of this and other troughs of Cretaceous and Laramie rocks in the mountains.

separated from the foot-hills, for the greater part of its length, by the eastern limestone range, named the Livingstone Range on Palliser's map. As already stated, however, there is a wide gap to the south of this range, through which this area inosculates with the foot-hills proper. This appears to occur also at one other point, where on the North Branch the limestone range is again interrupted for a few miles.

Folding of beds.

On the South Fork, probably owing to the absence of the protection afforded by the eastern limestone range, the Cretaceous and Laramie beds have been much more closely folded together and are more disturbed than they are elsewhere generally found to be in this area. On the Middle Fork or Crow Nest River, the beds are remarkably undisturbed, and generally lie at low angles, while on the North Fork, they are in an intermediate condition in respect to folding and disturbance.

Character of rocks.

With one exception, no marked difference is found between the rocks of this area and those of the foot-hills. They consist principally of sandstones of varied degrees of induration, interbedded with sandy argillaceous shales which are often greenish- or bluish-grey, and a series of dark shales with sandstone intercalations, from which marine Cretaceous fossils have been obtained, recur in a number of places. Conglomerates are not unusual, and it is evident that the deposition of the Cretaceous and Laramie rocks here occurred in proximity to a shore-line, or at least where insular masses of the older rocks were at hand to supply material of a coarse character. The exception above alluded to is the existence of an important intercalated series of bedded rocks of volcanic origin. These are for the most part coarse or fine-grained agglomerates or ash beds which have been arranged by water, but beds which appear to have been trappean flows are also found. The rocks of this part of the series are generally hard and compact, and vary in colour from purplish to greenish-grey, though the latter tint is most characteristic and universal. These rocks have a great thickness on the Crow Nest Pass, where they form a prominent ridge which runs for many miles north and south, and crosses the stream about seven miles west of the Livingstone or eastern limestone range. To the north, these rocks were again seen, but in very inconsiderable thickness, and probably dying out, on the North-west Branch of the North Fork. They appear three times on the South Fork, being repeated by the excessive folding, but are here again much less in thickness than on the Crow Nest Pass.

Contemporaneous volcanic deposits.

Coal-seams on South Branch of Old Man.

The occurrence of two thin coal-seams at the entrance to the North Kootanie Pass has before been referred to (p. 99 c). About four miles above the mouth of the Little South Fork, on the main river, an important coal-seam outcrops in the rocky banks of a small cañon through which the stream here flows. The beds are folded into a narrow synclinal, and there is some appearance of irregularity in the measures. The principal coal-seam is nine feet nine inches in thickness. It is underlain by eight inches of shale, below which is a second seam fourteen inches in thickness. These seams are capable, together, of yielding about ten feet of clear coal, and the quality appears to be excellent.

Coal-seams in Crow Nest Pass.

On the Crow Nest Pass, three miles west of the Gap, or western edge of the first limestone range, a considerable brook flows in from the north. Half a mile above the trail-crossing of this stream, three coal-seams occur in a bank about forty feet in height, which is chiefly composed of brownish, greenish, and blackish-grey sandy shales, and is capped by a massive grey sandstone.

The highest seam is two feet thick, the next two feet ten inches, and the lowest, one foot five inches. They are separated by such a considerable thickness of shales as to preclude their being worked together, but the quality of the coal seems to be very good. The dip is S. 85° W. <30°

Coal-seams on North-west Branch of North Fork.

On the North-west Branch of the North Fork, coal was found in two places. One of these is at the point at which the stream changes its general direction from south-east to east, about two miles and a-half up from its mouth. The section in the right bank is here as follows:—

	FEET.	INCHES.
Superficial gravels		
Coal	1	0
Shale	0	1
Coal	2	6
Shale	0	4
Coal	5	6
Shale	0	6
Coal	0	9
Sandstone	2	0
Coal and shale	2	0
Black shale	1	6
Sandstone	2	0
Black shale, with coaly layers and some ironstone	9	0
Clay shales and ironstone (to water)	6	0
Total coal	9	9

This coal is, so far as composition goes, of good quality, burning with a long flame and coking, but has been much crushed by the movement of the rocks, and is traversed throughout by slickensided surfaces, so that it crumbles very readily.

The second locality is about ten miles further up this stream, near the water-shed range, and in a somewhat inaccessible place. The outcrop examined is half a mile below a picturesque waterfall. The measures are very much disturbed, but there appears to be about three feet of coal in the seam, though much crushed like that last described.

Horizon of the coal.

The coal represented at these localities on the head waters of the Old Man, together with that previously noticed on the North Fork east of the Livingstone Range (p. 103 c), that on the Middle Fork (p. 101 c), and that at the entrance to the North Kootanie Pass are, on various grounds, not necessary to detail at present, supposed to be on the same or nearly the same horizon in the Cretaceous rocks, it being repeated by the folding of the measures.

Coals on Elk River.

There is reason for the belief that the coals on the head waters of the Elk River, west of the water-shed range, again occupy the same horizon. These, though examined in 1883, lie without the limit of the present report.

Thin coal-seams have also been observed on the head waters of the Highwood and Sheep Creek, and it is probable, from the stratigraphical arrangement of the rocks and from the observation of rolled fragments of coal in a number of places, that natural outcrops of coal may be found in many additional localities, in this area of Cretaceous and Laramie within the mountains. Those above noted may be said to have been discovered by us almost accidentally, and the complete examination of this rough wooded region would occupy much time.

Anthracite of Bow Pass.

No allusion is here made to the trough of similar rocks in which anthracite has been found, which occurs on the Bow Pass in the vicinity of the railway line, as this again lies to the west of the area of the present report. This trough is, however, merely a special instance of the inclusion of the newer coal-bearing series in the mountains, in which the disturbance and consequent alteration have been carried so far as to expel almost all the volatile constituents from the coal. Additional instances of included areas of the newer rocks may also probably be found as the mountains are more fully explored.

GENERAL GEOLOGY.

ARRANGEMENT AND COMPOSITION OF ROCKS.

On a former page, a synoptical table has been given of the arrangement of the sub-divisions of the Cretaceous and Laramie of the district. The following scheme shows the sequence and character of the formations of the district in a more detailed form, with the approximate maximum ascertained thickness of each series.*

* The discovery of the Miocene area in the Hand Hills, of which a small portion appears on the northern edge of the map, is the result of work by Mr. J. B. Tyrrell in 1884, in the next adjoining area. It is not described in this report. Prof. E. D. Cope, who has been so kind as to examine some of the bones obtained from this formation in the Cypress Hills, reports that these indicate its age to be lower Miocene equivalent to the White River group.

Table of formations.

Laramie.

Porcupine Hill beds. Sandstones, frequently thick-bedded and generally comparatively soft, with intercalated greyish and blackish shales and shaly clays Fresh water.—2,500 feet.

Willow Creek beds. Soft sandstones, shales, clays and sandy clays, generally with a pronounced reddish or purplish tint. Fresh water. —450 feet.

St. Mary River beds. Sandstones shales and shaly clays in frequent alternations, and generally well bedded. Fresh water except near base.—2,800 feet.

Cretaceous.

Fox Hill Sandstones. In some parts of the district well defined as a massive yellowish sandstone, but inconstant, and apparently often represented by a series of brackish-water transition beds between the Laramie and Pierre.—80 feet.

Pierre shales. Neutral grey or brownish to nearly black shales, include a zone of pale soft sandstone in the north-eastern part of district, and frequent intercalations of harder sandstones near the mountains. Marine.—750 feet.

Belly River series. Composed of an upper, or "pale" and lower or "yellowish" portions, and consisting of alternations of sandstones, sandy clays, shales and clays.—910 feet.

Lower dark shales. Grey to nearly black shales, frequently with arenaceous shales.—800 feet.

Thickness of series.

The figures above given may be regarded as representing the greatest thickness observed in each case, but with the exception of the Pierre shales and Fox Hill sandstones, and possibly of the St. Mary River series and lower dark shales, the exposures from which the thickness was determined were not such as to show that the whole of the series in question was displayed, so that the actual volume may be greater. It should also be remarked that as the measurements given have been derived from different parts of this somewhat extensive district, it may be that the rocks do not show the development above indicated in any one locality. It is probable, however, that the total normal volume of the series included in the list does not fall short of that resulting from the addition of the above figures, viz., 8,290 feet, of which 5,750 feet would represent the Laramie and 2,540 feet the Cretaceous proper.

No unconformity.

There is no evidence of disturbance or any unconformity greater than that caused by trifling local erosion throughout the whole of this great thickness of beds, the passage from one series to the next being frequently of so gradual a character as to leave the observer in some doubt as to the point at which the dividing line should be drawn.

With regard to the composition of the Porcupine Hill beds but little information can be given in addition to that above tabulated. But for the existence, in the southern part of the district, of the well marked Willow Creek horizon, the separation of these from the lower part of the Laramie would be impossible; and as previously stated, it has not been attempted to carry out on the map the subdivision of the Laramie in the northern part of the district. So far as examined, the Porcupine Hill beds are remarkable for the paucity of their organic remains, but further search will doubtless lead to the discovery of some localities in which fossils occur in greater abundance. So far as ascertained there are no palæontological grounds for a separation of these beds from the remainder of the Laramie. The fossil plants from "Shaganappi Point," about two miles west of Calgary, are from this subdivision.

Porcupine Hill beds.

The Willow Creek beds constitute a zone well defined by colour, and to some extent by physical character, in the southern part of the district. The most typical sections examined in detail are those of Belly Butte (p. 56 c) and of the upper part of the St. Mary River (p. 63 c), though the beds in the latter place are inclined at high angles and considerably indurated. The thickness measured at the first-mentioned locality is 190 feet, at the second 214 feet. On the Waterton, a thickness of 450 feet was actually observed, and it is probable that the subdivision is at least fifty feet greater. A thickness of 140 feet is actually seen in single banks on the Old Man River. The beds of this sub-division are also singularly poor in organic remains, and these (as with the foregoing sub-division) are so far as observation goes, confined to fresh-water molluscs, with the exception of a single chelonian. The reddish and purplish tint of many of the beds of this subdivision is their most characteristic feature, but these alternate with pale grey layers which differ from them in colour only.

Willow Creek beds.

The Willow Creek beds evidently extended well in to the base of the mountains in the southern part of the district, as narrow troughs of them occur in the disturbed belt. The section above referred to as occurring on the upper part of the St. Mary is one of these. On the Bow River this sub-division appears to be represented on both sides of the Porcupine Hill synclinal—as described on a former page—but has lost its distinctive colouring. The reddish tint of these beds is, with little doubt, connected in some way with a period of greater waste of the red (probably Triassic) beds of the Rocky Mountains, which occurred at the time of their deposition. This is rendered evident by the fact that the extension of the characteristic tint to the north is conterminous with that of the development of the above-mentioned red beds in the mountains; a fact which also tends to prove that a great part at least of the material of the Laramie was derived di-

Origin of Willow Creek beds.

rectly from the region of the present Rocky Mountain ranges on the west.

St. Mary River beds.

The St. Mary River sub-division is characterized by more rapid alternations in lithological character; sandstones, which are often thin-bedded or flaggy, and shales and sandy shales being represented on the whole in about equal proportion. The sandstones occasionally weather to a yellow colour, but are more usually grey or greenish-grey and often quite hard. The shales and clays are of similar colours but often also carbonaceous. On the Waterton River, the thickness given in the foregoing table was ascertained, but fifty feet or more of the upper portion of the beds here measured may belong to the overlying sub-division, and the base was not seen. At the Indian farm these beds have an estimated thickness of 2,700 feet, and this probably comprises almost the entire volume there developed. On the west side of the Porcupine Hill synclinal, on the Bow, a thickness of about 3,300 feet of the lower part of the Laramie is shown, but of this a portion probably belongs to the Willow Creek beds.

The St. Mary River beds have yielded numerous remains of fresh-water molluscs, the richly fossiliferous beds described as occurring on the St. Mary and Pincher Creek (pp. 57c, 97c, 37c) belonging to a horizon in its upper part. It has also afforded dinosaurian remains, and contains beds of lignite or coal, particularly in its lower part. The coals found near the Indian farm and Coal Creek probably belong to this series, and a well defined lignite-bearing zone outcrops at Scabby Butte, on the Little Bow, Bow and Red Deer Rivers.

Extent of Laramie.

The Laramie beds do not anywhere extend to the eastern edge of the map, and, with the exception of its northern part, are now represented only in its western half.

Fox Hill sandstones.

The Fox Hill sandstones are well defined only in the south-western part of the district, crossing the St. Mary with a thickness of about 80 feet, as above indicated. These typical beds have yielded no fossils, but they may evidently be regarded as an upper portion of the Pierre, with the shales of which some sections show an inter-bedding. They are included under a single colour with the Pierre on the map. On the Old Man River at Rye-grass flat, at Scabby Butte and on the Little Bow, Bow and Red Deer rivers, the western outcrop of the Laramie is associated with a thick series of yellowish and greyish sandstones and sandy shales and clays, holding a brackish-water fauna and passing down into the Pierre. As the Fox Hill beds proper are not here developed, it is probable that these may represent that series in whole or in part, but as their fauna appear to ally them most closely with the Laramie, they have not been separated from that series. These beds are also displayed at a number of places in the disturbed belt west of the St.

Extensive brackish-water transition series.

Mary and south of the Old Man. The most characteristic forms which they contain are *Corbicula occidentalis*, *Corbula* n. sp. like *C. pyriformis*, and a large rough *Ostrea*. At Scabby Butte they yield fragmentary dinosaurian and chelonian remains in great abundance. Coaly zones also occur, and the coals at the Indian farm and on the St. Mary River near the Boundary line are near this horizon and may possibly belong to it. At one place on the Bow (p 84 C) the passage upward from brackish-water or marine conditions to fresh-water may actually be observed in a single section.

A thickness of 840 feet of these beds was measured at Rye-grass flat, and they form a portion of the 990 feet of beds observed by Mr. McConnell to overlie the Pierre on the Red Deer.

Pierre shales.

The Pierre shales are as a whole remarkably characteristic and constant, and may be regarded as forming the key to the stratigraphy of the entire district. The only place in which a satisfactory estimate of their total volume has been obtained is on the Red Deer River, where they are 750 feet in thickness. They are marine throughout and in occasional layers highy fossiliferous, the fossils as a rule being preserved in the layers or nodules of ironstone, which are abundant. There is reason to believe that these shales—and probably the rocks of the entire section—are abnormally thin in the vicinity of Milk River Ridge.

Upper portion of Pierre shales.

On the Old Man River below Rye-grass flat, the upper portion of the series, for a thickness of about 40 feet, is composed of coffee-coloured sandy shales in very regular beds each of a few inches in thickness. North-eastward, on the Bow, these peculiar beds have increased to a thickness of 135 feet or rather more, and still further in the same direction, on the Red Deer, have a volume of 500 feet and constitute a large part of the whole series. These beds include red-weathering ferruginous layers and also, in the last-mentioned locality, greyish sandy beds. The Pierre on the Bow is capped by a good seam of lignite-coal, but this was not seen elsewhere. Near the base of the series on the Bow is a zone of pale soft arenaceous beds which is probably 50 feet or more in thickness.

Base of Pierre shales.

Wherever the bottom of the Pierre has been observed, it is characterized by a carbonaceous horizon, yielding coals or lignite-coals which are frequently of workable thickness. These are best developed on the Belly River and are illustrated in the sections facing p. 72 C. This horizon includes alternating greyish and blackish shales and arenaceous beds different in character from the typical Pierre shales. In it a bed holding *Ostrea subtrigonalis* in great abundance, with occasional fragments of *Unio* have been observed at the mouth of the St. Mary and at Milk

River Ridge. It evidently constitutes a series of passage beds between the Pierre and the next underlying series.

Pierre shales near mountains.

Near the mountains, the Pierre shales become much more arenaceous and include many beds of sandstone, which in a few places become actual conglomerates, and there is every evidence of approach to a shore-line in this direction. This renders the definition of the Pierre in the disturbed belt additionally difficult, and it is besides often impossible in this region to know whether a given shaly zone belongs to this or the lower shaly series.

Upper portion of Belly River series.

The pale upper portion of the Belly River series is well shown on the Belly above Coal Banks, and a typical section of a portion of it in Fossil Coulée, Milk River Ridge is described on page 50c. It is composed for the most part of sandy clays, with shales and sandstones, the latter often of considerable thickness, and usually rather soft, or irregularly hardened. Layers of ironstone nodules, which are at times very large, are of frequent occurrence, and the beds generally have a characteristic bluish- or greenish-grey tint, and are on the whole rather massive, and weather easily into bad-lands. In these features, with the occurrence of rolled clay pellets, and the rounded character of many of the included bones, there is evidence of a considerable amount of current or wave action.

In Fossil Coulée, a thickness of 123 feet of this part of the Belly River series was observed; on the Old Man River above Coal Banks, at least 200 feet; on the Red Deer River at least 460 feet.* On the Milk River east of the area of the present map at least 300 feet, and by Mr. McConnell on the South Saskatchewan (also east of the map) at least 400 feet. This and a part of the lower or yellowish portion of the same series are represented still further east by the section measured by me near the East Fork of Milk River.†

Fossils and coals.

Near the top of this upper pale portion of the Belly River series, marine or brackish-water molluscs are occasionally found, but it must be considered on the whole as a fresh-water formation. Molluscs are, however, everywhere rather rare, though dinosaurian remains are in some places moderately abundant. (See p. 38 c). At the base of this portion of the series, or near the summit of the next, a carbonaceous zone occurs on the Bow, Belly and South Saskatchewan Rivers. The lignite-coals of these somewhat widely separated localities may not represent a single seam, but are in all probability not far from one horizon. On the Red Deer two seams of lignite-coal occur which appear to be some distance above the base of the pale beds.

Lower portion of Belly River series.

The separation of the lower, or yellowish and banded portion of the

*Geology and Resources of the 49th Parallel, p. 120.

†Ibid, p. 114.

Belly River series, from that above referred to, is made merely for convenience of description and is probably not warranted in any other sense. The distinctive characters of the two portions of the series are indeed so indefinite that though little hesitation might be felt in relegating a given large exposure to one or other, the points of difference vanish when any attempt to draw a precise line is made. The yellowish and brownish colours of the lower beds are probably in connection with the fact of their brackish-water character, evidenced by abundant and well-preserved molluscs; but in addition, this lower portion of the series is more evenly bedded and composed of more rapidly alternating layers. These consist of sandy clays, sandstones, and shales, which frequently blend so completely with each other as to render it very difficult to give definite measured sections. Those described on pages 44c and 76c may be taken as most characteristic. The top of this portion of the series appears to be defined on the Belly River by some rather massive yellowish sandstones, and this is probably also the case on the Bow. On the Milk River near Dead Horse Coulée, and in the escarpment of the Rocky Spring Plateau, massive grey and yellowish sandstones, irregularly hardened and often weathering into remarkable castellated forms, occur at its base. Besides the molluscs above alluded to, dinosaurian, chelonian and other bones are found in some places in considerable abundance.

Thickness.

Of these yellowish beds about 350 feet was found on the Milk River east of Pā-kow-kī Coulée, and this is probably the full thickness at this place, while 150 feet or more is shown on the Belly underlying the lignite-coal last alluded to. Lignite seams are also found well down in these beds, but so far as observed they are quite unimportant in character.

The Belly River series has not yet been definitely identified in any part of the disturbed belt bordering the mountains, where, from the complicated character of the sections and absence of fossils, it is difficult to discriminate between it and the lithogically similar beds of the Laramie.

Lower dark shales.

The lower dark shales are clearly seen to underlie the yellowish portion of the Belly River series on Milk River at Pā-kow-kī Coulée. The main lithological difference which their upper portion shows, as compared with the Pierre, is the greater abundance of sandy and calcareous shales. The lower beds were not well seen, except in the country south of the Rocky Spring Plateau, where sections of limited size appear to show that they are soft and very dark shales. The fossils are marine, and with the exception of a few large reptilian bones from the west flank of the West Butte, all molluscs.

Thickness.

In Rocky Spring Plateau a thickness of 235 feet of these beds was examined (p. 42c.) It is probable that their entire thickness is about 800 feet at the West Butte. It is almost certain that a number of the bands of dark shales met with in the disturbed belt belong to this series.

Conditions of deposit implied by rock-series.

We thus find that the oldest Cretaceous beds so far defined in this district are marine, that the marine are succeeeed by brackish-water conditions, in the lower part of the Belly River series, while a fresh-water lake followed in the period represented by the upper portion. Renewed subsidence brought the sea once more over the region, and the Pierre shales were laid down, but toward the close of this period the waters became shoal, limited areas supported a brackish-water fauna, and as this was gradually extinguished the great fresh-water Laramie lake covered the region and continued to prevail to the close of this record. The whole district was probably one of gradual or intermittent subsidence throughout Cretaceous and Laramie time, and there is reason to believe that the amount of subsidence and thickness of sediments was greatest in the vicinity of the present position of the eastern ranges of the mountains. The Cretaceous and Laramie beds spread far into the mountain region, where they now occur in isolated troughs and basins, and it is evident that the greater portion of the existing Rocky Mountain range was upheaved at a date long subsequent to the latest of the beds here described. It is also shown, however, that land, possibly in the form of an archipelago, existed in this vicinity, and that rocks similar to those of the mountains of to-day and hardened to a like extent, were there undergoing denudation, and supplied the material not only for the conglomerates above alluded to, but also for the finer beds now underlying the area of the plains. It must further be conceded that tracts of low land appeared above the surface at a number of epochs, and indeed that at several stages the region was preponderatingly one of swamp and morass in which the vegetation which has produced the coals and lignites grew and accumulated.

Comparison with Peace River section.

The general sequence of events is precisely similar to that proved to have taken place mnch further north in the region of the Peace River, with the rock series of which the present section may instructively be compared.*

Stratigraphical position of the beds of the Belly River Series.

General bearings of the question.

As the general section of the rocks of the region embraced by this report differs so considerably from that usually taken as typical in the contiguous Upper Missouri region, it seems necessary to review the main points in evidence which have led to its adoption. These points have been carefully considered in all their bearings, and have also

*Report of Progress Geol. Surv. Can., 1879-80 been made the subject of additional special investigations in the field. It has not been till, as I conceive, every reasonable alternative has been proved untenable that I have been obliged to change the opinions expressed in 1875 in regard to a considerable part of the beds reported on in the Geology and Resources of the 49th Parallel, and to adopt the scheme here given, which appears also to involve some modification of Messrs. Meek and Hayden's later views on the order of succession of the Cretaceous subdivisions.

Dr. Hector's views.

The views now held, however, it may be mentioned agree more nearly with those entertained by Dr. Hector, in his final reports, which—judging from Missouri analogies and my own reading of the sections on the 49th parallel in 1874—I was inclined to doubt.*

Present position of the question.

Briefly stated, it would appear from the investigations now reported on† that considerable areas of the beds, which in 1874 I called "Lignite Tertiary"—here and in previous announcements designated as the Belly River series—must be relegated to a position below the Pierre shales, or at least to one below an upper portion of these shales. The beds thus separated as the Belly River series, were, in 1875, by me correlated with the Judith River series of the Missouri.‡ Additional and extensive collections of fossils since obtained, and now being worked out, confirm and strengthen this correlation, and lead to the presumption that the so-called Judith River series must also occupy a position well down in the undoubted Cretaceous. It may be added that this was the view originally held by Messrs. Meek and Hayden, and supported, it would appear, not alone on the supposed analogies of the vertebrate remains examined for them by Prof. Leidy, but also on stratigraphical evidence,§—evidence which perfectly agrees with the impressions resulting from such cursory examination as I was able to make of the Missouri sections from the deck of a steamer while ascending the river in 1881. It may further be interesting to note that the sequence of the Cretaceous subdivisions here maintained, brings these into exact parallelism with those previously studied on the Peace River, near the 56th parallel of north latitude.

While allowing that the question is one deserving still further investigation, it may be stated that a careful study of all the available facts in the region now under discussion, leaves me no option in representing these rocks as they appear on the map. It is proposed here to present a synopsis of these facts.

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* Geology and Resources of the 49th Parallel, p. 158.

† See also Note on Geology of the Bow and Belly River Region, 1882, Proc. Royal Society of Canada. Section IV., p. 39. Science Vol. iii., p. 647.

‡ Op. cit. p. 156.

§ Proc. Acad. Nat. Sci. Phil., Vol. viii., p. 114.

Wide undulations of the Cretaceous and Laramie.

Eastward from the edge of the disturbed belt of Cretaceous and Laramie rocks which immediately fringes the mountains, the general structural features of the district are very simple. We cross first a shallow synclinal, which widens much northward, and the axis of which is occupied for a considerable portion of its length by the Porcupine Hills. East of this, and occupying the whole eastern part of the map, is a still more diffuse anticlinal swell, the axis of which runs first a few degrees west of north, to the confluence of the Bow and Belly, then east of north to the edge of the district. The intrusive masses of the Sweet Grass Hills occupy the centre of this great anticlinal swell, where it crosses the 49th parallel; and around the northern flanks of these, and in the valley of Milk River opposite them, what appear to be the oldest rocks exposed in the district occur. These are dark shaly and sandy beds, elsewhere fully described, which though holding a rather mixed fauna, still show several forms usually considered as distinctively belonging to the horizon of the Pierre, and render it probable that these beds do not represent the typical Benton group, which their relations would otherwise appear to favour. These beds undoubtedly underlie the Belly River series, as is clearly shown on the Milk River, at the mouth of Pā-kow-kī Coulée. They re-appear in the south-eastern escarpment of the Rocky Spring Plateau immediately south of the 49th parallel. (See p. 42 c.)

Relations of series near east edge of map.

Along the eastern side of the broad anticlinal above defined, the relation of the Belly River series to the typical Pierre shales is very clear. Lying above the lower dark shales, at the point on Milk River just alluded to, it is continuously exposed in the valley of the river to the eastward to its crossing of the 49th parallel. The yellowish, or lower part of the Belly River series at first occupies the banks to the prairie level, but in consequence of a light eastward dip, which—as estimated in a distance of seven miles near the 49th parallel—amounts to at least thirteen feet to the mile, the whitish, or pale coloured upper portion of the series soon appears, forming a somewhat higher plateau on both sides of the river; and before the valley ultimately crosses the Boundary line, seems to occupy the entire height of the river-banks, with a thickness of at least 300 feet. The north-eastern edge of the higher plateau above noted, is found near the Lac des Marrons, beyond the edge of the present map, and in this region (which is at present being mapped by Mr. McConnell), similar light easterly dips have been found to prevail, though the angle is probably somewhat greater than on the Milk River. As a result of this dip the Pierre shales are soon found to occupy the whole surface of the country, notwithstanding the fact that the level of the prairie to the eastward is lower than that of the above-mentioned plateau. On Sage Creek, north of the Lac des Marrons, Mr. McConnell has actually observed the superposition of the Pierre on the upper or pale-coloured beds of the Belly River series.

As above stated, the axis of the wide anticlinal runs in a north-westward and south-eastward course near the 49th parallel, and about one hundred and seventy miles distant, at the mouth of the Milk River, nearly in the continuation of the same bearing, the arrangement just described appeared to be exactly repeated. It may be well to quote Messrs. Meek aud Hayden's observations on this point. These authors write :—"Near the mouth of the Milk River, Cretaceous strata which are not seen for a long distance below this on the Missouri, again rise to view. They consist of the upper two members of the series (No. 5 and No. 4),* which, in consequence of their inclination to the east, are found to rise higher and higher as we ascend the river, so that nearly all the hills close to the Missouri, between Milk and Mussel-shell rivers, consist of these formations. Some four or five miles below the mouth of the Musselshell River, a lower rock,—a sandstone,—rises above the water level. This is probably No. 1 of the series, No. 2 and No. 3,† not being represented here." * * * "In consequence of the increasing inclination of the strata, this last-mentioned sandstone rises in the vicinity of North Mountian River as much as 250 feet above the Missouri. Here, or near this, begins a wild and desolate region known as the *Mauvaises Terres* or Bad Lands of the Judith. At various places in these Bad Lands a sandstone similar to No. 1 was seen alternating with beds of clay and lignite, all of which are upheaved and much dis-torted. It was found impossible to devote to the examination of these formations time enough to determine their relations to the Cretaceous and Tertiary strata of this region, without running the risk of being cut off from the party and murdered by the Indians." After a notice of the fossils collected, it is added: "From these facts, we are strongly inclined to think with Prof. Leidy, there may be here, at the base of the Cretaceous system, a fresh-water formation like the Wealden. Inasmuch, however, as there certainly are, some outliers of fresh-water Tertiary in these Bad Lands, we would suggest that it is barely possible these remains may belong to that epoch, though the shells appear to be all distinct species from those found in the Tertiary at all the other localities in this region."‡

Similar sequence of beds on the Missouri.

It may be worthy of note, that not only the Sweet Grass Hills, as above stated, but the Bear's Paw and Little Rocky Mountains lie nearly on the line of the southern portion of the anticlinal swell previously referred to. I am unacquainted with the geological structure of the two

Line of intrusions along anticlinal.

* Fox Hill and Pierre.
† Dakota, Benton and Niobrara.
‡ Proc. Acad. Nat. Sci. Phil., Vol. viii., p. 114.

last named groups of mountains, but think it probable that it resembles that of the Sweet Grass Hills, while the disturbed region, above described by Messrs. Meek and Hayden, nearly forms a continuation of the same line, and the disturbances, which are of a local character, are connected with the appearance of igneous dykes and protrusions.

Base of Pierre shales proper.

As previously shown in detail in this report, one of the most constant features throughout the entire district is the occurrence of a coal-bearing or lignitiferous horizon at the base of the typical Pierre shales.*

Western edge of Pierre area beyond limit of map.

This is found in its usual position in the sections on Sage Creek above alluded to, and serves to assist in the definitive correlation of the overlying shales with those above the coal at Coal Banks, Belly River. On Sage Creek a length of outcrop of two miles showed a south-eastward slope of the base of the Pierre at the rate of twenty-five feet to the mile, though this may not represent the direction of greatest inclination here. Beyond this place, the general trend of the western or lower edge of the Pierre shales is a few degrees west of north for about forty miles, to the low hills near the Bull's Head and north of Peigan Creek, the outcrop of its base nearly following a contour line at a height of 3,000 feet, but declining slightly to the north. East of Lake Pā-kow-kī the Pierre forms well marked plateaus, while the lower country between these and the lake, in the valley of Many Berries Creek and two streams north of it, shows fine sections of the upper or pale-coloured portion of the Belly River series. After a concealed interval, the base of the Pierre shales, with its usual carbonaceous character, is again seen in a tributary of Peigan Creek, south of the main stream. From the hills above characterized as near the Bull's Head, where the base of the Pierre shales is found distinctly overlying the pale beds, it appears to run north-eastward for about twenty-eight miles to Ross Creek,† near the line of the Canadian Pacific Railway, where its relation to the underlying beds and coaly base were again observed by Mr. McConnell. In this distance the level of the base decreases by at least three hundred feet, though the direction of dip is probably more nearly east than north-east.

Eastern outcrop of upper part Belly River series.

With the exception of inconsiderable concealed areas, the upper portion of the Belly River series is traceable from the Bull's Head Hills north-westward to the South Saskatchewan near Medicine Hat, where it is again recognisable, and caps the lower or yellowish portion of the same series. North of the railway line, in this region, the drift covering is so deep that it is difficult definitely to trace the edge of the Pierre,

* This horizon I observed occupying the same position on the Missouri, where it is also described by Prof. Cope. Bulletin U. S. Geol. and Geog. Survey, Vol. VIII., p. 566.

† Near Irvine Station, sixteen miles east of Medicine Hat.

but on the Red Deer River, north of Rainy Hills, Mr. McConnell has observed the Pierre shales overlying the pale upper beds of the Belly River series, the thickness of the shales seen being about one hundred and fifty feet. The same circumstance is also reported by him on the South Saskatchewan, thirty miles north of Medicine Hat, where, however, owing to the small thickness of the overlying shales, there is perhaps some doubt as to their identity. In both localities, however, carbonaceous beds occur near the base of the shales.

Transverse sections of area of Belly River series.

From the Medicine Hat exposures of the Belly River series, these beds have been followed westward along the South Saskatchewan to the confluence of the Bow and Belly, and thence up both these rivers, continuously, or with but small and unimportant gaps where the beds are concealed, to the western line of outcrops of the Pierre shales, as defined on the map. The beds are throughout horizontal, or show merely light local undulations, scarcely greater than may be due to original irregularity in deposition. At two points, described on previous pages of this report, one on the South Saskatchewan and one on the Bow, the distinctively pale upper part of the series is seen overlying and passing into the lower yellowish and banded beds.

Relations of series near Coal Banks.

On the western side of the wide anticlinal, below Coal Banks on the Belly, the superposition of the Pierre shales on the pale beds of the Belly River series is perfectly clear, and is again well shown at the mouth of the St. Mary River. The same may be said of the Red Deer, where examined by Mr. McConnell. On the intervening Bow River this junction is not actually seen, but the general sequence in descending the river is the same. These sections are elsewhere fully described.

Relations of series in Milk River Ridge and on Milk River.

In the Milk River Ridge and on the Milk River west of the MacLeod-Benton trail the relations of the Pierre shales to the Belly River series are not so distinct, and had this been the only district available for study, it might have been assumed that the yellowish, and as I believe, lower portion of the Belly River series, formed an upper set of beds *overlying* the Pierre shales. Between the southern end of the Porcupine Hill synclinal and the great low anticlinal previously defined, an additional anticlinal swell of the slight kind characteristic in this region, is found. This is most pronounced at the Milk River Ridge, but may, perhaps, be traceable northward in a much reduced form to the Belly below the mouth of the St. Mary River. South of Middle and Ed. Mahan's Coulées, the Milk River Ridge is capped by the Pierre shales, the coal-beariug horizon being displayed in a number of places, but much reduced in importance as compared with its development at Coal Banks. The pale upper portion of the Belly River series is well shown in several places below it, particularly at the locality named Fossil Coulée, and a few miles east of this point an oyster bed, identical with that occupying a similar position at the mouth of the St. Mary, is associated with thin coal-seams. From Fossil Coulcé to a point on the Milk River, twelve miles south-eastward, the base of the Pierre dips at the rate of nearly sixty feet to the mile, and it is not known whether this is the direction of greatest slope. After a concealed interval of about a mile and a half on the river, yellowish sandstone and sandy clays appear, and so far as the rather limited sections show, run down the Milk River for many miles, nearly following its eastward slope.

Rocks on Verdigris Coulée.

Along Verdigris Coulée to the north-east, are good sections of beds which, from their lithological character might represent either the pale or yellowish portion of the Belly River series. The appearance is at first sight quite in favor of the belief that all these overlie the Pierre shales. On working out, however, the barometric elevations for this part of the country, it is found that to the north-east of the ridge, the general level of the surface descends about as rapidly as the slope above determined for the Pierre, for a part of the distance, and I believe that probably in consequence of a light westward dip affecting the beds of the region east of the McLeod-Benton trail, combined with the general descent of the level of the prairie, the Pierre shales run out eastward, and the beds above referred to on Verdigris Coulée occupy in reality an inferior position, as the previously detailed observations appear to prove elsewhere.

Thickness of Belly River series on Milk River.

On the hypothesis thus accepted, however, it is evident that the whole thickness of the Belly River series must outcrop along the Milk River between the Pierre shale exposures in the vicinity of the Mac-Leod-Benton trail-crossing and the appearance of the lower dark shales on the river north of the Middle Butte,—a distance of about thirty miles. As a matter of fact this distance is still further reduced to that between the McLeod-Benton trail and mouth of Verdigris Coulée—about twenty miles—by the circumstance that the castellated or pillared sandstones, the top of which sinks below the river level near the mouth of Verdigris Coulée, have been traced at a varying height along the sides of the main valley to the mouth of Dead Horse Coulée, and through this coulée, in a modified but perfectly recognizable form to its east end, where they closely approach, but were not observed in contact with the supposed lower zone of dark shales. Disregarding light minor undulations, these sandstones may be considered as indicating the proximate horizontality of the beds, for, in a short distance of three miles below Verdigris Coulée, they rise eastward at the rate of about twenty-three feet to the mile in the bank, a rise which is nearly accounted for by the slope of the river-valley itself, but perhaps favors the belief in a very light westerly dip in addition. From observations detailed elsewhere, there is little doubt that these sandstones immediately overlie the lower dark shales.

On the supposition of the horizontality of the beds, the increased elevation of the country westward to the Pierre shale outcrop near the McLeod-Benton trail-crossing allows a thickness of about four hundred and sixty feet of beds to be accounted for, adding to which the maximum observed thickness of the sandstones themselves, a total maximum thickness of about 530 feet might be allowed for the entire thickness of the Belly River series in this region. This is somewhat less than the thickness of the series as elsewhere developed would lead us to expect, and may by closer examination be still further reduced. In this connection, however, it is interesting to note that the Pierre shales on the Milk River—though their precise volume has not been determined—are evidently much thinner than on the Belly at Coal Banks, and further, that the sections on the Milk River, near the west end of the ridge, show that the lower, or St. Mary River sub-division of the Laramie, as compared with the section to the north, on the St. Mary, is quite thin also. These facts concur in indicating that the region now occupied by Milk River Ridge may have been an area of small deposition throughout later Cretaceous and Laramie time, probably owing to its greater elevation as compared with the rest of the sea-bottom. A further circumstance which may be referred to as favouring this view,—though in itself proving nothing,—is the existence of ripple-marked sandstones in several places along the St. Mary, to the north, indicating currents at right angles to the trend of the base of the mountains, which, if no tranverse barrier such as shoal water or land existed in this vicinity, it is difficult to explain.

Cretaceous and Laramie thin near Milk River Ridge.

Probable shoal near present position of the Ridge.

Before leaving this region, it may be well to note that while the dark shales of the series exposed in the south-eastern escarpment of the Rocky Spring Plateau, closely resemble those seen on the flanks of the West Butte, their agreement is not so satisfactory with those of the Milk River, north of the Middle Butte and at the mouth of Pā-kow-kī Coulée, while on the hypothesis adopted, all these localities must represent a single lower subdivision. The Milk River sections just referred to, however, show only the upper part of the series, while the alternative hypothesis, viz., that the whole belong to the Pierre shales proper, also necessitates this correlation and besides involves their identity with the Milk River and Coal Banks shales, which are still more dissimilar. We must, in any case, be prepared to allow considerable local diversity in this area.

Diversity in character of shales.

Taking the whole district into consideration, the only reasonable alternative scheme of arrangement of the beds by which the yellowish and banded series here included in the Belly River series and holding Judith River fossils can be assigned a position above the Pierre, implies their unconformity on the Cretaceous proper. There can be no possible doubt as to the position below the Pierre shales of the pale

Other possible hypotheses as to position of Belly River series.

beds which are here classified as the upper portion of the Belly River series. It might be *assumed* that the yellowish and banded beds overlie these unconformably, but we must then also admit that on the Bow and Saskatchewan rivers these are capped by a *second* pale series, lithologically precisely the same with that above referred to. Further, we must suppose that a great basin had been produced in the Cretaceous by denudation, and that this was so formed that around its whole margin, both on the east and west sides, its shore-line consisted of the pale beds known to underlie the Pierre shales proper. However improbable such a co-ordination, it appeared to afford a possible alternative. During the past season, however, it has been found that in a number of places, the pale beds actually seen beneath the Pierre shales, hold molluscs identical with some of those in the yellowish beds, and with those of the so-called Judith River formation. One of the most characteristic and abundant is *Corbula perundata.* Even the adoption of the improbable hypothesis above outlined, therefore, does not free us from the necessity of allowing the existence of a Judith River fauna below the typical Pierre shales, and it was this very circumstance which led to the endeavour to explain the section on the supposition of the superior position of the yellowish beds, and the wish to establish a line of distinction between these and the pale beds, with which all the observed facts seem to show that they are inseparably connected.

Palæontological evidence.

Without entering at length into the palæontological evidence, which is at present being investigated by Mr. Whiteaves, it may be proper to state, in further confirmation of the section here adopted, that where beds known to represent the brackish-water base of the Laramie occur, at Rye-grass flat on the Old Man River, at Scabby Butte, and on the Bow a few miles above Blackfoot Crossing, the general facies of the fauna differs considerably from that of the Belly River series. This is particularly shown by the constant presence in these beds of a large *Corbula* resembling *C. pyriformis,* but specifically new, which has not been found in the Belly River series ; also by the entire absence from these beds of *Corbula perundata,** one of the most abundant and characteristic forms of the Belly River series, and this though the conditions under which both sets of beds have been deposited, must have been practically identical.

Evidence afforded by fuels.

The position which the fuels contained in the rocks of the Belly River series, are found to occupy with respect to composition appears to afford additional conformatory evidence of the position assigned to them, from an unexpected quarter. (See p. 136 c).

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* A single exception to this statement may possibly be found in the case of a shell much resembling *C. perundata*, which occurs in the loose fragrant referred to on p. 37 c, as being probably of Laramie age.

USEFUL MINERALS.

COALS AND LIGNITES.

Great abundance of coals and lignites.

In the area included in the present report nothing is more remarkable than the universal distribution and vast aggregate quantity of fuels available for economic purposes. The Belly River series, the Pierre and the Laramie formations all contain fuels of a workable character, and it may be stated without exaggeration, that practically the whole of the area which in a preceding chapter is designated as "the plains," is, so far as can be ascertained from the natural exposures, continuously underlain by coals or lignites, while considerable tracts are underlain by two or three successive fuel-bearing horizons. Within the area of the accompanying map there is, in fact (with the exception of a small district in the north-east corner which may yet be found to lie near outcrops in the adjoining areas to the north or east) no point more remote than thirty miles from some natural coal or lignite outcrop suitable at least for local use, while the natural exposures in several localities serve to prove the existence of available and easily accessible fuel for centuries of consumption on the most liberal scale.

Estimates of quantity of fuel.

The data available from the natural outcrops are insufficient to enable any general estimate of the quantity of mineral fuel existing in the entire region, but of this some idea of an approximately correct character may be formed for certain limited districts, and this is amply sufficient to show that the supply is practically inexhaustible. The horizon at the base of the Pierre is the most persistently coal-bearing so far proved in this region, and has been found to carry seams of varying thickness and quality wherever good sections of it occur. The outcrop of these fuels which occurs on the Belly River, near Coal Banks, has been traced southward at intervals nearly to the 49th parallel, and north-eastward to the Red Deer, a total distance of about one hundred and fifty miles. The southern and south-eastern extremities of this outcrop can not, owing to the thin character of the seams, be ranked as workable, but on the Belly and lower part of the St. Mary a length of outcrop of fully eighteen miles may be considered—from the existence of numerous good sections—as workable throughout, and in the immediate neighbourhood of Coal Banks, as stated in the preliminary report, is estimated to hold 5,500,000 tons of coal per square mile. Assuming—an assumption probably far below the mark—that this fuel may be worked with the greatest facility for a width of a mile, the length of eighteen miles of outcrop above defined would alone contain 99,000,000 tons. It is the same coal-bearing zone which occurs at a

Coal-seams at base of Pierre.

distance from the St. Mary River sections of sixty-six miles, on the Bow River at Grassy Island, where a quantity of 5,000,000 tons has been estimated as underlying each square mile. This may be assumed as a probable minimum for the portion of the outcrop above stated. That it continues at this or a greater thickness along the entire intervening length can be actually determined only by a system of borings, but if it falls below this figure in some places, this is probably more than compensated by the increased thickness in others, and by the fact that it may be worked—in consequence of its nearly horizontal attitude—much further from the outcrop than one mile. Taking the above minimum figure, however—merely for the purpose of forming a rough estimate of the capabilities of this seam—it is found that the resulting quantity for one mile in width along the line of outcrop is 330,000,000 tons, or, allowing for waste, equivalent to an output of about 1,000,000 tons for a period of 300 years.

Medicine Hat seam.

The thickest seam found underlying the county in the vicinity of the Medicine Hat mines, may also be stated, on the average, to equal about 5,000,000 tons to the square mile, and the sections in the river banks may safely be assumed to prove its existence for an area of thirty square miles, the workable coal underlying which would, therefore, be about 150,000,000 tons.

Horse-shoe Bend seam.

The seam near Horse-shoe Bend, on the Bow, has been estimated to equal about 4,900,000 tons per square mile. As this seam has, however, only been seen at a few places in this one locality, and is probably of a local character, it would scarcely be safe to assume that it underlies more than ten square miles, giving a total of 49,000,000 tons.

Blackfoot Crossing seam.

The river exposures in the neighbourhood of the Blackfoot Crossing, together with the borings lately carried out by the Canadian Pacific Railway Company and the general persistence over the entire region of a seam at about this stage in the Laramie, appear to render it safe to state the proven area in this vicinity at about thirty square miles, which, as this seam is a thick one, should hold coal to the amount of 9,000,000 tons per square mile, or a total of 270,000,000 tons.

Practically inexhaustible character.

By computing the amount of fuel for a small area in connection with the outcrops on the Red Deer, and in the numerous localities in the foot-hills and mountains at which good seams occur, the figures above given for a few districts might be vastly increased, but the practically inexhaustible character of the deposits once conceded, these would possess little additional meaning. While over the area of the plains the nearly horizontal attitude of the beds and the persistent cover of drift deposits prevents the foot-by-foot tracing of the seams, they may be very readily proved wherever desired by boring, and may be cheaply and conveniently mined. As the foot-hill region becomes more thoroughly known and thickly settled, numerous additional coal localities will doubtless be found, for the seams are there repeated along a number of lines by the parallel folding of the beds, and nothing short of a very minute examination will serve to exhaust the possibilities of even the natural exposures. The seams are, in this belt, found at all angles up to verticality, and though thus likely to cause greater complications in extraction, this is compensated for by their superior quality, the fuels of this district being all true coals, as distinguished from the lignite-coals and lignites of the plains. The same remarks apply to the very interesting areas of Cretaceous and Laramie rocks forming basins or troughs between the Palæozoic ranges of the mountains. Coals in the foot-hills.

Touching the quality of the coals and lignites, full and precise details will be found in the accompanying report by Mr. C. Hoffmann, where also remarks and experiments bearing on their practical value and utilization are given. Further statements under this head, which it is unnecessary to repeat, are published in my preliminary report, forming a part of the Report of Progress for 1880-82. It may be desirable to add, however, that some of the coals of the mountains and foot-hills rank no whit behind those of the Carboniferous or coal-bearing formation of Nova Scotia and the Eastern States, while even those classed as true lignites are greatly superior to wood in heat-producing power, and may, with suitable conditions of combustion, be employed successfully not only for ordinary domestic heating, but for steam-raising and in manufacturing purposes generally. For use in burning bricks, which on account of the scarcity of wood for purposes of construction is an important consideration, lignites of even the lowest class may be employed. Quality of the fuels.

The value of the coals of the mountains and foot-hills in connection with the mining, smelting, and reduction of the metalliferous deposits likely there to be developed, is very obvious ; and for purposes of this kind some even of the more remote and inaccessible seams may eventually be utilized.

The annexed list enumerates the principal localities where natural outcrops of coal have been found, and serves, in this regard, as a key to the descriptive portion of the report :—

List of the principal localities in which natural outcrops of coal and lignite are known to occur, within the area covered by the present report and map.

	Locality.	Thickness of Seam.	Page of Report on which deposit is described.
1	Milk River, 8 miles west of MacLeod-Benton trail-crossing	3 to 4 seams of about 6 inches	39 c.
2	Milk River Ridge; north slope at head waters of Middle and Ed. Mahan's Coulées	1 ft. 6 in.	50 c.
3	Three miles north of Milk River, opposite Dead Horse Coulée	3 ft. 6 in.	43 c.
4	Coulée 3 miles south of east end Lake Pa-kow-ki	1 ft.	
5	Forty-mile Coulée, near Cypress trail-crossing	1 ft. 2 in.	53 c.
6	St. Mary River, 2 miles north of 49th parallel	1 ft. 6 in.	54 c.
7	Upper Belly River, 16 miles north of 49th parallel	1 ft.	61 c.
8	St. Mary River, 9 miles above mouth (several seams, two separated by two inches shale)	2 ft.	59 c.
9	St. Mary River, 7 miles above mouth (several seams, thickest)	3 ft. 8 in.	60 c.
10	St. Mary River, at mouth	3 ft. 6 in.	69 c.
11	Coal Banks, Belly River (main seam)	5 ft. 4 in.	70 c.
12	Belly River, 6 miles below Coal Banks (main seam)	6 ft.	73 c.
13	Belly River, 9 miles below Coal Banks (main seam)	4 ft. 8 in.	73 c.
14	Belly River, near Woodpecker Island	3 ft. 3 in.	75 c.
15	Belly River, north-west angle of Drift-wood Bend. (The seam referred to in this and the note immediately foregoing is the same, and is seen in a number of places along this part of the river).	1 ft. 6 in.	75 c.
16	South Sasketchewan River in numerous exposures from near Medicine Hat to a point 24 miles west of that place	1 to 8 ft.	77 c.
17	Scabby Butte	1 ft. 3 in.	79 c.
18	Bow River, near mouth of Highwood	A few inches	83 c.
19	Bow River, 4 miles west of Blackfoot Crossing	1 ft.	85 c.
20	Bow River, 3 miles east of Blackfoot Crossing (several seams closely related, total coal)	8 ft. 11 in.	86 c.
21	Coulée 6 miles south-east of Blackfoot Crossing (two seams closely related)	4 ft. 6 in.	86 c.

List of the principal localities in which natural outcrops, &c.—Continued.

	Locality.	Thickness of Seams.	Page of Report on which deposit is described.
22	Bow River, 3 miles south of Horse-shoe Bend	4 ft. 4 in.	89 c.
23	Grassy Island, Bow River (main seam)............	4 ft. 6 in.	90 c.
24	Bow River, south-east of Little Rolling Hills (thickest seam)	1 ft. 6 in.	92 c.
25	Little Bow River, north of Black Spring Ridge	About 3 ft.	
26	Red Deer River, near mouth of Rosebud...........	4 to 7 ft.	94 c.
27	Red Deer River, 18 miles below mouth of Rosebud .	3 to 4 ft.	94 c.
28	Red Deer River, about 8 miles above Hunter's Hill (two seams)................................	2 ft. and 3 ft.	95 c.
29	Red Deer River, 13 miles above Hunter's Hill......	1 ft. 3 in.	
30	Indian Farm Creek near Pincher Creek	2 feet or more	98 c.
31	One mile south of road-crossing of Pincher Creek...		98 c.
32	Mill Creek, 4 miles above the mill.................	9 ft.	99 c.
33	South Fork of Old Man, 3 miles west of Garnett's house	2 ft. 10 in.	99 c.
34	South Fork of Old Man, about five miles east of Garnett's house (reported)....................	1 ft. 6 in. (?)	100 c.
35	Middle Fork of Old Man River, 6 miles north of Garnett's house (two seams)..................	3 ft. & 3 ft. 6 in	101 c.
36	North Fork of Old Man River, 1½ mile from mountains.....	4 ft.	103 c.
37	Highwood River, Middle Branch 3½ miles above Forks	1 ft.	104 c.
38	Highwood River, 4 miles above Forks.............	1 ft. 6 in.	104 c.
39	Near Highwood River at east base of Mountains ...	2 ft.	106 c.
40	Jumping Pound River, a few miles above Bow (reported)...................................	Not known	81 c.
41	Coal Creek, Bow River	1 to 3 ft.	80 c.
	Within Mountain Area.		
42	South Branch, Old Man, 3 miles above mouth of Little South Fork..............................	9 ft. 9 in.	109 c.
43	Crow Nest Pass, 4 miles west of the Gap..........	2 ft. 10 in.	110 c.
44	North-west Branch of North Fork, 2½ miles above mouth	8 ft. or more.	110 c.
45	North-west Branch of North Fork below Fall	3 ft.	111 c.
46	Hills between North-west Branch of North Fork and sources of Highwood, near water-shed range....	Numerous thin seams	111 c.

Change in composition of fuels near the mountains.

A point previously alluded to and of much interest in connection with the coals and lignites of the district included in the present report—whether regarded from a theoretical or practical point of view—is the gradual change which these materials are found to undergo on approaching the mountains. Though the analysis available for the North-west at the time of the publication of my report on the Geology and Resources of the 49th Parallel were comparatively few in number, and represented fuels scattered widely over the whole territory; this examination enabled the following general statement to be made :—

" On reviewing the whole of the analysis of the fuels, and referring them to their localities on the map, it will appear that lignites which contain, when thoroughly air-dried, above twelve per cent. of water, occupy the eastern part of the area occupied by the Lignite Tertiary, while beyond about the 113th meridian, many, if not most, of the fuels met with, contain less than that amount of moisture, and pass by easy gradations in some instances to coals indistinguishable from those of the Carboniferous formation. These two regions are not, however, mutually exclusive, for west of the line above indicated, lignites of the former class are often found, and also, apparently, fuels representing all intermediate stages. The mixture of the two classes in the extreme west would suggest either the presence of two distinct coal-bearing formations, or two different horizons of the same series of rocks."*

The increase of our knowledge of the fuels of this region has served to confirm, in a general way, the proposition then first stated. It has since been several times referred to in discussing their character, and it has been possible to make it even more definite than at that time.

Data available in this district.

The series of very carefully conducted analysis made by Mr. Hoffmann, (p. 11 M, et seq.) of specimens specially collected by us as representative of the various seams, renders possible a more precise investigation of the nature and amount of change by which the fuels have been affected in relation to their proximity to the mountains. It is still, however, a subject on which much more information is desirable, and the following discussion is to be regarded rather in the light of a suggestion than otherwise, as the number of analysis for the present region might, in this regard, be advantageously increased by three- or four-fold.

Positions of the fuels.

We have in this region, on the west, the Rocky Mountains, consisting largely of Palæozoic rocks, but including also several long troughs of Cretaceous and Laramie Rocks. The eastern Palæozoic range is remarkably straight and even in outline, and constitutes the edge of the mountains proper. East of this is a belt averaging about fifteen miles in width, composed entirely of Cretaceous and Laramie rocks, folded

* Geology and Resources of the 49th Parallel, p, 180.

parallel to the direction of the base of the mountains, frequently vertical or nearly so for miles in width and everywhere showing evidence of intense lateral pressure and disturbance. The eastern edge of this belt is again very definitely bounded, and the rocks subside almost at once to a condition of practical horizontality, and so continue over the entire area of the Great Plains.

Coals of mountains and foot-hills.

In the now isolated Cretaceous and Laramie basins of the mountains, the included fuels are for the most part of the character of bituminous coals, but in one case—that of the Cascade and Bow Rivers basin—where pressure from the west has been such as to completely overturn the synclinal trough, the alteration has proceeded so far as to produce an anthracite. In the disturbed belt of the foot-hills the fuels are also all entitled to rank as coals, and the hygroscopic water in the fuels of the region may be stated, according to Mr. Hoffmann's analysis, to range from 1·63 to 6·12. The eastern edge of this belt—at a mean distance, as above stated, of fifteen miles from the mountains—may be said practically to coincide with a water-content of 5 per cent.* On arranging the remaining analyses in their relative order of distance from the edge of the disturbed belt, without reference to their stratigraphical positions, the percentage of hygroscopic water is found to increase in very regular proportion with that of the distance, while the mount of volatile combustible matter shows a similar increase. That of the specific gravity of the fuels is too much affected by the quantity of ash to form a basis of comparison.

Percentage of water decreases uniformly westward.

Fuels compared by water-content.

With a view to arrive at the best standard of comparison, the united per-centages of the water and volatile combustible matter have been compared in a similar way, and the subjoined table also shows the percentage of the former constituent calculated for the fuels without ash, which it was thought might be eliminated with advantage. The result, however, shows but little difference from that obtained by considering the water as a constituent of the fuel in its natural state—ash included.

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* Of Mr. Hoffman's analysis Nos. 23, 24, 25 and 28, may be taken as almost exactly representing this edge of the disturbed belt. These, with a specimen from the continuation of the same line on the St, Mary River (Geology and Resources 49th Parallel), represent the margin of the disturbed belt for a length of 170 miles, and give an average water-content of 5·14 per cent.

Table (1) showing per centage of Water, Volatile combustible matter, &c., of Fuels, arranged in order of distance from edge of Disturbed Belt. (From analyses by Mr. C. Hoffmann.)

Locality.	Miles from edge of Disturbed Belt.	Hygroscopic Water p. c.	Hygroscopic Water p. c. relatively to Combustible Constituents of Fuel.	Hygroscopic Water and Volatile Combustible matter p. c.	Ash p. c.
1. Indian Farm. Pincher Creek.	0	5·38	5·92	32·57	9·09
2. St. Mary River	35	7·02	7·49	36·43	6·29
3. Milk River Ridge	38	9·84	13·82	38·50	18·83
4. Coal Banks. Belly R.	42	6·50	7·03	38·09	7·55
5. Belly R., below Little Bow	64	9·18	9·85	39·84	6·85
6. Blackfoot Crossing, (mean of 4)	64	11·55	12·33	41·82	6·31
7. Horse-shoe Bend. Bow River.	74	11·13	12·26	47·65	9·19
8. Grassy I. Bow R.	86	11·90	12·65	43·10	5·93
9. Red Deer R. (mean of 2)	86	13·64	14·19	44·84	3·87
10. Red Deer R. (mean of 2)	100	13·34	14·59	43·66	13·34
11. Red Deer R. Coal Banks seam.	100	12·62	13·80	44·70	8·58
12. Medicine Hat	128	17·70	18·41	46·33	3·84

It will be observed that with the exception of one specimen† the results are closely concordant with the rule above referred to, and by arranging them in the form of a diagram in which each of the vertical lines represents a distance of ten miles from the edge of the disturbed belt, while the horizonial indicate the percentage of water, this is made even more apparent, and the rate of increase is shown to be about one per cent. in ten miles, very nearly.

Influence of stratigraphical position on water-content.

On a careful inspection of the figures, however, it is observed that while the relation of the fuels to the disturbed belt has preponderant influence, there is also a quite perceptible effect due to stratigraphical position, the lower and older containing relatively less water than the

†This (No. 3) is from Milk River Ridge. The seam is very thin and earthy, and the results are quite anomalous, however treated. It is just possible that the specimen may have been wrongly assigned. It has been practically disregarded.

higher. With a view to eliminating as far as possible the latter factor, the analyses may be arranged in three series, corresponding with the three formations in which the fuels occur thus:—

TABLE (2) showing percentage of Water, Volatile combustible matter, etc., of Fuels, arranged according to age and in order of distance from the edge of the Disturbed Belt. (From analyses by Mr. C. Hoffmann.)

LOCALITY.	Miles from edge of Disturbed Belt.	Hygroscopic Water p.c.	Hygroscopic Water p.c. relatively to Combustible Constituents of Fuel.	Hygroscopic Water and Volatile Combustible matter p.c.	Ash p.c.
Laramie.					
1. Indian Farm. Pincher Creek.	0	5·38	5·92	32·57	9·09
6. Blackfoot Crossing (mean of 4).	64	11·55	12·33	41·82	6·31
7. Horse-shoe Bend. Bow River.	74	11·13	12·26	47·65	9·19
9. Red Deer R. (mean of 2)	86	13·64	14·19	44·84	3·87
Pierre.					
2. St. Mary R.	35	7·02	7·49	36·43	6.29
3. Milk River Ridge.............	38	9·84	13·82	38·50	18·83
4. Coal Banks. Belly R...........	42	6·50	7·03	38·09	7·55
8. Grassy I. Bow R..............	86	11·90	12·65	43·10	5·93
11. Red Deer R. Coal Banks seam.	100	12.62	13.80	44.70	8.58
Belly River Beds.					
5. Belly R., below Little Bow.....	64	9.18	9.85	39.84	6.85
10. Red Deer R. (mean of 2)......	100	13.34	14.59	43.66	13.34
12. Medicine Hat................	128	17.70	18.41	46.33	3.84

In the second diagram the stratigraphical arrangement is illustrated, the lines representing separately the rate of increase in water of the

Explanation of diagram.

fuels of each of the three horizons above referred to. The unbroken line is drawn with reference to the points representing the Laramie fuels, and it is quite probable that all of these are near the base of the formation and practically on the same horizon. The points on the dotted line represents the seam at the base of the Pierre, with the exception of No. 7, which is a seam locally developed at the top of that series. The line of dashes is drawn with reference to the points indicating the fuels of the Belly River series, and these again are very probably on precisely the same stratigraphical plane. This diagram, therefore, brings out very clearly the difference due to stratigraphical position, and by applying our local knowledge of the thickness of the strata, it would appear that in this district it amounts to about two per cent. of water for 1,000 feet in thickness of strata, that being approximately the volume of the beds intervening between the Laramie and Pierre seams. This fact has further a bearing on the question of the age of the Relly River series discussed in a preceding portion of this report (p. 118 c et seq.) as if this series really held a position above the Pierre, the fuels derived from it should in the diagram occupy positions in the upper line, rather than on a level with or rather below those of the Pierre. These fuels, from their comparatively large water-content might, at first sight, seem to compare more closely with those of the Laramie, but when the difference due to their greater geographical distance from the disturbed belt is allowed for, they fall naturally into the place assigned to them in the table of formations.

Bearing of composition of fuels on question of age.

Definition of limit of Laramie fuels containing 10 per cent. water.

Mr. Hoffmann, in the introductory portion of his report, alludes to the possibility of defining three zones parallel to the base of the mountains, the fuels in which correspond generally to the divisions adopted by him in classifying them in relation to composition. By marking on the geological map the positions of the various fuels represented by analyses, with the percentage of water in each, and measuring from these towards or from the edge of the disturbed belt, in lines drawn at right angles to it, on the basis above determined of a mean difference of one per cent. in ten miles; a theoretical line can be drawn separating the fuels which contain less from those which contain more than ten per cent. of hygroscopic water. In endeavoring, however, actually to define this line, it is found that it shows a marked eastward trend in the vicinity of the Belly River, whereas the edge of the disturbed belt here actually retreats in the opposite direction. This, however, evidently depends on the fact that the coals here used as standards belong entirely to the Pierre zone, and by applying a correction of two per cent. to these (equal to twenty miles in distance) the line falls back at this point and assumes an almost perfect parallelism throughout to that of the edge of the disturbed belt. The line thus arrived at for

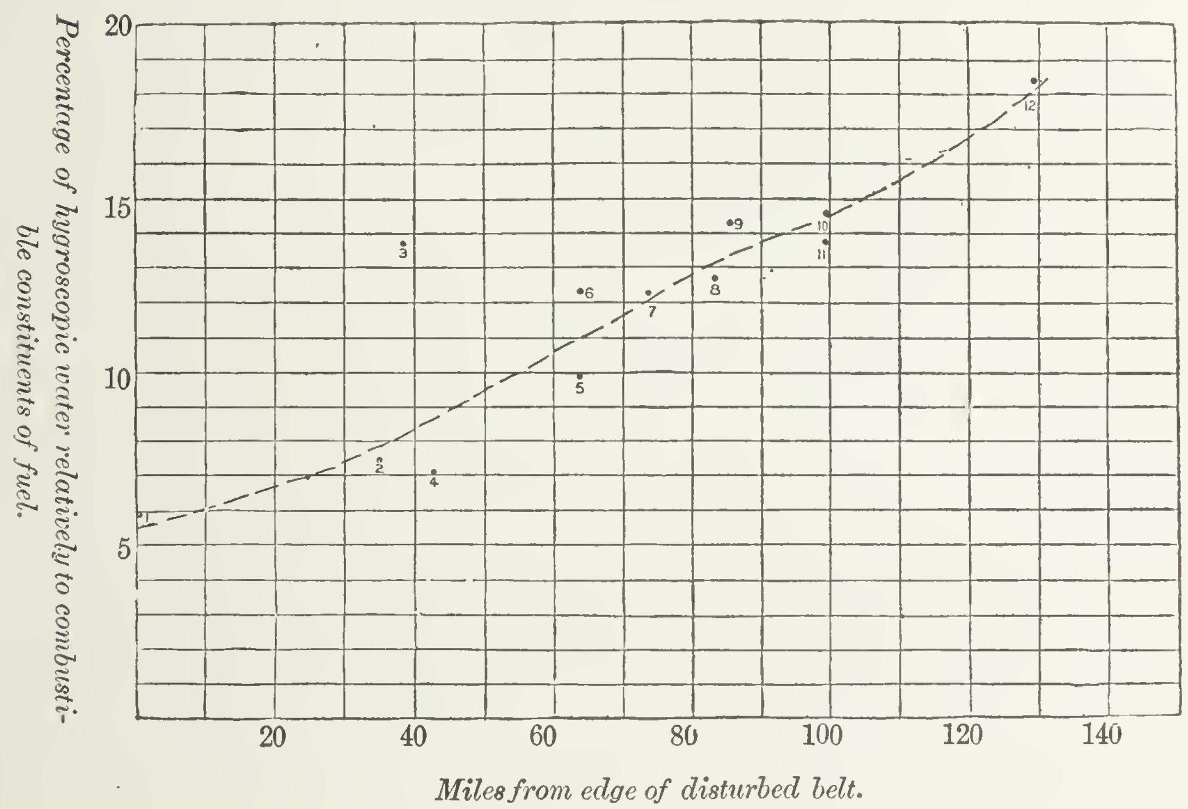


DIAGRAM I.

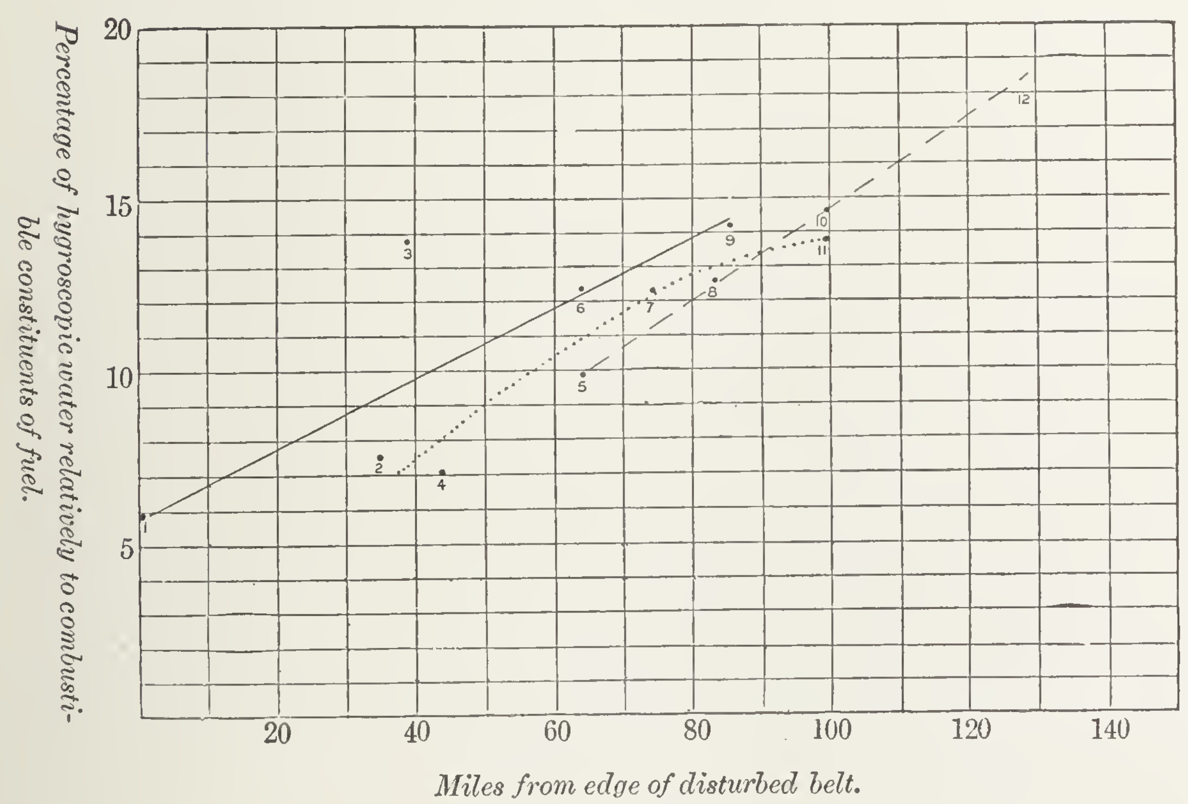


DIAGRAM II.

DIAGRAMS ILLUSTRATING RATE IN DECREASE OF HYGROSCOPIC WATER IN LIGNITES AND COALS ON APPROACHING THE MOUNTAINS.

the Laramie, or upper fuels, crosses the Bow about ten miles west of the Blackfoot Crossing, the Belly near Coal Banks, and is at an average distance of fifty-three miles from the eastern edge of the disturbed belt.

Possible causes of change in composition.

Touching the causes which have produced the remarkable change observed in the fuels of the plains, as they approach the disturbed belt:— If the flexure and disturbance of the beds obtained over the entire area, becoming *gradually* reduced eastward, and the contained fuels were found to change in character *pari pasu*, it might be supposed that the change was directly due to the disturbance. East of the edge of the sharply-defined disturbed belt, however, as before stated, the beds are practically horizontal. On an inspection of the second diagram it becomes evident that the actual amount of change in the fuels must be due to the combination of two or more causes. Three factors only seem worthy of consideration,—age, (a), pressure as represented by the thickness of superincumbent beds, (p), metamorphism by heat or otherwise, (m). The increasing change which occurs in approaching the disturbed belt may therefore have resulted from one or more of these causes in the following probable combinations. $a. + m$; $(a + p) + m$; $(a + p) + (m + p)$; $(a + p) + p$; or $p + p$.

Required thickness of overlying beds.

Assuming, as by the last hypothesis, pressure to be the only factor; from the approximate measurement before arrived at—2 per cent. of difference in water for 1000 feet of strata—it would be necessary to admit a thickness of superincumbent beds 2,500 feet greater at the edge of the disturbed belt (5 per cent. line) as compared with that of the 10 per cent. line, and to assume that this thickness of beds has since been removed by denudation. By the fourth of the above hypothesis we must attribute a portion of the loss of water to age, and if that be supposed to equal half the total effect, the figures last given must be increased to 5,000 feet. Both these figures would also require to be nearly doubled for the disturbed belt itself.

Direct influence from mountains improbable.

We have therefore to suppose either that a great additional thickness of overlying beds existed in a belt of uniform width along the base of the mountains, the strata gradually thinning eastward from this belt, or that some other agent, which may be denoted as metamorphism, and can scarcely have been other than heat, operated or assisted in producing the change. As igneous intrusions are practically absent from this part of the mountains it would appear that any heat emanating from the ranges must have been that produced by the crumpling and compression of the beds. It is difficult, however, to conceive that heat produced in this way could have had other than a local influence, and almost impossible to believe that it could have affected horizontal beds to a distance of at least one hundred miles.

Probable conditions of chahge.

With reference to the first of the above hypotheses we have previously found reason to believe that a shore-line existed near the present position of the mountains, and it is quite probable that the strata are thicker in this part of the region and that overlying beds—like those of the Porcupine Hill series—may have been developed here only and subsequently removed by denudation. In the disturbed belt itself a heaping up of beds to almost any required amount may probably have occurred at the time at which the folding occurred. The burial of the fuels for a prolonged period under a great depth of strata implies not only greater pressure, but their subjection to the influence of the proper heat of the earth, and these two causes may probably be assumed as sufficient to account for the facts without resource—except locally—to the influence of the heat developed during the plication of the beds of the disturbed belt.

IRONSTONE, LIMESTONE, ETC.

Clay-ironstone.

Clay-ironstones, of varying quality, occur in a great number of localities in association with the Cretaceous and Laramie rocks of this district, and in some cases in proximity to the coals. In a few places this material has been found in considerable quantity, notably on that part of the Bow River described on p. 91 c, and on the Kananaskis near its mouth. The manufacture of iron in this district—unless some very rich class of ore should be found in the mountains or foot-hills in large quantity—must, however, in the present state of the iron trade, be considered as a possibility of the remote future only. (See Appendix III.)

Cement stone.

Calcareous and argillaceous concretions and nodular layers, likely to prove useful in the manufacture of hydraulic cements, are abundant. None of these have so far been put to any practical test, but they are likely to be in demand soon.

Brick and pottery.

Some of the boulder-clays, and the silty deposits in some places overlying them, may doubtless prove applicable to the manufacture of ordinary bricks, but in the clays, soft argillites and fine silty materials of the underlying Cretaceous and Laramie series, materials suitable for the production of bricks of a very high class exist in the greatest abundance.

Some of these are true fire-clays, and would be available for the manufacture of the heavier and rougher grades of pottery, and for tiles and drain-pipes.

Building stone.

Stone suitable for building purposes is by no means so universally found, and considerable care should be used in selecting Cretaceous or Laramie sandstones for masonry, as those of the plains are often but feebly coherent, with a scanty calcareous cement, and likely to disintegrate rapidly under the influence of the weather. In the foot-hills, however, many sandstones of excellent quality occur, and may be locally employed, while the railway affords a means of bringing down from the mountains the limestones and other hard Palæozoic rocks there abundant.

Limestone can scarcely be said to occur in the plains or foot-hill belt, except in the form of scattered boulders, transported thither in the glacial period, and occasionally in sufficient numbers to be locally useful. The massive limestones of the mountains must serve as the main source of supply of lime for the entire region. These are well situated for working where the railway enters the mountains, particularly in several places on the line between Kananaskis and a point eight miles west of that station. The eastern border of the Palæozoic rocks, as defined on the map, may be said to be throughout composed of limestone, with the exception of a length of about twenty-eight miles northward from Waterton Lake, in which older silicious and slaty rocks—all probably of Cambrian age—are largely developed in the eastern range. Limestone.

The occurrence of gold, which in some of the streams may be found to exist in remunerative quantity, is referred to on a subsequent page, in connection with the description of the drift deposits. Gold.

SUPERFICIAL DEPOSITS AND GLACIATION.

The superficial deposits, or those materials which, resting indifferently on the worn beds of the Cretaceous and Laramie, form the actual surface of the district now under description, are so largely those of the glacial age that to describe them is practically to outline the history of that very interesting period. In general the older rocks are deeply mantled with these deposits, and it is seldom, except in the neighbourhood of the mountains, that these appear, save in the deep river-valleys. The superficial deposits have, in fact, not only greatly modified the appearance of the county as a whole, but have given character to, and impressed a general uniformity on, the nature of its soil. Influence of drift deposits.

The general characters of the several deposits of the glacial period are, however, so similar, that it will not be necessary to enter in great detail into the description of localities. One of the most striking features, indeed, of the glacial deposits of the North-west is their extraordinary persistence and similarity of character over immense areas. Compared to their vast extent their thickness is almost infinitisimal, yet they everywhere characterize the surface in uninterrupted continuity for hundreds of miles.

As a part of the discussion of the superficial deposits of the plains as a whole, in connection with the Boundary Commission exploration, I Previous notes on glaciation.

have already given such facts as came under observation in the immediate vicinity of the 49th parallel, and while the greater knowledge of the district now obtained enables much to be added to these descriptions, it does not alter them in their main features.*

Pre-glacial condition of the country.

The pre-glacial aspect of the county has been much rougher and more diversified than that which it at present presents. It must have been for a very long time in the later Tertiary periods subjected to denudation, and deeply marked by rain and rivers. The glaciating agents have doubtless planed off many of these irregularities, and the surface has besides been deeply buried in its deposits, to which the general name of drift has been applied in the preceding parts of this report. These have been laid down in greatest thickness in the pre-existing hollows and low tracts, and the general effect has been a filling up of the asperities, and the production of wide areas of almost perfectly level prairie. That this has been the case is evidenced by the fact that while some of the higher plateaus and ridges are but scantily covered with drift, the thickness shown in many of the river sections is over two hundred feet.

Old and new river channels.

Whatever the courses of the pre-glacial rivers (and there is no evidence that they departed widely from the present west-to-east system of drainage) the new streams which began to form channels for themselves when the glacial conditions had passed away, certainly did not follow the old beds. This is shown by the fact that while in some cases almost the entire height of the scarped banks along the streams is formed of Cretaceous and Laramie rocks, in others these banks are altogether composed of drift deposits, the base of which lies even lower than the present river-bed.

General thickness of drift.

As a rough estimate of the importance of the drift deposits in the district, it may be stated that in the region east of the Porcupine Hills, they probably average at least one hundred feet in thickness.

The following is a list, in descending order, of the superficial deposits developed in the region under discussion :—

Table of deposits.

Stratified sands, gravels and silts.
Upper boulder-clay.
Interglacial deposit with peat.
Lower boulder-clay.
Quartzite shingle and associated beds.

Quartzite shingle below boulder-clay.

Resting immediately on the surface of the Cretaceous and Laramie, in a number of widely separated localities, is a deposit of well rolled pebbles or shingle, consisting for the most part of hard quartzites, and

* See Quart. Journ. Geol. Soc., Nov., 1875, and Geology and Resources of the 49th Parallel. 1875.

G. M. D. Photo. June 27, '83.
Geological Survey.

Artotype—G. E. Desbarats & Co., Montreal.

DRIFT BLUFFS IN BELLY VALLEY. "COAL BANKS CROSSING."

At A, Quartzite Shingle underlying Boulder-clay. B, Lower Boulder-clay. C, Intercalated stratified sandy deposit, overlain by Upper Boulder-clay in distant bank.

derived entirely from the Palæozoic rocks of the Rocky Mountains.* Limestone is occasionally found in this bed near the mountains, but the shingle as a whole has evidently been subjected to such prolonged wear while on its eastward course, that this and other soft materials have been altogether ground down before attaining any very great distance from the place of origin. The pebbles are seldom more than a few inches in diameter, and are often very uniform in size, forming a closely packed bed, in which the stones are arranged with their longer axes parallel to the plane of deposit.

Distribution of quartzite shingle.

This quartzite shingle bed has been observed on the Old Man River below Fort MacLeod, in several places. It is entirely wanting on the upper part of the St. Mary River, appearing for the first time at a point six miles from its mouth. It may be seen on the Belly, on the right side of the valley near the trail-crossing at Coal Banks, and in several other places on its lower course, as at Big Island bend, the north-west angle of Drift-wood bend, and in the north bank opposite Wolf Island. At the last-mentioned locality it is associated with stratified sand and clay beds, a circumstance not elsewhere observed.

The section here is as follows, in descending order :—

Section at Wolf Island.

	FEET.
1. Pale yellowish-grey, more or less perfectly stratified boulder-clay, about	100
2. Purplish, finely-bedded sandy clay, with thin layers of ironstone and a lignite bed eighteen inches thick. A few Laurentian pebbles near the base	8
3. Unstratified boulder-clay, holding stones up to 2′ 6″ diameter	15
4. Stratified yellowish and brownish-yellow sands, with a few stones, some of which are Laurentian	15
5. Fine pale purplish-grey clay	4
6. Stratified yellowish sands	6
7. Quartzite shingle deposit, without Laurentian fragments, becoming clayey and full of derived fragments from underlying rocks at base (about)	15
8. Cretaceous shales and sandstones with eroded surface (to water)	10
	173

Quartzite shingle on Bow and Red Deer Rivers.

On the section formed by the Bow River, the quartzite shingle is seen in a number of places. It was first recognised at a point a few miles above Highwood River, where it has a thickness of fifteen feet,

* There is no admixture of Laurentian or Huronian material, to which an eastern or north-eastern origin would have to be assigned. It is possible that a portion of the quartzites and associated rocks may have been originally derived from portions of the Rocky Mountains range far to the north, but in the absence of any evidence to that effect, and in view of the fact that the lithological characters—even some of a peculiar and expectional kind—found in the pebbles of the shingle, are precisely those of the rocks of the mountains to the west, it is most probable that they have been thence derived.

and is near the water-level. Below the Highwood it was seen at one place near the lower end of Pine Cañon at an elevation of sixty feet above the river. At a point, a few miles above the Arrow-wood Creeks, it has a thickness of fifteen to twenty feet, the base being about twenty feet above the water, and the summit capped by ten to fifteen feet of hard boulder-clay. About three miles above the Blackfoot Crossing it is again well shown. Its existence was also suspected at several points below the Blackfoot Crossing, but could not be proved owing to the extensive slides which have occurred in the banks. It was also recognized by Mr. McConnell at several places on the Red Deer River within the limits of the map.

Origin of shingle.

The origin of the quartzite shingle is a question of great interest, but at the same time a very difficult one. It at first appeared to be certain that it must have been brought eastward from the mountains by rapid streams, of a date immediately preceding the glacial period, and that it must either still occupy the channels of these, or have been spread abroad in some wide body of waters into which they flowed.

Miocene conglomerates.

The discovery in the Cypress Hills, in 1883, by Mr. McConnell, of an extensive Miocene formation, the greater part of which is composed of precisely similar shingle more or less cemented together by calcareous matter, must now, however, be taken into account. It is possible that this formation which now caps the high plateau known as the Cypress Hills, at one time spread much more widely, and that its gravels have been re-arranged and spread over the neighbouring plains by pre-glacial streams as denudation proceeded, and further, that these Miocene beds may have supplied much of the quartzite material which enters largely into the composition of the boulder-clay and its derived deposits. The fact, however, that exactly similar quartzite gravels can be traced up into the foot-hills, in the valleys of some of the streams, forming a thin layer beneath the boulder-clay, where there is no evidence whatever of the existence of any Miocene beds, tends to prove that a portion, at least, of the quartzite gravels here referred to, have been derived immediately from the mountains, in times just preceding, or marking the initiation of, the glacial period. The question is one admitting of much additional investigation.

Two sources of supply.

Irregularity in distribution of shingle.

The level of these pre-glacial gravels, often differs very considerably in the river sections, as compared with the water-level of the modern rivers. The gravels, however, tend generally to characterize the lower parts of the district, and are, for example, quite wanting along almost the entire course of the St. Mary. They are by no means universally spread even in the parts of the district which they characterize, a fact which may be due either to an original irregularity in distribution, or to their subsequent partial removal and mingling with the general substance of the drift of the glacial period. No glaciated stones were anywhere found in these gravels, and the line between them and the boulder-clay is usually a perfectly distinct one. The only section which shows a blending with the base of the boulder-clay is that already quoted at Wolf Island, apart from which the shingle might be regarded as a deposit referable to the last stage of the Tertiary.*

The boulder-clay.

The boulder-clay, which constitutes by far the most important member of the drift deposits, is very variable in thickness, having in some places a volume of nearly two hundred feet, while in others it is quite thin. It presents the usual characters of this deposit, being, as a rule, a hard sandy clay, containing a variable and often very considerable proportion of Laurentian and Huronian erratics, mingled with fragments of quartzites from the Rocky Mountains, and sandstone blocks from the Cretaceous or Laramie. The mass of its finer components, however, usually appears to have been derived from the beds underlying it at no great distance, and has been formed of these materials ploughed up and kneaded together. In consequence of this circumstance its colour varies considerably, ranging from dark blackish- or bluish-grey to lighter tints of the same, and often becoming yellowish-grey or fawn-coloured, especially where weathered. On the St. Mary, it was observed to have in some places a distinctly reddish tint, due to the colours of the neighbouring reddish clays of the Willow Creek subdivision of the Laramie. Where shown in good sections, it is generally divisible into an upper and lower part, the latter being more compact, and though not without stratification planes, showing them in a less marked manner, while the former is, as a rule, not only more distinctly stratified but also less compact. This feature is specially well shown on the BellyRiver below Coal Banks, and between the upper and lower boulder-clays the remarkable sedimentary deposits, described in a succeeding paragraph, here occur.

Colour.

Upper and lower parts.

Distribution.

The boulder-clay, from its massive character, frequently weathers in

* Since the above was written, Mr. J. B. Tyrrell, in the course of the geological examination of the country north of the Red Deer River, has found gravels or incoherent conglomerates capping the Hand Hills, precisely like those of the Cypress Hills. These have yielded no fossils but there can be little doubt that they are like those of the Cypress Hills, of Miocene age. This discovery appears to show that the Miocene shingle-beds may have been much more widespread and important than previously supposed, though but occasional remnants of them, capping the higher plateaus, are now found. It may even be, that in the distribution of the quartzite gravels above described as underlying the boulder-clay, we have a general definition of the area of the Miocene formation, the immediately pre-glacial gravels having resulted from its waste, and accumulated in the valleys of streams which ran through the old Miocene area. It must still, however, be admitted that similar gravels underlie the boulder-clay near the mountains, and that these have probably no connection with the denudation of Miocene beds, but have been derived directly from the mountains. The question of the mode of transport of so great a quantity of coarse gravel to such a great distance from its source in the mountains, and its deposition on the soft beds of the plains in Miocene times, without any evidence of ice action, is a very difficult one.

river-cliffs into prismatic and columnar forms, and it is this deposit which is concerned in most of the heavy land-slides which occur along the valleys of the streams. It may be regarded as entirely covering by far the larger part of the surface of the district, but on approaching the base of the mountains is replaced by morainic accumulations due to local glaciers. Certain tracts characterized by the presence of a great thickness of boulder-clay have already been alluded to in the general description of the river sections. It rests often directly on the Cretaceous and Laramie rocks, even in the immediate neighborhood of localities where the intervening shingle deposit was observed well developed, and its base is often below the level of the water, even in the deeper river-valleys.

Interglacial beds.

The intercalated finer beds, above alluded to, are well shown in the section at Wolf Island (p. 141 c). They are seen also in a number of places on the Belly between Wolf Island and Coal Banks, and the body of water in which they were laid down must have been a very extensive one. On the east side of Drift-wood bend, seven miles west of Wolf Island, the following section occurs:—

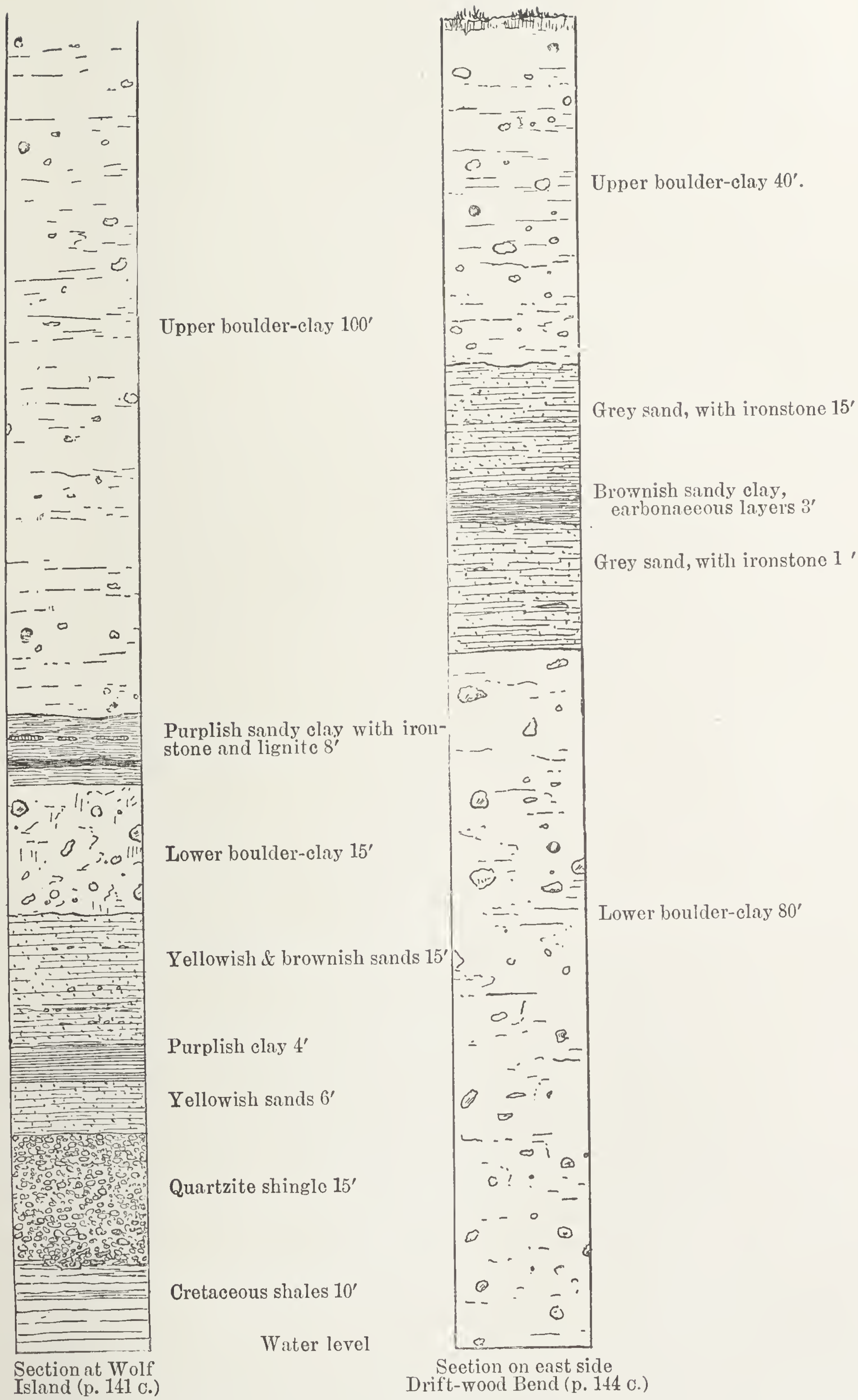
Section at Drift-wood Bend.

	FEET.
1. Boulder-clay, with traces of stratification, to top of bank....	40
2. Finely stratified, pale-grey sand, with irregular lenticular masses of soft ironstone, a few inches thick	15
3. Brownish-grey, earthy, sandy clay, distinctly stratified, with carbonaceous layers, which in places become impure lignite; small selenite crystals and concretions. 3′ or more (variable.)	3
4. Grey, fine sand with ironstone concretions, (like No. 2)	15
5. Massive boulder-clay with large stones and boulders, sometimes distinctly glaciated. Laurentian and quartzite fragments (to foot of bank)	80
	153

Interglacial peat.

Four miles further up the Belly, at the north-west angle of Drift-wood bend, the same beds are again shown, but the carbonaceous layers have here coalesced to form a distinct bed, about a foot thick, of imperfect lignite or indurated peat. A specimen collected here has been examined by Mr. C. Hoffmann. It is very strongly acted on by caustic potash, affording a dark-brown liquid. On analysis by the method adopted for the Cretaceous and Laramie fuels it yielded the following results:—

Hygroscopic water..................................	7·74
Volatile combustible matter........................	23·13
Fixed Carbon.......................................	22·05
Ash..	47·08
	100·00



SECTIONS ON THE BELLY RIVER ILLUSTRATING RELATIONS OF UPPER AND LOWER BOULDER-CLAYS, INTERGLACIAL DEPOSITS AND QUARTZITE SHINGLE.

In the approximate equality of volatile combustible matter and fixed carbon, and its percentage of water (when allowance is made for the large proportion of ash) this material resembles a poor lignite or good quality of peat.

Overlying the boulder-clay are wide-spread stratified deposits, the distribution of which assists materially in giving uniformity to the tracts of level plain. It is, indeed, quite exceptional to find the surface soil consisting of boulder-clay disintegrated in place, and this occurs only on the slopes of plateaus, or in hollows formed by denudation. That the beds overlying the boulder-clay have not been merely formed by its re-arrangement in water without the addition of new material, is indicated by the fact that in many places erratics much larger than those chararterizing the boulder-clay of the locality are found strewn over the surface of the country. The beds observed in river sections and elsewhere to overlie the boulder-clay are generally gravels or sands below and sandy or clayey loams above. The latter form the subsoil over most of the region, and are generally rather pale brownish- or yellowish-grey in colour. Deposits overlying boulder-clay.

Along the base of the Rocky Mountains, moraines, in a more or less degraded condition, are abundant, and evidently due to considerable local glaciers which debouched from the present valleys of the range. The material of these moraines, when seen in section, differs considerably from the boulder-clay proper, not only in the fact that the included fragments are entirely of Rocky Mountain, or local origin, but in its greater degree of hardness, the greater roughness and angularity of the stones, and so far as observed the complete absence of bedding. Moraines distinguished from boulder-clay.

On the Waterton River, moraine material of this kind was first seen about ten miles from the base of the mountains. West of the river, for some miles below the lake, a ridge which has evidently been a lateral moraine of the Waterton Lake glacier, occurs; and several hills of the same character, with large blocks derived from the mountains protruding from and scattered over them, are found about the lower end of the lake and opposite the valley of the South Kootanie Pass. For about thirty miles northward along the base of the range, moraines are of constant occurrence, and can easily be recognized owing to the sparsely wooded character of the foot-hill belt in this region. Each little valley now giving issue to a brook, has formerly contained a glacier, and the old lateral moraines, sometimes still very well preserved, run off from the base of the mountains like spurs. Moraines near the mountains.

The Bow River valley, in correspondence with the large area of mountains tributary to it, appears to have held a glacier of larger size than any elsewhere originating in the mountains in this district. In several places some miles up the pass the rocks bear traces of heavy Bow valley glaciers.

glaciation, and at "the Gap" the limestone is deeply grooved and fluted by the passage of ice. Near and above Morley, portions of lateral moraines of this glacier project through terraces of later date as ridges, parallel to the direction of the valley.

Between Morley and Calgary on the Bow, a deposit more closely resembling boulder-clay than true morainic matter was observed in several places, but the stones in it are entirely those of the mountains or sandstone blocks from the underlying beds.

Terraces and planes of denudation.

Terraces are prominent features in some parts of the river-valleys in this district, but are generally clearly due to the action of the river itself at a former period. The extensive tracts of almost perfectly level prairie which occur, afford evidence of water action of some duration, and may be regarded as wide terraces. The eastern face of the Porcupine Hills appears from a distance to be very distinctly terraced, but this aspect was found to be due to the outcrop of the nearly horizontal sandstone beds. On approaching the mountains, however, true terraces of a more significant character present themselves in many places. Terraces in the entrance to the South Kootanie Pass at a height of about 4,400 feet have already been described in my Boundary Commission report. In the valleys of Mill and Pincher Creeks, and those of the Forks of the Old Man, east of the actual base of the mountains, wide terraces and terrace-flats are found, stretching out from the ridges of the foot-hills, and running up the valleys of the various streams. Actual gravelly beaches occasionally mark the junction of the terraces with the bounding slopes, and they have no connection with the present streams, which cut through them. The level varies in different localities, but the highest observed as well characterized attains an elevation of about 4,200 feet.

Highest terraces.

Terraces in Bow Valley.

In the Bow Valley near Morley, and thence to the foot of the mountains, similar terraces are found which are quite independent of the modern river; and in the wide mouth of the valley of the Kananaskis Pass a series of terraces were seen from a distance, which must rise to an elevation of at least 4,500 feet.

Terraces in the mountains.

In the Bow and Crow Nest Passes, within the first range of the mountains, terraces are in many places well developed, but as local conditions, such as the stoppage of these valleys by transverse glaciers, may account for the existence of water at the elevations they mark, they do not possess so much interest as those above described.

Laurentian and Huronian boulders.

The occurrence of Laurentian and Huronian fragments in vast numbers as erratics over the district now described, at such a great distance from the nearest points of outcrop of the parent rock, and at elevations so considerable, is a matter of much interest. The western limit of the Laurentian and Huronian drift may be said to reach the base of the

Western limit.

Rocky Mountains, in the vicinity of the 49th parallel, for fragments of these rocks were found on the Waterton River two miles below the lake, within three miles of the actual edge of the Palæozoic rocks, and at an elevation of 4,200 feet. Northward, on the head waters of the Old Man, Laurentian drift is found, though sparingly, as far west as the mill on Mill Creek, at a height of 3,800 feet, and a single Laurentian boulder was seen about half a mile west of Garnett's, near the trail leading to the Crow Nest Pass, at a height of about 4,200 feet. I did not, however, observe any Laurentian drift on the North Fork of the Old Man, and it is probable that it is absent or nearly so in the district sheltered by the higher parts of the Porcupine Hills. On the Bow River no Laurentian or Huronian erratics were seen west of Calgary, and even after their first appearance they are very scarce for some distance. As the height of the Bow River at this point is only about 3,300 feet, the western limit of the Laurentian drift cannot conform strictly to any contour-line of the present surface of the country.

Drift deposits in northern Montana.

South of the 49th parallel, the country travelled over from Fort Benton, on the Missouri, by the MacLeod trail, is all more or less thickly strewn with Laurentian erratics. South of the Marias River, the stones were observed to be chiefly quartzites of varying colours and doubtless of Rocky Mountain origin, but with these are mingled in larger or smaller proportion, granitic, gneissic and schistose Laurentian rocks, and these occur equally in the river-valleys and on the highest portions of the plains crossed by the trail. There is also, however, particularly in the vicinity of the Missouri, a proportion of granite boulders with flesh-purple felspar and bluish, rather opalescent quartz, which I did not recognise as Laurentian, and which may be derived from some not far remote mountain region. North of the Marias the conditions continue similar, and are, in fact, practically identical with those of the region more especially treated in this report.

No crystalline rocks in the mountains.

In this entire district there is no possibility of confounding the Laurentian and Huronian erratics with those from the Rocky Mountains, which do not afford any granitic or gneissic rocks or crystalline schists.

Great elevation of Laurentian and Huronian erratics.

The actual heights at which Laurentian and Huronian erratics are found are in some instances very great. A few of the more striking cases may be noted. The heights given are probably trustworthy to within fifty feet, having been worked out by comparison with the regular barometric observations at Fort Benton, which have been kindly supplied by General Hazen.—At the summit of the high ridge forming the southern continuation of the Porcupine Hills, which is crossed by the road between Fort MacLeod and Pincher Creek at an elevation of 4,390 feet, Laurentian stones were found, though not abundant. In 1883 several indubitable Laurentian boulders, representing three varieties of granitic and gneissic rocks, were found about twenty miles north of the 49th parallel, at an elevation of 5,280 feet. They occur on the summit of a high ridge, which is evidently of morainic origin, within a few miles of the Palæozoic rocks of the mountains, but for the reasons elsewhere given they can not have been derived from these mountains, and their origin must be sought with that of those so numerous at lower levels, to the east or northeast. This is the highest point at which Laurentian boulders have been found in the district. Numerous similar erratics are found on the high country near the Milk River, and between that stream and the St. Mary River, about the intersection of the 49th parallel and 113th meridian, at an elevation of about 4,200 feet.

No drift on summit of Rocky Spring Plateau.

A few miles south of the 49th parallel, on the MacLeod-Benton trail, the Rocky Spring plateau is crossed. The south-eastward front is a steep escarpment facing a comparatively low plain, and is very thickly strewn with Laurentian and Huronian erratics as though it had at one period constituted a shore-line. Northward, the plateau slopes gradually down from its greatest elevation of 4,176 feet. The highest point of the plateau, crossed by the trail, is, for a mile or more, quite without drift deposits or erratics, but before any considerable descent is made to the north, erratics become abundant, though not large, and much resemble the remains of an old beach deposit. The height of the Laurentian drift here is about 4,100 feet. From other observations it is certain that this elevation does not constitute the limit in height of the Laurentian material, and it seems possible that the summit of this plateau was occupied by a snow-field during glacial times which prevented the accumulation of the deposits elsewhere found.

Erratics on flanks of Sweet Grass Hills.

The Three Buttes, forming isolated high summits in the centre of a wide plain, offer peculiar facilities for the determination of the highest points attained by the glaciating agent and Laurentian erratics. Much more time might profitably be employed in the investigation of the facts here than I was able to spare. In 1881 an examination of the western flanks of the West Butte, however, proved that Laurentian boulders of small size, with cream-coloured limestone resembling that of the Winnipeg basin, are abundant at an elevation of 4,600 feet, while the highest observed Laurentian fragments attained a height sixty feet greater.

Occasional great size of boulders.

Very large boulders were noted in a few places in the district. A remarkable group of these, composed of Huronian quartzites, occurs near the lower part of the Waterton River, and it is notable generally that some of the heaviest boulders are found not far from the western

G.M.D., PHOTO., AUG 14TH 81.

BOULDER OF HURONIAN QUARTZITE, NEAR WATERTON RIVER.

limit of the Laurentian and Huronian drift. One of these erratics is 42×40×20 feet, a second 40×30×22, and both are partly buried in the soil. The height of this point was not exactly determined, but must be between 3,200 and 3,300 feet. In common with all the larger boulders of the district these are surrounded by a shallow saucer-like depression, caused by the pawing of the buffalo, and their angles are worn quite smooth and glossy by the rubbing of these animals upon them.

Post-glacial denudation.

While the main river-valleys whether on the area of the plains or in the foot-hills and Porcupine Hills, evidence very considerable post-glacial erosion, the general surface of the plain country east of the Porcupines seems to have suffered very little in this respect since the waters, (which under any hypothesis must have covered it at least at the close of the glacial period), left its surface. In the numerous lakes and pools occupying shallow depressions and without defined outlet, in the entire absence over considerable areas of drainage channels, and their general infrequency, evidence appears to be given that the rainfall of the eastern portion of the district has been continuously very small since the glacial period. Wherever the surface has locally been considerably lowered by denudation, great numbers of boulders appear, and their comparative rarity over great portions of the plains can be due only to the persistence of the finer surface covering since glacial times.

Mode of glaciation of the Great Plains.

Theoretical conclusions as to the mode of glaciation of this district have, as far as possible, been excluded from the foregoing summary of the facts. Apart from the local glaciers of the Rocky Mountains, it is evident that it has been accomplished by some agent moving westward or south-westward from the Laurentian axis which bounds the region of the Great Plains to the east. This agent has carried with it great quantities of Laurentian and Huronian material, which in the vicinity of the 49th parallel reaches at its extreme limit a point over 700 miles distant from the nearest exposures of the parent rock, and to an elevation more than twice as great as that attained by any part of the Laurentian area. To explain this latter fact it seems now almost certain that we must assume that the western region was, in glacial times, relatively to the Laurentian area more depressed than at present. As I have elsewhere, in the publications before referred to, discussed at some length the question whether a glacier or floating ice best accounts for the facts, it is not here proposed to recapitulate the arguments. Two theories only, however, seem tenable. Etiher a great confluent glacier, occupying the Laurentian highlands or passing over them from the Hudson's Bay region, stretched continuously to the slopes of the Rocky Mountains, or such a glacier, extending but a limited distance from these highlands, supplied numerous and massive icebergs which floated in a great inland sea occupying the present position of the plains.

Significance of old drainage channels.

I still believe that the latter supposition best accounts for the facts of the glaciation and glacial deposits of the plains. I would, however, point out one circumstance which seems to give some colour to the former hypothesis. This is the existence of a number of wide, old, abandoned water-channels, which may be supposed by this theory to have carried the drainage of the county, and water produced by the melting of a great glacier of the kind implied, round its front at different periods in its retreat. The existence of these I am unable otherwise satisfactorily to explain, except on the supposition of considerable relative changes of level of different parts of the district in post-glacial times. Mr. Warren Upham has lately traced a number of such channels in Dakota (hypothetically extending his reasoning also to western Manitoba), for which he accounts by the first-mentioned or great-glacier theory.

Great coulées.

In the southern part of the district of the present report, and particularly in the country south of the Belly River, great old channels of the kind above referred to are displayed in a very striking manner in Verdigris, Etzi-kom, Pā-kow-kī, and Chin Coulées and their tributaries. These resemble old river-valleys long disused and now carrying little or no water. I am inclined to regard them as a portion of the earliest drainage system of the plains, outlined at the time at which the waters which distributed the stratified materials overlying the boulder-clays first subsided, and when the rainfall of the region was considerably greater than at present. That these first channels have not, in the particular part of the region now referred to, continued to be the drainage-channels of the country, is perhaps in part due to the much greater depth and importance rapidly attained by the valleys carrying copious and perennial streams derived from the mountains. In the entire obliteration of the original south-eastward slope of the valleys of Verdigris and Pā-kow-kī Coulées, and other peculiar circumstances referred to, in a previous part of this report (p. 14 C) in connection with their present aspect of Milk River, as well as in several local details respecting the relations of the present drainage and the old channels, we appear to find evidence of a greater amount of elevation of the southern as compared with the northern part of the district.* So far as it has affected these old drainage-channels this must have occurred in immediately post-glacial times, and may have been a continuation of the same process which has resulted in the present much greater elevation of erratics in the southern as compared with the northern part of the region.

Their probable origin.

Greater post-glacial elevation to the south.

* See also Geology and Resources of the 49th Parallel, p. 264.

Unless explained by relative differences in level during the glacial period, such as those above suggested, between the Bow River country and that near the 49th parallel, the absence of Laurentian erratics, over the region west of Calgary can only be accounted for by the existence of Rocky Mountain glaciers of sufficient size in this region to fend off the eastern glaciating agent. It is not improbable that such glaciers obtained, and if they can be proved to have existed, it would also prove, in the most convincing way, the approximate contemporaniety of action of the glaciating agents of the Rocky Mountains and Laurentian region. It is certain, however, that the glaciers of the mountains had somewhat decreased before at least the final period of dispersion of Laurentian erratics, for these have been found overlying distinct morainic material of Rocky Monntain origin.

Proof of great uplift of western region.

That the elevation of the western as compared with the eastern part of the plains, was relatively much less in glacial times than at present, seems a reasonable supposition, but must be regarded no longer as merely an hypothesis, for the position of the interglacial materials in the boulder-clay offers a strong positive argument in its favour. It must be supposed that these beds, from their finely stratified character and evidences of tranquil deposit, were laid down, not along the gradually retreating edge of a lake, but in the bottom, and at depths not very considerable. This being the case, the deposits give us the means of recognizing a surface—that of the lake bottom—which was at least proximately horizontal during the interglacial period at which they were formed. From Wolf Island to Coal Banks, the two points furthest apart at which the deposits were observed, is a distance of forty-five miles in a direct line, on a bearing of about S. 70° W. The height above the river of the deposits at the former locality is seventy feet, at the latter, one hundred and five feet, giving a slope eastward of 0·77 feet per mile in addition to that of the present river bed. The latter may be assumed as indicating that of the present surface of the country, as a whole.

Plane of interglacial deposits.

The elevation of the beds in the intermediate Drift-wood bend section is about ninety-six feet, but the locality is only about six miles westward on the same line, and the resulting slope per mile is 4·3 feet, in addition to that of the river, in the same easterly direction, a rate of fall locally much greater than that above determined for the whole distance.

The rate of fall of the Belly River, by its course, between Coal Banks and its mouth, is 6·8 feet to the mile, but on the line above defined (which is that of its general direction) between Wolf Island and Coal Bank, 12 feet to the mile. Adding the general slope previously ascertained for the intercalated beds, we find their eastward inclination to be 12·77 feet to the mile.

General eastward slope of plains produced in post-glacial times.

The general eastward slope of the plains from the base of the mountains to that of the Laurentian region at Lake Winnipeg is about 5 feet to the mile, but the elevation increases more rapidly westward and in the region now considered; and if the intercalated beds referred to were again brought back to horizontality, the plains between the mouth of the Belly River and Coal Banks would become nearly horizontal also.*

Distribution of placer gold.

Besides the effect of the glaciation of the country on its soils and general features, a further result of economic importance in connection with this period is the distribution of gold. Dr. Selwyn in 1874† expressed the belief, based on an examination of the country near Edmonton, that the gold found in the rivers of the Great Plains has been derived from the Laurentian and Huronian region to the east, and not from the Rocky Mountains. The facts met with in the district now reported on conclusively prove the correctness of the above statement. In favourable spots on all the streams of which the banks and beds show abundance of Laurentian and Huronian drift, fine gold may be obtained, while beyond the edge of this drift in the immediate vicinity of the mountains, I have never been able to detect a "colour."

It would be premature to state positively that none of the streams in the mountains yield gold. It is possible that local auriferous deposits may occur, though from the nature of the rocks so far observed in the eastern ranges, not very probable. The general auriferous character of the rivers of the plains depends, however, on the distribution of gold, usually in a very fine state, which has been derived from the old crystalline rocks of the Laurentian and Huronian. In the Bow and Belly district no systematic attempt has yet been made to work the placer deposits on the rivers.

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* In the region west of the Missouri, the present inclined position of the Pliocene beds shows that since the time of their disposition that part of the region in the vicinity of the Rocky Mountains has been greatly elevated. It may well be that the eastward slope of the portion of the plains here treated of may have been produced as a result of the same great movement, and if so the facts above recorded would assign it a date subsequent to that of the glacial period.

† Report of Progress, 1773-74, p. 58.

APPENDIX I.

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LIST OF ELEVATIONS.

The following list comprises the stations on the portion of the Canadian Pacific Railway within the limits of the map accompanying this report:—

	FEET ABOVE SEA LEVEL.
South Saskatchewan River at Medicine Hat	2,101
Stair	2,403
Bowell	2,559
Suffield	2,431
Langevin	2,471
Kininvie	2,405
Tilley	2,438
Bantry	2,449
Cassils	2,493
Southesk	2,477
Lathom	2,534
Bassano	2,563
Crowfoot	2,672
" (Creek)	2,715
Cluny	2,823
Gleichen	2,926
Namaka	2,945
Strathmore	3,005
Cheadle	3,165
Langdon	3,268
Shephard	3,344
Calgary	3,388
" (River level)	3,366
Keith	3,522
Cochrane	3,712
Radnor	3,825
Morley	4,032
Kananaskis	4,170
Bow River—Water level at point of issue from the mountains ("The Gap")	4,100

Elevations Barometrically Determined.

The elevations of the following points have been determined with some accuracy by one or more selected readings of aneroid barometer, compared with the regular observations of the mercurial barometer at Fort Benton, corrected by interpolation to correspond with the hour at which each of the aneroid readings was made. The height of the observing point at Benton is taken at 2,700 feet. I am indebted to General W. B. Hazen, Chief Signal Officer, U.S.A., for a copy of the observations at Fort Benton.

Principal Elevations Barometrically Determined, 1881.

MacLeod-Benton Trail.

	FEET ABOVE SEA LEVEL.
Plain N. of Marias R., Montana	3,007
Plain immediately S. of Rocky Spring Plateau	3,322
Camp at spring, Rocky Spring Plateau	3,659
Summit of Rocky Spring Plateau	4,176
Camp at Red Creek Crossing (water-level)	3,549
Milk River Crossing (water-level)	3,546
Lake at 9-Mile Butte	3,514
Ed. Mahan's Coulée (water-level)	3,449
Lake at 15-Mile Butte	3,082
"Coal Banks," Belly River (water-level)	2,717
Fort MacLeod (water-level)	3,096

Confluence Bow and Belly Rivers (water level)	2,212
Camp, prairie 4 m. W. of Seven Persons' R., 9 m. N. of Cypress Trail	2,640
Seven Persons' River, trail-crossing (water-level)	2,673
Plain 10 m. S. of Crossing, long. 111°	2,676
Crest of ridge N. of L. Pa-kow-ki, long. 111°	2,811
Lake Pa-kow-ki (water-level)	2,735
Milk R. at Pa-kow-ki Coulée (water-level)	2,816
Flank of W. Butte. (Laurentian drift abundant)	4,601
" " " (highest observed Laurentian drift)	4,662
Milk R. at Verdigris Coulée (water-level)	3,065
Milk R. 20 m. W. of MacLeod-Benton trail-crossing (water-level)	3,720
Milk R. 1 m. N. of 49th parallel, long. 113° (water-level)	4,173
Camp at two lakes 5 m. W. of above point	4,116
St. Mary R. 6 m. N. of 49th parallel (water-level)	3,850
Waterton R. near mouth (water-level)	3,217
Waterton Lake	4,245

S. Branch Drywood Fork at issue from mountains	4,711
Southern stream of N. Branch Drywood Fork ½ m. W. of edge of Palæozoic rocks	4,892
Mill on Mill Creek (water-level below dam)	3,807
Kootanie Brook at Forks in S. Kootanie Pass	4,703
E. base of Summit Ridge, S. Kootanie Pass	5,701
Summit of S. Kootanie Pass on trail (approx.)	7,070
Summit of peak 1 m. N. of S. Kootanie Pass	7,878
Calgary Trail 4 m. S. of Pine Coulée	3,240
Highwood R. at trail-crossing (water-level)	3,383
Blackfoot Crossing of Bow R. (approximate only)	2,595
Middle Fork Old Man R. at issue from mountains (water-level)	4,170
Crow Nest Lake, in Pass	4,426
Summit Crow Nest Pass (5 m. W. of first watershed)	4,853
Camp 3 m. W. of summit Crow Nest Pass	4,533
Camp W. base of Porcupine Hills, about 40 feet above N. Fork of Old Man R., at angle	4,116
N. Fork Old Man R. at issue from mountains (water-level)	4,437
Little Bow at crossing of Blackfoot Crossing trail (water-level)	3,053
Camp summit of Buffalo Hill	3,857
Lake in Snake Valley	2,872
Camp near summit level of Rocky Buttes	2,972
Camp at lake on plain at S. E. base Rocky Buttes	2,650
Camp at S. base of Black Spring Ridge	3,030
Camp on plain near Scabby Butte	3,112
Mouth Little Bow R. (approximate only)	2,578
Summit of Hog's Back on trail W. of Ft. MacLeod	4,390

Principal Elevations Barometrically Determined in 1883.

	FEET.
Plains 6 m. N. E. of mouth of Pa-kow-ki Coulée	2,892
" 11 m. N. of E. end Dead Horse Coulée	3,050
" 18 " " "	2,967
" near S. bend Etzi-kom Coulée	2,971
" 13 m. N. W. of mouth of Verdigris Coulée	3,000
" 8 " " "	3,030
Suds Lake, Verdigris Coulée	3,060
Middle Coulée at trail-crossing	3,117
Camp in valley of stream near head of Fossil Coulée	3,460
Nine-Mile Butte Lake	3,540
Fifteen-Mile Butte Lake	3,096
Coal Banks, Belly River	2,655
Summit N. Kootanie Pass	6,690
Summit S. Kootanie Pass (mean of obs. of 1881-83)	7,040
Garnett's House, near S. Fork Old Man	4,160
Middle Fork Old Man, trail-crossing	3,904

Crow Nest Lake (mean of obs. of 1881-83).............	4,387
Summit Crow Nest Pass (5 miles W. of first watershed)	4,838
" " " (mean of obs. of 1881-83)......	4,845
Camp in valley at E. foot Livingstone Range, 10 m. S. of North Fork Gap	4,920
North Fork Old Man River (inside Gap)..............	4,600
North Branch North Fork Old Man R., 2 m. from Gap.	4,709
" " " " " 16 "	5,371
N.W. " " " " 8 "	4,966
" " " " " (above fall) ...	5,512
Camp in valley in foot-hills 6 m. S. of N. Fork Old Man	4,670
Mouth S. Branch S. Fork of Old Man	4,239
Small lake in foot-hills near Upper Pincher Creek	4,751

APPENDIX II.

Blackfoot Names of a Number of Places in the North-west Territory, for the Most Part in the Vicinity of the Rocky Mountains.

Note.—The names in these lists were received from Mr. J. C. Nelson, who, in association with Mr. A. P. Patrick, was during several years engaged in surveys in the North-west. The phonetic values of the letters are not stated, and I have not ventured by transliteration to make the orthography conform to any phonetic system. It appears, nevertheless, desirable to place the original Indian names of places on record as far as possible.

Places within the Area covered by the accompanying Map of the Bow and Belly Rivers District.

Locality, or English Equivalent.	Blackfoot.	Literal Meaning.
Slide Out	eh-pit-seht-zoaskoi	Point of timber running out.
Big Island (at Forks of Belly and Waterton R's).	oh-max'-inay	
Little Owl Lake (middle of Waterton Lakes)	se-pisto-maxi-kimmi	The lake in the pound.
Little Bow River	namagh-ty	Naked river.
Seven Persons River	ikitsīka-etapix	
Rocky Mountains	mis-tōkis	
Porcupine Hills	ky-es-kaghp-oghsuyiss	Porcupine tail.
Buffalo Fat Pound Coulée (on the Belly River, five miles above Dutch Fred's)	pomi-piskan-kawagh-kway	
On river $1\frac{1}{2}$ miles below Fort MacLeod, also above Blackfoot Crossing	nimex	The bank abreast of the wind.
Whoop Up	ākka'-inow-skway	Many Blood Indians died.
Forks of the Bow and Belly Rivers	omak-etaow-towughty	Big forks.
The Elbow	moki-nist-sis	
Near Coal Banks, (right bank of river)	mek-kio-towaghs	Painted rock.
Elbow of Belly River (30 miles east of Coal Banks)	akka-kima-toskway	Many woodpeckers.
The Chin (of map)	misto-amo	The beard.
Belly River	mokowanis-etughty	
Belly Butte	mō-kō-an-etōmō	

Turnip Butte	mas'-etomo	The ridge between the rivers.
Ridge between Belly and Waterton Rivers	sitoko-pawaghkway	Ridge below the water.
Blackfoot Crossing	soyogh-pawaghkway	Berries up the hill-side.
Cherry Coulée	ami-onaskway	
Far-out Coulée (on Belly River)	piyami-pawaghkway	
Drift-wood Bend	akka-kowatchis-kway	Drift-wood place.
Above Coal Banks, right bank	assini-etomotchi	Where they slaughtered the Crees. (?)
Black Spring Ridge	sitoko-kghis-kom-pawaghkway	
Scabby Butte	api-kmmikway	
The Valley, south of Chin Coulée	etzi-kom	
About 35 miles below Blackfoot Crossing on Bow	nitzi-tohtzi-pekiskway	Little rolling hills by the river.
Beaver Creek	kak-ghik-stakiskway	Where the beaver cuts wood.
Crow Lodge Creek (enters Old Man, opposite Peigan agency)	ataw-is-toik-akawpi, *or* mastowisto-ek-oka-pi	The lodges with crows painted.
South-east spur of the Porcupines	otsi-tchiksis-apikimikway	The ridge that slopes down to the river.
Bad Lands near mouth of Bow River	agh-pao-tagh-ka	Ground over ground.
Long Lake (at junction of Chin and Seven Persons Coulée)	eno-kimi	
The Big Cairn (near mouth of Bow River)	oh-maki-ya-kotop, *or* oh-max-ŏkotok	
Parflesh Creek (Crowfoot Creek)	eht-si-manis	
Thigh Hills	motuksina	Thigh flesh.
Snake Creek	ak'-ustsik-siniskway	Place of many snakes.
Arrow-wood Creeks	nehts-ziks-kway	Arrow-wood place.
The Beautiful Butte, near Pi-yami Coulée	ists-sa-natskimikway	The beautiful hill that can be seen from afar.
Picture Butte, near Pi-yami Coulée	a-natskimikway	The beautiful hill.
Seven miles above Whoop Up	ehts-sin-no-kaka	Where they hunt the elk.
Three miles above Fort Kipp	eh-issa-kaghko	Left hand cut bank.

PLACES WITHIN THE AREA COVERED BY THE ACCOMPANYING MAP, &c.—*Continued.*

LOCALITY, OR ENGLISH EQUIVALENT.	BLACKFOOT.	LITERAL MEANING.
Many Berries Coulée (between mouth of Bow River and Cherry Coulée	ako-niskway	
Many Rosebuds River	ako-kiniskway	
Spy Hill (three of this name—one at Calgary, opposite the Nose; one between Coal Banks and Rocky Coulée; one N. of Red Deer River)	sah-a-misapi	
Middle Butte (near mouth of Highwood River)	eh-tutzeh-kigh-kimi-kway	
Sounding Lake (two of this name—one near Hand Hills and one between Little Bow and Bow River)	oghta-kway	
Big Grass Marsh (at head of second Sounding Lake)	o-mu'-kutzi-mook	
Stone Rib Creek (north of Red Deer River)	seh-soo-wa-taghs	The rock without ribs.
Berry Water Lake (between Blackfoot Crossing and Little Bow, on road)	nimi-oghkee	
Rocky Buttes (between St. Mary and Belly Rivers)	okotok-skway	
Lake, between Blackfoot Crossing and Red Deer River (Tide Lake)	awy-kimiska	The lake that runs up and down.
The Rainy Hills	sotah-ygh kimi-kway	
A point between Blackfoot Crossing and Red Deer River	ponoka-emilă-omukty-neep	Where the horse died.
Fort MacLeod	stamix-otokan-okowy	Bull's head's home.
Fort Calgary	mok-kinistsis-in'-aka-apewis	
Shaganappé Point (above Calgary)	eh-naok-keet-tox-kway	Half point.

The Old Man's Bed (on the Red Deer, near the Rosebud River)	napia-okanes	
Leaning Hill (between Blackfoot Crossing and Red Deer River)	kegh-keep	Propped up hill.
Above Calgary, on the Bow	inew-teneks-is-dop	Where the buffalo run down the hill.
Fishing Lake (near Hand Hills)	mamis-kway	
A point on Red Deer River	eh-taka-okeeneema	Where many lodges of the dead are.
Jumping Buffalo Hill (on the Bow River)	otse-tchik-sisa-pagh-ki-ote-seh	
The Inner Rainy Hills	pists-sotah-ygh-kimi-kway	
The Inner Big Cairns (in Rainy Hills)	pists-omakiya-kotop	
Bad Water Lake	pāk-oghkee	
Sarcee Plain	sarcee-sowkee	
Picture Rocks (on stream at Big Hill above Calgary)	omisinah	
St. Mary River	opoghto-maxi-kimi-'tughty	South Big Lake River.
Old Man River	napia-otzi-kagh-tzipi, *or* natok-kiokas.	
Milk River	kinok-kxis-ughty	Little river.
Highwood, or High River	spitzii	
Fish Creek	stokan	Medicine lodge.
Ghost River	opskoonakaz	River with rapids.
Sweet Grass Hills	katoyis	
Hand Hills	oht-tchis-tchis	Strawberry Hills.
The Nose (above Calgary, on opposite side of river)	mōk-sis-sis	
Big Hill, or Blackfoot Hills (east of Calgary and north of Bow River)	o-muk-etomo	
Egg Lake (in Hand Hills)	aka-'waskway	Many eggs place.
Enemy's Pound (on east side of Porcupine Hills)	pinotzi-piskan	

PLACES WITHIN THE AREA COVERED BY THE ACCOMPANYING MAP, &c.—*Concluded.*

Locality, or English Equivalent.	Blackfoot.	Literal Meaning.
Crow's Stone Hill (on Red Deer River, north of Blackfoot Crossing)	masto-wy-oka-etomo	
Wolf's Peak (four miles above Whoop Up)	muk-kwy-otchekan	
Buffalo Pound Creek (east side of Porcupine Hills)	ehtzi-pāk-si-kini-kawts	Where we smashed their heads in the mud.
Tasting Lake (east side Porcupine Hills)	mata-pokway	
Ghost Pound (east side of Porcupine Hills)	staow-piskan	
Woman's Pound	aki-piskan	Woman's Pound.
	nehts-is-omiope	Where we approached the enemy.
Men's Pound (Jumping Pound River of map)	nina-piskan	
The Lone Tree (on Peigan Reserve)	ly-poy-yi	
Blood Green-water Lake (on or near Chin Coulée)	kinaow-oghkee-komino-was	
Peigan Green-water Lake (on or near Chin Coulée)	peigani-oghkee-komino-was	
Middle Heights (between Mosquito Creek and High River)	sitook-spagkway	
Mosquito Creek	pāk-si-may-so-yiskway	White willow place.
The White Precipice (on Elbow River, about 10 miles above Calgary)	istztcha-payks, *or* apa-zeaks-aghk.	
The Plateau (above Calgary, on same side of river)	spas	
Grassy Lake (half-way from Fort MacLeod to the Little Bow River)	moyi-kimi	
Rocky Coulée (about 12 miles east of MacLeod, on Old Man River)	ah-mistokiskway	
Sheep Creek	okotokxi-etughty	Rocky river.
Tongue Flag Creek	matsin-awastam	

The Drifting Sand Hills (above Blackfoot Crossing, on the Bow River)	kasapō-spatchikway	
Many Berries Creek (runs out of Bad Water Lake)	aka-ehniskway	
Sun Dial Hill	onoka-katzi	
Chief Mountain	nina-stokis	
Hunting Hill Coulée (on Bow R., below Big Cairn)	sah-a-misapi-kawaghway	

PLACES EAST OF THE AREA OF THE ACCOMPANYING MAP OF THE BOW AND BELLY RIVERS DISTRICT.

The Ford of the Drowned (on South Saskatchewan, 30 miles above mouth of Red Deer).	eh-ty-nehts-ope-piney.	Where we were drowned.
Forks of the Red Deer River	ponoka-si-oughty-ototughty	
The Gap (in Cypress Hills)	ā-ygh-kimi-kway	
Medicine Hat	sah-a-mis	
The Great Sand Hills (north of Cypress Hills)	omaxi-spatchikway	
The Middle Sand Hills (between Red Deer and South Saskatchewan Rivers)	sitoko'-spatchikway	
At Standing Hill, north of Cypress Hills, (bottom land of the South Saskatchewan)	agh-pot-sikimi	Where it overflowed.
Standing Hill	pī-is-koas	
Large Lake, north of Cypress Hills	aka-'amuskis-skway aka-naywass	Many lizards or many islands lake.
Red River	maokootzi-tughty	
The Forehead (Forks of Red Deer and Saskatchewan Rivers)	moh-nisey	
Ghost's House (30 miles north-east of Cypress)	sta'-apewis	
Elk-water Lake (at head of Cypress)	ponoka-oghkee	
Wood Mountains	ā-ygh-kimi-kway	Gap in the hills.
Eyebrow Hills	napisp-piw'-tomo	
Fort Walsh	ā-ygh-kimi-kway-in-aka-apewis	

Places North of the Area of the accompanying Map of the Bow and Belly Rivers District.

Locality, or English Equivalent.	Blackfoot.	Literal Meaning.
Edmonton	amakowis	The big house.
Fort Pitt	eh-tutzi-kughs-apewis.	
Battleford	kenoksis-is-ughty-oto-tughty	
Fort Carlton	napia-poka-okowy	White man's child's house.
Little Red Deer River	asino-ka-sis-ughty	
The Head Pine (on road from Calgary to Rocky Mountain House)	olokan-exi	
Battle River	kinok-kxis-sis-ughty	Little or half river.
Bear Hill (30 miles south of Edmonton)	kyo-etomo	
Beaver Hill (near Fort Saskatchewan)	kaghghik-staki-etomo.	
Neutral Hills	kghx-yx	
Rocky Mountain House	ā-pastan	
Wild Cat Hills, (E.N.E. of Morley)	natayo-paghsin	
Macpherson's Coulée (21 miles north of Calgary)	namaghkanes.	Rifle bed.
North Saskatchewan River	omaka-ty	Big river.

Places West of the Area of the accompanying Map of the Bow and Belly Rivers District.

Country beyond the mountains	sat-tos	Across the mountains.

Places South of the Area of the accompanying Map of the Bow and Belly Rivers District.

The Knees (on Benton trail)	motuksis	
Marias River	kyo-eis-'ughty	Bear river.
Missouri	amiskapo'omakaty	Big south river.
Yellowstone	ponakasis-'ughty	Elk river.
Bear's Paw (in Montana)	kyo-'tsis	
Little Rocky Mts. (in Montana, near Wolf Hills)	muck-kwyé-stokkis	
Helena	aka-ota-kotsis	Great cactus plain.
Diamond City	aka-oto-tughty	Many river forks.
Fort Benton	amiska-poghts-aka-apewis	South many houses.
Deer Lodge	awatuyé-okowy	White-tail deer lodge.

Names of Places whose Exact Positions are Unknown.

Little Blackfoot Crossing	enax-soyogh-pawaghkway	
The Lone Point of Trees (on Red Deer River)	nitoks-kaskway	
Wild Cat Pound	natayo-piskan	
Pemmican Hill (on Red Deer River)	moka-keh-etzitato-ope	Where we lost the pemmican.
Many Cherry Bushes Valley	aka-onaskway	
Elk River	ponokasis-'ughty	
Three Hills	nioka-etomox	
Pigeon Hill	mom-mo	
Dried Meat Hill	kyé-'tomo	
Willow Hill	pak-kitze-kimi-kway	
Snake Hill	piksisina-oksisis	
Buffalo Lake	ini-'oghkee	
Coulée above Medicine River	py-yotami-kawaghkway	The coulée coming this way.

NAMES OF PLACES WHOSE EXACT POSITIONS ARE UNKNOWN.—*Continued.*

LOCALITY, OR ENGLISH EQUIVALENT.	BLACKFOOT.	LITERAL MEANING.
The Horns .... On Red Deer River.	oht-skanaix	
Muddy Bed .... " " "	pāk-sikkaghko-kanes	
Red Rock .... " " "	maok-skoistch	
The Orphans' Place .... " " "	eh-is-tuyé-pokaex	Where the orphans were cold.
Where He Slept .... " " "	eh-to-kitzi-keenis-staow-pee	
The Peigan's Hill .... " " "	sah-ami-es-kapeep	
Big-mouthed Spring .... " " "	sokoge-oksis-kom	
Lake Pound	omuk-sikimi-piskan	
Timber Incline	matsi-pa-sat-sikway	
Eagle Hill	pitah-etomo	
Beard Spring (north of Red Deer River)	misto-kxis-kom	

NOTE.—The following names of places were obtained by myself from Blood Indians known as Bull Shield and Button Chief. In these the vowels have the "Continental" values and the spelling generally is conformable to that employed in vocabularies previously published by the Survey.—G. M. D.

St. Mary River	pa-toxi-a-pīs-kun	Banks damming the river.
Belly River	mo-ko-un-se-te-ta	
Chief Mountain	min-ai-sto-kwa.	
St. Mary Lake	puh-to-mux-okin	
Old Man River	na-to-ke-okos	Two medicine lodge.
Pincher Creek	in-oks-spit-zi	Little high wood river.
Willow Creek	stai-a-pis-kun	
Porcupine Hills	kai-skop-o-soi-us	
Milk River	ki-nuh-si-suht.	The little river.
Milk River Ridge	amuh-pow-ēkwi	
Belly Butte	mo-ko-ons.	The belly.
Blackfoot Crossing	soi-a-poh-kwe	
Little Bow Water	na-muh-tai	
Bad Water Lake	pā-kow-kī	
Seven Persons Coulée	ki-tsuki-a-tapi	
Bull's Head Hill	ine-o-to-ka	
Cypress Hills	ai-ēkun-ēkwe	
Sweet Grass Hills	kat-e-is	
Medicine Hat	sa-a-mis	

APPENDIX III.

The following are partial analyses by Mr. G. C. Hoffmann, of specimens of clay ironstone, derived from the rocks of the district embraced by the foregoing report. These analyses are quoted from the Report of Progress, 1880-82.

Bow River, eight miles above Grassy Island, (p. 90 c.)

Ferrous oxide	40.347
Ferric oxide	.878
Water, hygroscopic	.856
Insoluble residue	16.121
Metallic iron, total amount of	31.996

Bow River, twelve miles above Prairie Island, (p. 91 c.)

Ferrous oxide	28.818
Ferric oxide	.818
Water, hygroscopic	.938
Insoluble residue	13.935
Metallic iron, total amount of	22.987

Kananaskis or Rapid River, near its confluence with Bow River, (p. 107 c.)

Ferrous oxide	13.786
Ferric oxide	.772
Water, hygroscopic	.473
Insoluble residue	66.966
Metallic iron, total amount of	11.263

Belly River, at Coal Banks, (p. 72 c.)

Ferrous oxide	41.458
Ferric oxide	.328
Water, hygroscopic	1.042
Insoluble residue	10.294
Metallic iron, total amount of	32.475

Belly River, about seven miles below Coal Banks, (p. 73 c.)

Ferrous oxide	30.730
Ferric oxide	1.398
Water, hygroscopic	1.272
Insoluble residue	23.754
Metallic iron, total amount of	24.880

Belly River, about seventeen miles eastof the mouth of the Little Bow River, (p. 74 c.)

Ferrous oxide	30.302
Ferric oxide	1.487
Water, hygroscopic	1.445
Insoluble residue	12.120
Metallic iron, total amount of	26.165

Mill Creek, at coal outcrop, about four miles above the mill, (p. 99 c.)

Ferrous oxide	37.985
Ferric oxide	.811
Water, hygroscopic	.634
Insoluble residue	12.511
Metallic iron, total amount of	30.112

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

REPORT

ON PART OF THE

BASIN OF THE

ATHABASCA RIVER,

NORTH-WEST TERRITORY.

BY

ROBERT BELL, M.D., LL.D., C.E., F.G.S., F.R.S., CAN.

1882-3.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL.
DAWSON BROTHERS.
1884.

A. R. C. Selwyn, LL.D., F.R.S., &c.,

Director Geological and Natural History Survey of Canada.

Sir,

I have the honor to submit the annexed report on the geology and topography of a part of the basin of the Athabasca River and the adjacent territory to the south and east of it; also the accompanying map illustrating the report. This map having been constructed since I had the honor of submitting my report * on the region referred to, in December, 1882, I have been able to describe the geology, &c., more fully and minutely than was possible at that time. The map, which is on a scale of eight miles to an inch, is entirely original, and it forms part of a large sheet, on the same scale, constructed by Mr. A. S. Cochrane, showing his own track-surveys as far east as Reindeer Lake. Lake Athabasca and the Clearwater River, as represented on this map, are from Mr. Cochrane's track-surveys, all the rest of the topography being from my own.

I have the honor to be,

Sir,

Your obedient servant,

ROBERT BELL.

Ottawa, May, 1884.

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* On the 16th January, 1883, I received the usual summary Report of the season's operations from Dr. Bell. This was referred to in my report to the Minister, and also pages 14 to 15 Geological Survey Report for 1880-81-82. The present report was submitted to me in type in November, 1884. A. R. C. S. 27th Dec., 1884.

REPORT

ON

PART OF THE BASIN OF THE

ATHABASCA RIVER,

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BY

ROBERT BELL, M.D., LL.D., C.E., F.G.S., F.R.S., CAN.

The principal object of the exploration of 1882 was to investigate the geology of the heretofore unexplored portion of the Athabasca River between the junction of the Lac la Biche River and the Clearwater, but my instructions also directed me to examine more carefully than had hitherto been done the relations of the rocks of the river below the latter stream, especially with reference to the mode of occurrence of petroleum and asphalt. Track-surveys were to be made of the routes travelled over, and, as usual, observations were to be noted in regard to geographical facts, surface geology, soil, climate, agriculture, natural history, etc. It was supposed that a canoe-route existed between the southern part of Lake Athabasca and Isle à la Crosse Lake, and, in coming home, I was to have followed it and ascertained something of the nature of the extensive and unknown region lying between the former lake and the upper waters of the Churchill River. It was found, however, that the supposed route was not known to exist, and I therefore returned by the Clearwater River, the Long Portage, Methy, Buffalo and Clear Lakes. The interim report furnished soon after I reached Ottawa gave an account of the mode in which I had endeavoured to carry out the above instructions, including a narrative of the journey to and from the most distant point reached, with dates of arrival at the principal points and other details. It also contained an epitome of the geological results, more particularly in reference to the petroleum and asphalt. A map has since been prepared by Mr. A. S. Cochrane, showing my track-surveys in a connected manner along with those made by Mr. Cochrane the previous

Region to be explored.

Instructions.

Interim report.

Map.

year. This enables me now to give distances and directions and the positions of localities with sufficient precision for permanent reference, and, in connection with these topographical features, I am enabled to furnish the geological description with tolerable accuracy as to geographical details. A portion of this map on a scale of sixteen miles to an inch accompanies this report. I was assisted in the field-work by Mr. A. C. Lawson, B.A., who always carried out my instructions with intelligence and energy. From Winnipeg we proceeded by the Canadian Pacific Railway to the end of the track, and thence with horses and buckboards, by way of Forts Qu'Appelle, Carleton and Pitt, to Lac la Biche, the distance by the trails followed being about 770 miles. From this lake I continued my journey northward by canoe, Mr. Lawson being sent with the horses by way of Carleton to Green Lake, where he was to meet me on my arrival from Isle à la Crosse.

Route travelled.

A track-survey was first made of Lac la Biche itself, and then of La Biche River, showing every bend in its entire length. A similar survey of the Athabasca was carefully made, all the way from the junction of La Biche River to its mouth in Athabasca Lake, a distance of about 270 miles in a straight line, or 380 following the sinuosities of the river. Throughout the whole of this long stretch, the rocks proved to be of much geological interest, and they will be fully described further on. A cursory examination was next made of the rocks of the western part of Athabasca Lake. Our knowlege of the geography of the delta of the Athabasca was added to by track-surveys on the return journey. A survey of the same kind was carefully made from Methy or Long Portage, through the various lakes and rivers followed, to Isle à la Crosse, and thence by the Beaver River to Green Lake, which was also mapped, the whole distance in a straight line being 195 miles, or 245 miles following the courses of the rivers and lakes. Mr. Lawson having arrived with the horses at Green Lake, we proceeded thence by Fort Carleton, Prince Albert and the Touchwood Hills to Troy, on the Canadian Pacific railway. The distance thus travelled was about 355 miles, measured in straight lines between the Hudson's Bay Company's posts, but about 470 following the courses of the trails. The distance actually travelled in going out and returning would, therefore, be as follows:—

Track-surveys made.

Distances.

	MILES.
From the end of the C. P. R. track to Lac la Biche	770
From Lac la Biche to Fort Chipewyan	380
From Fort Chipewyan to Green Lake, by the Methy or Long Portage	520
From Green Lake to Troy, on the C. P. R.	470
Total distance by horses and canoes	2,140

The distance travelled by rail from Ottawa in the spring and returning in the autumn amounted to about 3,460 miles, so that the total distance covered during the season was about 5,600 miles.

Geological Description.

Geological description.

No rocks older than the drift were seen *in situ* before reaching the Biche River, and I shall therefore begin my geological description with this stream, reserving my notes on the drift for a subsequent part of the report. The Biche River leaves the western extremity of Lac la Biche, and flows in three stretches in the form of the letter Z, having an aggregate length in three straight lines of forty-five miles. The upper and central courses flow through a very marshy country. The general course of the latter is north, but both it and the third or lowest stretch are very crooked. The latter is full of shallow rapids over pebbles and cobble-stones. According to my barometrical observations the level of Lac la Biche is 186 feet over that of the Athabasca River at the junction of the Biche, and 126 feet of this fall takes place in the last stretch of the river. In some places in this stretch the banks of the river, which are mostly of clay, are fifty feet in height. Small sections of rocks *in situ* occur along this part of the stream, which are quite similar to the Cretaceous strata seen not far off on the Athabasca. They consist of dark drab and indigo-colored marls and shales, with nodules and thin layers of clay-ironstone, lying quite horizontally. Biche River.

The water of the Athabasca River is more muddy than that of the Biche. Its breadth at the junction of the two streams is from 150 to 200 yards, and it varies but little all the way to the Clearwater, below which it becomes considerably wider. From the Biche River to Point la Biche the general course of the river is N. 8° E (ast.), and the distance 88 miles, and from this point to the Clearwater the general course is N. 70° E. and the distance 55 miles. The following are the distances, in straight lines, of the principal features in the former stretch from the junction of the Biche River:—Quito River, from the west, 8 miles; Mississtiquaio-sipisis or Big-mouth Brook, from the east, 22 miles; Shaitaik or Pelican River, from the west, 52 miles; House River, from the east, 74 miles; the Grand Rapid, 82 miles. Athabasca River. Branches.

Between the Biche River and the Grand Rapid the Athabasca has a smooth, uniform current of two to three miles an hour, and above the Biche the same character is said to extend up to the Athabasca Landing. Frequent soundings were taken in the middle of the river from the Big-mouth Brook to House River, on the 27th and 28th of August, and the depth was found to vary from 12 to 22 feet, the average being about 15 feet. The water was at about a medium height at this season. Depth of the river.

Character of river and banks.

From the Biche to the Pelican River the Athabasca flows between sloping banks from 50 to 150 feet, and at a few points 200 feet in height, the general elevation gradually increasing in descending the stream. The bed of the river is probably fully 200 feet below the general level of the flat country on either side, but the full height of the banks is seldom seen from the river. The sloping banks are partly wooded and partly bare, owing to the sliding of the clayey strata of which they are composed. The timber consists of spruce, balsam, rough-barked poplar, aspen, and white birch. The beach, and apparently also the bottom of the river, are paved with cobble-stones and small well-rounded boulders, consisting mostly of quartzite and gneiss, all packed tightly together and pressed down to an even surface by the drifting ice in spring. This natural pavement often shows scratches parallel to the course of the river, which have been caused by the passing ice.

Geology of banks.

Throughout the above distance the banks consist of dark clayey Cretaceous marls, having a general horizontal attitude, but often appearing to dip at various angles, owing to the sliding of large masses on the slopes. Along the edges of this part of the river numerous large concretions are met with, which are evidently derived from the marls. They are mostly tortoise-shaped and are often six or eight feet in their greatest diameter. Sometimes smaller concretions are attached to the large ones. When broken they are found to consist of a drab-colored calcareo-ferruginous argillite. The surface of these concretions often presents a reticulated appearance, being divided by veins of yellow calcspar into five or six-sided spaces. A highly crystalline mass of this mineral, or a hollow space lined with it, is often found in their centres. Occasionally the concretion consists of a mere shell of the compact ferruginous argillite, divided into sections by the calcspar veins, and either hollow in the centre or more or less filled up with crystalline calcspar. Besides these large concretions there are numerous nodules of clay-ironstone, and in some places crystals of gypsum were observed in the dark-colored marls. On the east side of the river, four miles below the Big-mouth Brook, in a cliff of dark marl thirty feet high, a layer of fine crystals and crystalline aggregates of iron pyrites was found near the water's edge. Fossils are rare in the marly strata along this section of the river, a small species of Ostrea being the only one found *in situ*. Fragments of fossil wood, which have, no doubt, been derived from the marls, were not uncommon on the surface. On the west side, just below the mouth of the Pelican River, a considerable deposit of brown ochre was noticed on top of a bank of drift.

Concretions. Ironstone, gypsum and pyrites. Fossils. Ochre.

From Pelican to House River, a distance of 22 miles in a straight line, the Athabasca has about the same character as above, flowing smoothly between sloping banks, about 100 feet in height. At first they consist almost entirely of the dark, indigo-colored marls, with a few lighter layers, still quite horizontal, but soon a very soft-grey sandstone, the weathered surface of which has a light, yellowish-grey color, shows itself at the foot of the bank on either side, and as we descend the stream it appears to become constantly higher, owing to the fact that the bed of the river itself is gradually sinking into the strata at an average rate of about three and a half feet in the mile, measured in a straight line. At two miles below the Pelican River, the east bank shows 100 feet of blackish marls with lighter marls toward the top, underlaid by 10 feet of the soft-grey sandstone. At three miles the sandstone at the base has increased to 20 feet; at four miles, to 25 feet, and at five miles to 40 feet, with 60 feet of the dark marls above it; but in this vicinity the strata have a slight dip to the south-eastward. The sandy strata are interstratified with numerous dark shaly layers. For about four miles in the central part of the above 22 miles, the sandstone forming the lower part of the banks has an almost uniform thickness of 50 feet and is interstratified with some blackish marly bands. On the west bank at 18 miles below Pelican, and four miles above House River the following approximate ascending section occurs:—

Soft sandstone.

Marls.

Section.

	FEET.
Very soft or slightly coherent, grey sandstone	40
Dark, indigo-colored marl	20
Soft, light-grey sandstone	15
Dark, indigo-colored marl	25
Drift to the top of the bank	20
	120

Here there is a slight dip to the south-south-westward. A similar section is exposed, also on the west side, two miles further down, or within two miles of House River. In the above portion of the Athabasca River, the sandstones are so incoherent that they seldom form perpendicular cliffs. Only certain portions of the strata appear to be able to withstand the weather for any great length of time.

From House River to the Grand Rapid, the distance is ten miles. For a few miles before reaching the rapid the river is flanked on both sides by cliffs about 40 feet high, of soft, fine-grained, bluish-grey sandstone, weathering yellowish-grey, with patches of a lemon-color. Grand Rapid is the principal obstruction to the navigation of the Athabasca. The rapid is about half a mile in length, with a fall of twenty to thirty feet. The canoe portage trail, about three quarters of a mile long, is on the right side, but the boat portage passes over the larger island. The

Soft sandstone.

Grand Rapid.

river is here divided by two islands, but the greater part of the water follows one channel, down which scows laden with the boilers and machinery of a steamboat to be built for the Hudson's Bay Company, at Fort Chipewyan, had been successfully run a short time before we passed. The lower beds above the rapids contain some tortoise-shaped concretions, and indurated, lenticular patches which appear to differ from the rest of the sandstone only in their greater hardness, and containing a little carbonate of lime. Several of these masses, which had

Fossil wood.

been split open, were observed to contain fragments of fossil wood, of a dark brown color, but weathering white and showing the ligneous structure very distinctly. Some of the concretions have been formed around aggregations of sticks and vegetable debris. One piece of the fossil wood, embedded in sandstone, was found to be six feet long, and 18 by 14 inches in diameter. Seams of carbonaceous matter, two to three inches thick, occur in the cliff on the right-hand side, and along with them are thin layers of fine conglomerate, consisting of small,

Small polished pebbles.

highly-polished pebbles, from the size of a number 4 shot to that of beans, of green, olive and black chert and white quartz. In some parts these glossy little pebbles are scattered through the sandstone. On the beach at the head of the rapids, fragments of lignite, and of bright-red burnt marl, like fine-grained brick, were found, and at the foot of the rapid many fragments of blackened manganiferous and ordinary clay iron-stone, apparently derived from the sandstone. At the Grand Rapid the bed of the river breaks down into a band of sandstone, which is conspicuous for a long distance below, owing to its being more or less

Spherical concretions.

thickly studded with spherical concretions differing from the matrix in containing some argillaceous matter. Towards the foot of the rapid great numbers of these boulder-like concretions are heaped in the bed of the river and are remarkable for their prevailing spherical form. The left bank of the river at the foot of the rapid presents the follow-

Section.

ing section, in descending order, the figures being only approximate :—

	FEET.
1. Soft, grey, fine, homogeneous sandstone, studded with spherical concretions of a more argillaceous character than the matrix. They vary from 1 foot to 6 feet in diameter, the average being about 3 feet	20
2. Soft, fine, homogeneous, grey sandstone, without visible lines of stratification	25
3. Marly arenaceous layer	4
4. Soft, fine, homogeneous-grey sandstone like	20
5. Dark, aranaceous marl	30
6. Soft, friable, grey sandstone, weathering light yellowish-grey, and forming a perpendicular cliff	25
7. Dark marl on top of bank	15
	139

Geological Survey of Canada. From a sketch by Dr. Bell, 1882.

GRAND RAPIDS, ATHABASCA RIVER, LOOKING SOUTHWARD OR UP STREAM.

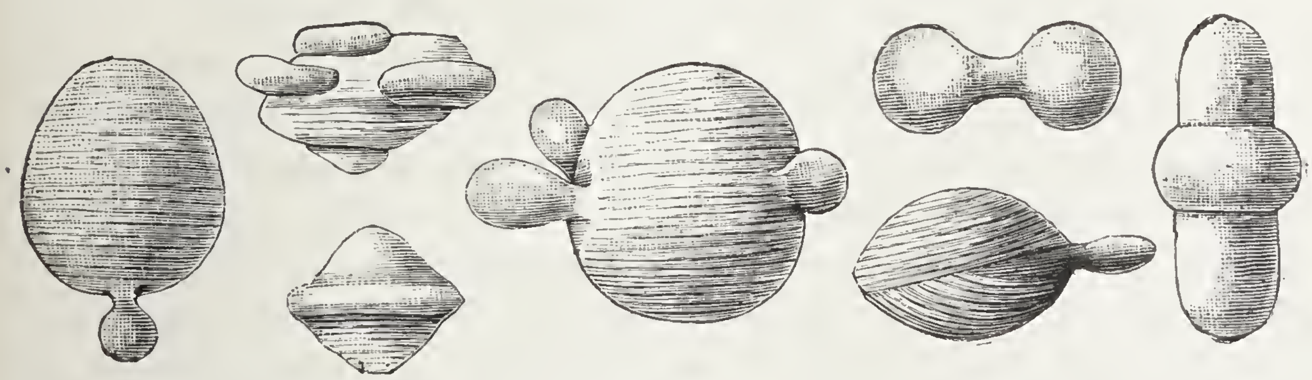
Below the Grand Rapid the concretionary band forms a conspicuous feature in the cliffs along the river for a distance of over thirty miles, gradually rising higher above the water. On the right side of the river at twelve miles in a straight line below the foot of the larger island in the Grand Rapid, where the bank is over 100 feet high, the top of this band is just below the middle line of the cliff, or about 50 feet over the water, indicating a fall of 4.16 feet per mile in the river, assuming the strata to be perfectly horizontal, and this agreed with the difference of level as determined by the barometer. On the left side of the river, between the Rapide Milieu and the Rapide Pas-de-Bout, at a distance of 20 miles in a straight line, or about 40 by the river (from Grand Rapid), the bank is about 300 feet high, and the top of the concretionary band appeared to be about 200 feet over the water, indicating on the same assumption an average fall of 6.9 feet per mile, in a straight course, or 5 by the river.

Concretionary band of sandstone.

Rate of descent in the river.

Leaving the foot of the larger island in the Grand Rapid the river continues broken for a mile and a-half, the descent in this distance amounting to 36 feet, as indicated by the barometer, but below this the water is smooth for more than fifteen miles. For several miles from the above island a bank of soft, grey, friable sandstone, about 90 feet high, continues down the left side of the river. The concretionary band forms a cliff along the edge of the water, having a uniform height of about 20 feet. The concretions are piled thickly along the right side of the stream. Many of them are perfectly spherical, but the largest ones are flattened. Some of the latter are 20 feet in their greatest diameter while many would average 8 and 10 feet. The lines of stratification of the sandstone run through some of the concretions, causing them to split most readily in that direction, while others break with equal facility in any direction. In some parts of the sandstone, the concretions or nodules (as the smaller ones might be called) are so closely crowded together as to almost touch each other. Some are widely and others closely reticulated on the surface, but most of them are smooth. A few of the more characteristic forms are represented in the accompanying cut.

Large concretions.



CONCRETIONS IN CRETACEOUS SANDSTONES AND MARLS, FROM TWO TO TEN FEET IN DIAMETER.

Great Bend.

Pointe la Biche is the name given to the Great Bend of the Athabasca six miles below Grand Rapid, or 88 in a straight line below the junction of the Biche River. Here, as before stated, the general course of the river changes from N. 8° E (ast.) to N. 70° E(ast.), on which it now runs for 55 miles till it is joined by the Clearwater from the right. As Pointe la Biche, or the Great Bend, will be used for reference in stating the directions of localities further down the river, the number of miles in straight lines to the principal points may be here given for convenience:—

Distances from the Great Bend

	MILES.
Little Buffalo River, from the left	7
Burnt Rapid	11
Petite Rivière Bouffante, from the right	21
Drowned Rapid	25
Rapide Milieu	27
Rapide Pas-de-Bout	30
Crooked Rapid	34
Isle la Biche	36
Cascade Rapid	39
Mountain Rapid	48
Fort McMurray at the junction of the Clearwater	55

Lignite.

The banks on both sides of the river at the Great Bend are from 170 to 180 feet in height, and consist principally of soft sandstones. Beds of lignite are seen towards the top of the cliff, on the left side, for about two miles, at this locality. One of these, four feet in thickness, which occurs just at the Great Bend was examined. Its position is 155 feet above the level of the river, and twenty below the top of the cliff. The underlying strata consist of homogeneous fine grey sandstone, with some interstratified carbonaceous layers, a few inches thick, while the twenty feet above it consist of shaly and thin-bedded sandstones. The lignite itself consists of alternating shaly and solid laminæ with shining fracture. Some parts of the bed are entirely shaly and others are sandy. It also holds calcspar and yellow ochre, so that its general quality is poor. Two miles below the Great Bend the cliff on the left is 170 feet high, and consists of five or six alternating bands of homogeneous and distinctly stratified grey sandstones. A band of thirty feet, about one-third of the distance from the bottom, is much darker than the rest. A portion of the band at this locality is weathered into pillars, one of which has a fantastic form. On the same side of the river, at five miles from the Great Bend, or two above little Buffalo River, a seam of lignite, from two to three feet thick, runs along horizontally near the top of the sandstone cliff, which is 100 feet in height. A smaller seam was noted two miles further up. Shaly and marly drab sandstones occur along the edge of the river between this locality and the last mentioned river.

Sandstone pillars.

On the upper side of the mouth of the Little Buffalo River the water of the Athabasca, near the shore, is much disturbed, or, as the natives say, it "boils," with the bubbles of gas which rise very thickly and rapidly from the bottom, and are probably due to the existence of a seam of lignite under the bed of the river. At and just below this tributary, the river makes a westward bend, the sandstone cliff on the left forming a great amphitheatre 200 feet high. The cliff on the opposite side is called Point Brulé, and is equally high. It is shaly or marly towards the base; the concretionary band, which is here thirty feet thick, occurs at about one-third of the height of the cliff, the rest of which consists of the yellow-weathering grey sandstone. Coarse shingle and rounded boulders of the drift period rest on top of this cliff. Three miles below the Little Buffalo River and on the right side of the stream, a seam of impure lignite, six feet thick, occurs near the top of the cliff, which is rather more than 100 feet high. This place is twelve miles in a straight line from the Grand Rapid, and, as already mentioned, the top of the concretionary band is here about fifty feet over the water. Two miles further down, and on the same side, a seam of lignite, from a foot to two feet thick, appears in the cliff on top of about 100 feet of sandstone, and overlaid by about ten feet of marl.

Bubbling gas.

High cliffs.

Lignite.

Lignite.

At the Burnt Rapid, where the descent is about eight feet, the cañon of the river looks narrower and deeper than above. Near the edge of the water at this rapid there are some beds of brittle, light drab-colored ironstone and others of somewhat calcareous, green sandstone, containing shells of Cretaceous age, which will be again referred to further on. It also holds many large and small fragments of dark silicified wood, which weather white. They consist of stumps, broken logs, splinters, and round sticks. Fragments of lignite occur along the shore. Angular masses of conglomerate, which appear to be derived from the bed of the river, are also met with at this locality. The pebbles of the conglomerate, which are small, consist of green, black, drab, and white chert and white quartz, and have highly polished surfaces. It also contains pieces of a peculiar ironstone, exactly like that of the Manitounik Islands on the east side of Hudson's Bay.

Burnt Rapid.

Cretaceous fossils.

Two miles below the Burnt Rapid the cliff on the right side is 200 feet high, in four terraces or steps of about fifty feet each. The first, or lowest, consists of soft drab sandy marl, the second, of the yellow-weathering, concretion-bearing band; the third, of soft grey homogeneous sandstone. (On the opposite side of the river the band corresponding with the last-mentioned has a thin seam of lignite near the top.) The fourth or top step consists of very soft grey homogeneous sandstone, weathering yellow, which occupies the lower two-

Terraced cliff.

Lignite.

Pointe Terre Brulé.

thirds, while the upper third of the cliff consists of drift. At Pointe Terre Brulé on the right side, five miles below Burnt Rapid, and six above Petite Rivière Bouffante, the bank is 200 feet high in three steps, the first or lowest consisting of dark drab finely arenaceous marl; the second, of the concretion-bearing bed, and the third, of homogeneous grey sandstone in the lower half and stratified sandstone in the upper.

Rapids begin a mile and a-half below the Petite Rivière Bouffante, and continue at short intervals all the way to the junction of the Clearwater, the average fall in this part of the river being from five to ten feet in the mile. At the Drowned Rapid, four miles below the last named river, some fossils were found in the harder arenaceous beds. Upon these, and those found at the Burnt Rapid, Mr. Whiteaves reports as follows:—(1) Fossil wood, apparently coniferous; (2) an *Ammonitoid*, like *Olcostephanus* or *Haploceras*, a species with a comparatively simple sutural line; (3) a small gasteropod, like *Cinulia*; (4) a *Tellina* or *Thracia;* (5) a *Venus* or *Cyprina ;* (6) a *Protocardium ;* (7) a *Nucula;* (8) an aviculoid shell, probably *Inoceramus;* (9) a *Pecten* and some other lamellibranchiate bivalves. These fossils evidently belong to the Cretaceous system. They are tolerably well preserved, but most of the specimens collected are broken, and are not sufficiently perfect to determine the species with any certainty.

Drowned Rapid.

Black petroleum-bearing sandstone.

At the Drowned Rapid a black petroleum-bearing fine-grained sandstone first makes its appearance, and becomes abundant and conspicuous henceforward nearly to the delta of the river or within a short distance of Athabasca Lake. It underlies all the strata heretofore desrcibed, and further down the river it was found to have a thickness of 200 feet. Only ten feet are exposed at Drowned Rapid, but this increases to twelve at the top and fifteen at the bottom of the Rapide Milieu, and to forty feet at the Rapide Pas-de-Bout. The blackened bed at the Drowned Rapid appears to represent the highest of the petroleum-bearing strata so largely developed further down. The overlying marls, which are probably the means of preventing the petroleum in any quantity from rising higher in these rocks, also contain a little of the oil and yield its characteristic odor. The petroleum-impregnated marl, which is dark, unctuous, and glossy, throws off the water, or allows it to pass unabsorbed through any openings which may exist. "Mud" of this kind was used to cover a roof at Fort McMurray, after the usual fashion adopted in the country, but it was found to allow the rain to pass so freely through that it became necessary to replace it by clay of another kind. It is possible that the indigo color or other dark tints of some of the Cretaceous marls higher up in the series may be due to traces of petroleum.

Petroleum-impregnated marl.

Slaty cleavage.

The fine-grained marly sandstone, blackened by petroleum at the

Drowned Rapid, has a strong cleavage, the planes of which run N. 35° E., and underlie to the north-westward at an angle of 20° from the perpendicular. It is divided also by horizontal planes which probably represent the bedding. At a temperature of 60° Fahr. the mass is sufficiently plastic to bend considerably before breaking. When cut with a knife the shavings or chips curl up like those of hard soap. When worked in the hand it becomes softened, and may be moulded like putty, and is quite as brittle. In a fire of wood it soon ignites, burning for some time with a smoky flame, and then falling to powder, which floats if thrown into cold water. If a piece of it be immersed in a hot state it will not part with the oil, but repels the water strongly.

Properties of petroleum-bearing sandstone.

The Rapide Milieu occurs at two miles below the Drowned Rapid, and the Rapide Pas-de-Bout at three miles further. Between these two, as already mentioned, the top of the concretionary band, which is about fifty feet thick, has gained an elevation of 200 feet above the river in a bank about 300 feet high. At the Rapide Milieu a split sandstone concretion was observed on the right side of the river, which measured twenty-five feet in diameter on the surface of the dividing plane. Along the right side of the Rapide Pas-de-Bout the black fine-grained marly petroleum-bearing sandstone forms a steep bank forty feet high. In order to gain a foothold in lowering our canoe past the rapid it was necessary to chop numerous notches in the face of this bank, and it was observed that the tough pitchy mass had no perceptible effect in blunting the axes, so that the fine particles of sand, of which it is principally composed, must have been free to yield before the edge. At some places where there appeared to be an excess of asphalt, the bank had softened in the sun's heat and flowed down, forming large pitchy masses at the bottom. About a mile above the narrow point at the Crooked Rapid, the black petroleum-bearing strata have a slight dip to the south-west on the left, and to the north-east on the right side, while on the point itself they dip south-east, at an angle of 10° to 15° in the lower part of the section, which consists of sixty feet of sand saturated with petroleum, but they are perfectly horizontal in the upper part, which is formed of about sixty feet of sandy marls with petroleum, thus showing a local want of conformability.

Highbank.

Flowing asphalt.

Local unconformability.

On the upper or south-west side of this point the first, of the Devonian rocks are seen at the water's edge. They consist of a few feet of earthy, bluish-grey crumbling or "lumpy" limestone, with a solid bed of the same color, a foot thick at the top. The stratification is as level as the surface of the water, so that the overlying beds of the blackened Cretaceous sandstone rest upon them at the above-mentioned angle of 10° to 15°. This, however, is only local, for in most cases further down the river, where the contact is frequently seen, both

First Devonian rocks.

rocks are horizontal, notwithstanding the great space in geological time which separates them. The whole of the 120 feet of fine sandy strata resting on the limestone on the upper side of the Crooked Rapid is more or less impregnated with petroleum. A slight incrustation of salt was seen on these rocks in some parts of the steep bank at this locality. They are capped by about thirty feet of drift. The whole height of the bank was found by barometer to be 153 feet.

Estimate of strata.

Having now reached the base of the Cretaceous rocks on this part of the Athabasca, an estimate may be given, as follows, of the total thickness of these strata in descending order, between Lac la Biche and Crooked Rapid :

	FEET.
Clayey marls, mostly indigo-colored, holding thin layers and tortoise-shaped concretions of impure clay-ironstone. These strata form the banks from the Biche to the Pelican River.	200
Arenaceous marls and homogeneous fine-grained grey sandstones in the banks from Pelican River to the foot of Grand Rapid	170
Bands of grey sandstone, studded with concretions, which are mostly spherical, and of large size, from 30 to............	50
Marls, mostly arenaceous, grey, drab, &c.....................	140
Fine sandy strata, mostly blackened by petroleum.............	200
	760

The fall in Crooked Rapid and Rock Rapid, just below it, amounts to about thirty feet. The portage trail which crosses the narrowest part of the point at the Crooked Rapid is 320 paces in length. At the foot of the portage is a cliff at the river's edge, exposing seventeen feet of perfectly flat, crumbling or "lumpy" drab grey limestone, the interstices between the lumps, which are small, being occupied by argillaceous material. The harder portions of the rock are full of broken fragments of brachiopod shells and small encrinal columns, which were also abundant in the low ledge of the same rock, at the upper end of the portage. The looser beds hold *Atrypa reticularis* and a small *Orthis.* At ten feet from the top of the section a hard bed, six inches thick, produces a projecting ledge or terrace, which runs along the bank of the river for several hundred yards. The surface of this bed is thrown into a succession of little rounded ridges, about three inches high, at regular intervals, of three feet apart. The ridges run E. N. E. and W. S. W. (mag.) The surface of this bed is covered with fucoids, which are also abundant in the rest of the section. It also holds a few small rounded pebbles.

Limestone.

Section.

Opposite the foot of the Crooked Rapid portage, or on the left side of the river, the following approximate ascending section occurs :—

	FEET.
Devonian limestone, like that just described	15
Petroleum-bearing fine sand, not so thoroughly saturated with the oil as further up the river	90
Soft, incoherent, greyish sandy marls	135
Drift	40
	280

On the left side, opposite to Isle la Biche, the petroleum sand is 50 feet thick, but apparently not so rich as usual in the oil. The limestone has here sunk to near the level of the river, and henceforward all the way to the Cascade Rapid it keeps an elevation of only 2 to 4 feet over the water, but the marls increase in thickness, and their bedding forms a small angle with the level surface of the limestone.

On the left side of the river, about mid-way between Isle la Biche and the Cascade Rapid, the sandy petroleum-bearing marls form a bank nearly 200 feet high. They were observed to contain some boulders, or large concretions, but the whole of the section is below the position of the concretionary band, which formed so conspicuous a feature higher up the river, unless it has been let down by a fault. 200 feet of petroleum strata.

A few feet of the limestones are seen at the foot of the bank on either side of the river, all the way from Crooked Rapid to Fort McMurray, a distance of 20 miles, except at a place four miles below the Cascade Rapid, and another about four miles below Mountain Rapid, where its surface sinks below the level of the water. They generally undulate slightly and are usually planed down to an even surface, so that the petroleum-bearing sand rests unconformably upon them. At a few places, in approaching Fort McMurray, the surface of the limestone is uneven, and covered over by the petroleum strata. Unconformability of limestones.

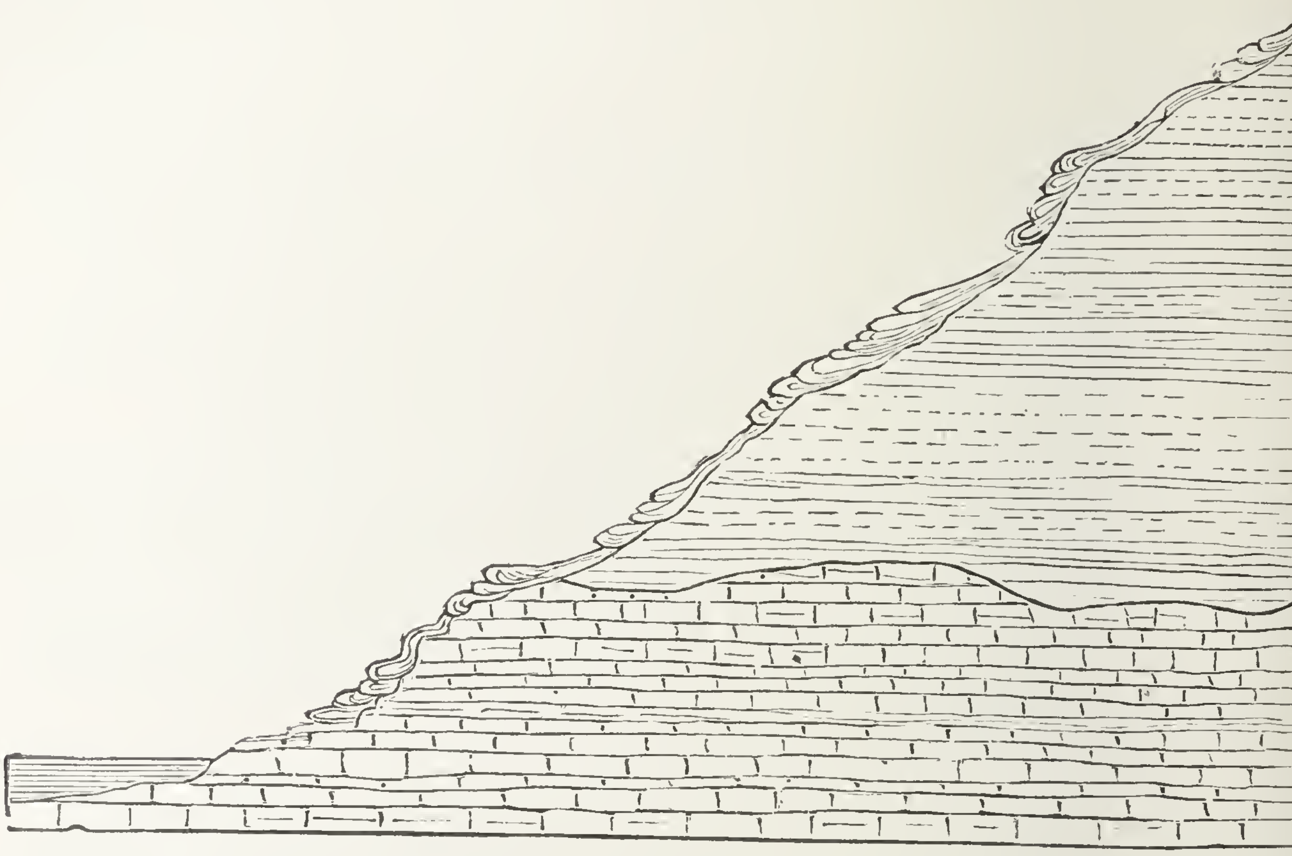
The river at the Cascade Rapid passes down over two or three broad ledges or steps in the limestone, the descent amounting to 8 or 10 feet. Five or six feet of the same rock are exposed in the left bank of the river. Resting on this is a bed of conglomerate, which varies from a foot to four feet in thickness, made up of rounded pebbles and a few small boulders of quartzite, ironstone, gneiss and limestone. Above it are 80 or 90 feet of the petroleum-bearing sandy marl. In one place a patch of sandy pitch, soft and plastic in the sun's heat, has run out over the limestone of the beach. Three miles below the Cascade Rapid, on the left side, are 80 feet of petroleum strata. The upper 40 feet are marly, of a brown color, and show the lines of stratification, while the lower 40 feet are black, homogeneous and massive, forming an almost perpendicular cliff. This part is evidently quite saturated with the Cascade Rapid. Conglomerate. Tar.

2

Mountain Rapid.

thickened petroleum. The "tar" runs out of it in many places under the heat of the sun, and in one place it forms a little stream.

On the right side of the river, at the Mountain Rapid, fine, pitchy sand forms a bank 80 to 90 feet high. Eight or nine feet of the limestone are seen under this bank, in the form represented in the cut.

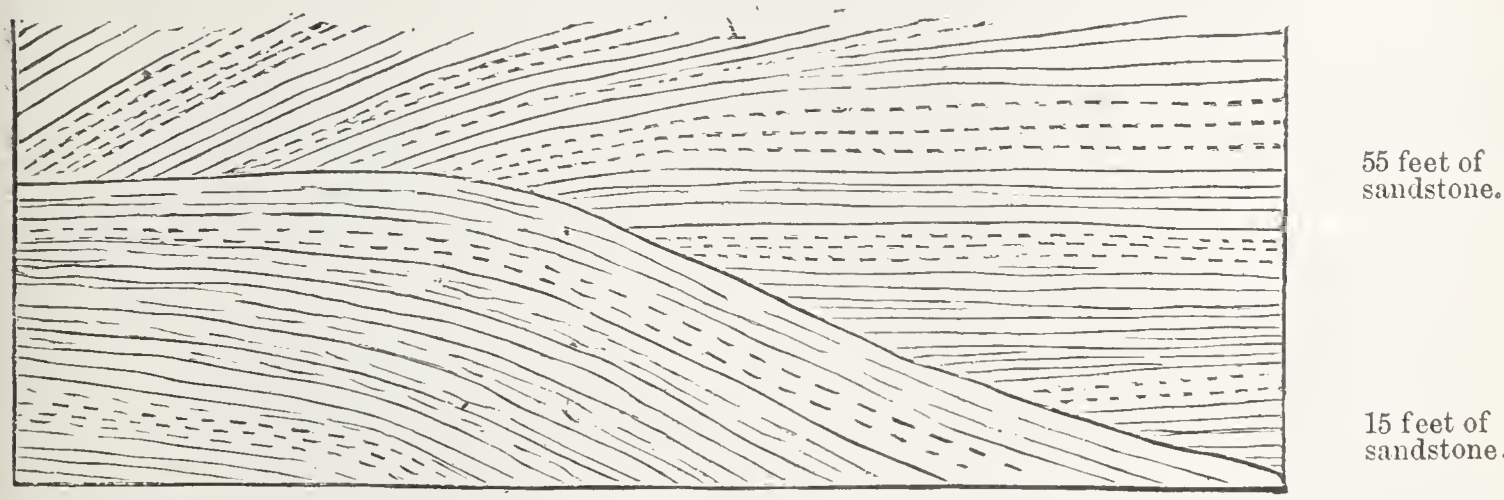


Section of Cretaceous Sandstone overlying Devonian Limestone unconformably; showing sandy pitch flowing down the bank. Athabasca River.

The sandy pitch softens under the sun's heat, and flows in large viscid masses down the face of the bank and over the limestone at its base. Tar and pitch were noticed flowing down the banks in several places between this Rapid and Fort McMurray. A shallow depression has been scooped out of the limestone on the left side, at the foot of the Mountain Rapid, and on the opposite side of the river a low rounded elevation has been left on the denuded surface of the horizontal beds, as seen in cross section. At about one mile below the foot of Mountain Rapid, where the limestone has sunk beneath the level of the river, the petroleum strata, which are upwards of 100 feet thick, dip up stream, at angle of 10° in the upper part of the section, while in the lower part, the layers are nearly horizontal. On the right side opposite the mouth of the Little Fishery River, three miles above Fort McMurray, where about 70 feet of the petroleum sand are exposed in the bank, a want of con-

Little Fishery River.

formity in the strata occurs at about 15 feet above the river, but the line marking this change in the stratification, slopes down to the level of the water, as shown in figure.



SECTION OF CRETACEOUS SANDSTONES SHOWING A LOCAL UNCONFORMABILITY. ATHABASCA RIVER.

The limestone has a height of about 12 feet above the water, on both sides of the river at Horse-trail Creek above Fort McMurray.

It will be observed by the map that the general upward course of the Clearwater River, from its mouth to the Methy Portage, has nearly the same bearing as the downward course of the Athabasca from the Great Bend at Pointe la Biche. The point of junction of the two rivers is known as The Forks. The mouth of the river at Lake Athabasca lies due north from The Forks, the distance being 132 miles, and the stream lies wholly on the west side of a straight line drawn beween these points, but at no great distance from it. On entering the low ground lying to the south of the lake, the river forms a delta, which begins by giving off the Rivière des Embarras, at 112 miles in a straight line from The Forks. The Athabasca flows in a tolerably direct course from The Forks to the head of the Delta. If a straight line be drawn between these points, it will be found to have a bearing of N. 7° W. (ast.) and to cut the river just mid-way between them, the upper half lying close to its west, and the lōwer half close to its east side. For the first twenty miles, the course of the stream is so direct on this bearing, that it does not vary from it to the extent of its own width, which is about twenty chains. The lower half of the section between The Forks and the head of the delta has many islands, all along, and the average breadth is increased to nearly half a mile. From The Forks to the head of the delta the river is rather shallow, and flows with a swift current, exposing many sand-bars at low water, but from this point the main channel is deeper and narrower, with only a few islands, and no sand-bars. The Rivière des Embarras appears to take less than a third of the water, and below it the principal channel soon turns to the north-east, and at 18

The Forks.

Course of the Athabasca.

Islands.

Rivière des Embarras.

miles in a straight line divides at the Grand Rammon into two almost equal branches, the western one flowing north, for about 11 miles to the open lake. At the end of this distance Fort Chipewyan is seen to the north-westward on the opposite side of the lake at a distance of 10 miles.

Distances from Fort McMurray.

Fort McMurray, at The Forks, is situated on the upper side of the mouth of the Clearwater. According to my track-survey of the river below this point, the following are the distances in straight lines from Fort McMurray to the principal localities, which are here given for convenience of reference :—

	MILES.
Upper Steep-bank River from the right	21
Isolated bluff of Devonian limestone, on right, 35 feet high. A similar bluff on the opposite side of the river. Salt is deposited from water flowing over a bluff of the petrolenm strata, half a mile to the eastward of the first-named limestone bluff. The locality is called La Saline	25
From the last locality low cliffs of Devonian limestone are frequent along the right side of the river for 10 miles, or to	35
Lower Steep-bank River on right	30
Little Red River on left	31
Moose River on left	41
Tar River on left	42
Rivière au Calumet on left	47
Pointe-aux-Trembles on right	81
The grave of a former Indian Chief known as The Carcajou's Sleep on the left	90
Head of the delta, or commencement of the Rivière des Embarras on left of main stream	112
The three mouths of the Athabasca, close together, and due north (ast.) of The Forks	132

Steep right bank.

Leaving The Forks, in going down the stream, a bare steep bank skirts the river for many miles on the right side, while on the left there is a level interval of half a mile to a mile in width, on the west side of which a wooded slope rises to a height corresponding with the bank on the right. For the first twelve miles the right bank varies from 100 to 150, and in some places to nearly 200 feet in height, and consists of fine quartz sand saturated with petroleum, which gives it a coaly appearance, when freshly exposed, resting on a few feet of Devonian limestone. The stratification is generally nearly horizontal, but the tendency to cleave across the bedding, as described when these rocks were first met with at the Drowned Rapid (*vide ante*), which sometimes develops itself in the more homogeneous beds, and the lamination of others may have induced former travellers, such as Sir John Richardson and Professor Macoun to call the rocks " bituminous shales "; but, as already stated, they were found to contain fossil wood, lignite and Cretaceous shells. Owing to the black color of the whole mass the fossil wood and the lignite would escape ordinary observation, but they may be found in greater or less quantity when carefully looked for at

Coaly appearance.

Lignite and Cretaceous shells.

almost any locality where these rocks occur. Near the top of the high bank on the right, at twelve miles from Fort McMurray, there is a seam of lignite, apparently three or four feet in thickness. Among the fresh fragments which had fallen from it were some blocks a foot in diameter. Lignite.

Below this point the right bank diminishes in height, but still consists of the black, petroleum-soaked, fine sand until reaching a point fourteen miles below Tar River, or fifty-three miles below Fort McMurray. Further down, banks and hills of loose sand are occasionally seen, on the right side, either overlooking the river or at a short distance back from it. Four miles above Pointe-aux-Trembles the right bank, composed of sand, rises to a height of 60 or 70 feet, and, a little lower down, sand hills 150 feet high are seen on the same side, a short distance back from the river. Similar hills, 70 or 80 feet high, extend at a short distance inland, from six to nine miles below the point just referred to. Further on, banks of reddish, yellowish and light grey sand, about 30 feet high, occur at a few places on the same side to within nine miles of the head of the delta, where the last of them is passed. Banks and hills of sand.

On the west side, as already mentioned, there is a level intervale, nearly a mile wide, between the river and the foot of the main bank, extending for several miles below The Forks. The bank comes close to the river at 18 miles down, and from Tar River, at 42 miles, it follows the side of the stream for a distance of 20 miles. The last bank near the river, on the west side, is 13 miles further down, or at 73 miles, in a straight line, from Fort McMurray; but rising ground was observed a short distance back, opposite to Pointe-aux-Trembles, at 81 miles from the same place. It will, therefore, be observed that the east or right bank of the Athabasca, below The Forks, is the highest, and that it keeps more closely to the river than the other. West bank.

The petroleum-bearing sandy strata, which are so well seen on the east side for the first 53 miles below The Forks, occur only at intervals along the left side of the river. They were noted at the following distances, measured in straight lines from Fort McMurray, namely:—18, 42 (Tar River), 49, 51, 74 and 87 miles (both sides). Almost everywhere along the black banks on the east side the asphaltic sand has softened under the sun's heat and flowed down to the foot of the bank in viscid masses, which appear to contain a rather larger percentage of petroleum than the undisturbed strata. At a temperature of about 60° Fh. the sandy pitch of these flows has the consistence of hard cheese, and when cut or penetrated by a knife it has no tendency to stick to the blade. In some places, however, it is much thinner, and even small pools of oil and thin tar had formed in connection with it. At the Petroleum-bearing strata. Softened asphaltic sand.

ordinary temperature it generally yields only very slightly to the pressure of the foot, but on warm days the men employed in tracking the boat up the river occasionally experienced some inconvenience from their feet sinking into the pitch. If worked in the hand, this pitch, and even the undisturbed petroleum-bearing sand, as already stated, will adhere to the fingers very tenaciously.

Pebbles and boulders in pitch.

In flowing, with a rolling movement, over the beach of the river, the sandy pitch incorporates the pebbles and boulders, which, in some places, become a large proportion of the mixture, and when this is flattened by the pressure of the passing ice it forms a natural asphaltic pavement.

Tar oozing from banks.

During the warm weather, tar, or thin pitch, free from any mixture of sand, oozes out of the banks, as if by pressure, in places where the black strata appear to be supersaturated with the thickened petroleum. This accumulates among the vegetable matter on low ground, and may be collected in considerable quantities. It is possible that the tar also rises in some places by pressure from beneath. It is taken in barrels to the posts of the Hudson's Bay Company and to the mission stations, and after boiling it down so that it will harden on cooling, it is used for paying over boats, roofs, etc. Tar is taken for these purposes near the bank of the river, at points situated at the following distances in straight lines from Fort McMurray, all being on the right side: 19, 33, 36, 40 and 51 miles. Bishop Faraud, of Lac la Biche, informed me that he had seen a large quantity of this tar on an island in the river, which would be about 60 miles below Fort McMurray. At the first of these localities, 19 miles down, the tar is found at 640 paces back from the bank of the river, on ground between 50 and 100 feet above its level and a short distance from the foot of a second bank about 15 feet high. The surface at the place is formed of hardened pitch, overgrown with moss, etc., and more or less mixed with vegetable matter and fine sand. The latter may have been washed down from the bank above mentioned. Sixteen small holes had been broken through this crust, and, at most of them, tar had been extracted from beneath it, with wooden spatulas. The locality at 40 miles down is scarcely a mile above the mouth of Moose River, which enters from the opposite side. Here the tar oozes out with springs of clear water only a few feet above high water mark and 20 or 30 yards out from the foot of a bank of the petroleum-bearing sand 30 or 40 feet high. Both the water and tar are covered with a crust of hardened pitch mixed with moss and other vegetable matter, but which is still plastic enough to yield to the pressure of the foot. Holes are broken through the crust and the fresh tar is collected with wooden spatulas, and placed in barrels for removal. A thick kind of tar is found in holes

Localities of tar.

Crust over tar.

under the clear water, while a thinner variety floats on top of it under the hardened crust.

All along the banks of the Athabasca, in the neighbourhood of the asphaltic deposits, an odor of petroleum, which in this case is not unpleasant, pervades the air, especially in warm weather. Blotches of irridescent oily scum and small patches of petroleum may be seen floating on the water near the edges of the river all the way from The Forks to the mouth, and these occasionally collect together against projecting sticks and logs. The economic value of the petroleum and asphalt of the Athabasca region will be referred to further on. Odor of petroleum.

The yellowish-grey Devonian limestone forms low ledges and bluffs along the foot of the banks of petroleum-bearing sand on the east side, all the way from the Forks to a point six miles below the mouth of the Little Red River, a distance of thirty-seven miles. It is also seen at a number of places on the west side to within three miles of the same distance. The rock is generally thin-bedded and somewhat earthy, with rough surfaces. Devonian limestone.

Some beds of a drab color and containing a considerable percentage of carbonate of iron, in fact approaching the character of clay-ironstone, were found about four miles below The Forks. Clay ironstone.

Fossils were collected from the limestones here and there all the way from The Forks to the last exposure on the river. Among them the following have been recognised by Mr. Whiteaves: *Pleurotomaria*, well-preserved casts; a *Bucania*, *Paracyclas elliptica* (Conrad sp.), a *Palæoneilo*, a *Leptodesma*, and two other species of Aviculidæ, ; a *Meristella* or *Athyris;* a *Spirifera,*—like *S. Ziczac* (Hall); *Orthis striatula*, (Schlotheim) or possibly the young of *O. Iowensis* (Hall); *Atrypa reticularis* (Linn), abundant and well preserved; *Strophalosia productoides*; and a small fragment of a Stromatoporid. One of the most singular fossils collected from these rocks is a brachiopod shell, like an *Atrypa*, about three-fourths of an inch long, with a thin smooth and translucent shell, remarkable for having preserved its original colors. It shows eleven rows of distinct brown spots on the dorsal valve, radiating from the beak, and six or seven rows on the ventral valve. Sir John Richardson mentions having also found a fossil in these rocks which had preserved the color of the shell when alive. Instances of this phenomenon are very rare in such ancient rocks. A Cephalopod, like *Gomphoceras* or *Cyrtoceras*, was found in these limestones at Mountain Rapid, higher up the river. Fossils.

The general attitude of the strata is about horizontal; the bedding is however, seldom quite level for any great distance, but undulates slightly in all directions, until it finally disappears under the river, and nothing is seen in the banks but the petroleum-bearing sand and the drift.

Indications of the origin of the petroleum.

The walls of the transverse joints and other spaces in the limestone were frequently observed to be blackened with petroleum, and at a place nearly opposite to the mouth of the Little Red River, some irregular cavities contained inspissated pitch. These limestones were not found to yield petroleum on fresh fracture, although they had occasionally a bituminous smell, but traces of the oil were afterwards found in a bed of limestone on the Clearwater River, which would be much lower down in the formation. There is little doubt but that the vast quantities of somewhat altered petroleum contained in the soft Cretaceous sandstones of the Athabasca region have been derived from the Devonian limestones, immediately underlying them, which are probably very thick.

Petroleum.

Sir John Richardson mentions the occurrence of black pitch or bitumen in patches, and as filling fissures in several places in the limestones of this formation along the Slave and Mackenzie Rivers. Copious springs of liquid petroleum are known to rise out of these limestones in the western part of Great Slave Lake. These have been described by myself from the verbal accounts of officers of the Hudson's Bay Company, in the Journal of the Canadian Institute (Toronto) for 1881, to which the reader is referred for fuller details. That the petroleum came from below would be expected in accordance with natural laws, and from the fact that the higher rocks of these regions to the south and west would have been very unlikely to produce any petroleum, even if they had once extended all over this region. Where the contact of the sandy petroleum-bearing strata with the higher Cretaceous rocks was seen at the Drowned Rapid, it was observed that the oil was prevented from passing upward by tenaceous clayey strata. It may occasionally find an upward passage through these confining argillaceous beds, and this would account for the isolated springs or wells of petroleum which are reported as occurring in various parts of the Athabasca-Mackenzie country. The drift resting on the black petroleum-bearing strata was nowhere observed to be impregnated with the oil, showing that it had saturated the Cretaceous strata, probably as a thin liquid, and become altered to its present state long before the glacial period. The supposition that this petroleum has been derived from the Devonian rocks is in harmony with what is known to occur in Gaspé, Western Ontario and the States of Ohio and Pennsylvania.

Source of the petroleum.

Age of petroleum-producing strata.

South shore of Lake Athabasca.

High ground, like the east bank of the river below the Forks, is seen near the shore of Lake Athabasca, to the eastward of the mouth of the river. Very little is known of the southern shore of the lake, as it is but little frequented. Two men were met with, however, who had travelled along it, and from them it was learned that low cliffs and ledges of limestone are to be seen at a few points. On the south side of the eastern extremity, and on Black Lake further east, Mr. A. S. Cochrane, in 1881, found red sandstone and red sandstone-conglomerate, with rounded pebbles of white quartz. Red sandstone is said to occur at the second fall on the Clearwater above the Methy Portage, and at a distance of about twelve miles from it. Mr. Walter Francklyn informed me that he met with what he supposed to be red sandstone on the Deer's River, by which he travelled from the Churchill River to Cree Lake, the largest sheet of water lying to the south of Athabasca Lake. The boulders about Fort Chipewyan are principally of reddish sandstone, with white quartz pebbles, and reddish-grey quartzite. The south-westward course of the glacial striæ in this neighborhood shews that these boulders came down the lake. The gravel and sand are also chiefly formed of the debris of red sandstone.

Red sandstone.

The northern side of Lake Athabasca presents a great contrast to the southern. The latter consists of either low ground, or level plateaus, underlaid by almost horizontal strata, and all clothed with timber, while the northern is formed of rounded hills of Laurentian and Huronian rocks, with little soil, and often denuded of its timber by fire. At Fort Chipewyan, the rock is a red gneiss, strongly banded and ribboned. The average strike is S. 15° W (mag). The islands and points around the western extremity of the lake and at the outlet of Lake Mammawee, are all composed of gneiss. At the latter locality, the average strike of the gneiss, which is mostly red, is S. 8° W (mag). The Huronian series, which Mr. A. S. Cochrane found on the northern side of the lake, about thirty miles north-eastward of Fort Chipewyan, and at three other localities further east on the same side, was not detected around the western extremity of the lake.

North side of Lake Athabasca.

On the return journey, as before mentioned, the route followed was that by way of the Clearwater River, and Isle a la Crosse. In ascending the river, the plateau of petroleum-bearing Cretaceous bands which comes out in the east bank of the Athabasca, below The Forks, appears to continue for some miles up the north side. Large masses of the sandy pitch, such as flow down the steep banks of the Athabasca, were found in the bed of the Clearwater river, at 11, 13 and 17 miles above The Forks. Small quantities of petroleum were observed floating on the river up to the last-mentioned point.

Clearwater River.

Petroleum-bearing rocks.

Devonian limestone, like that of the Athabasca, was observed at intervals along the Clearwater, for the first twelve miles in going up, and again at all the portages, which are five in number, and begin at about two-thirds of the distance from The Forks to the Methy Portage. The empty boats can he towed past all the rapids at these portages except the uppermost. The first is called the Cascade; the second, the Bonne, and the third the Gros Roche. These all follow each other in

Devonian limestone.

Five portages.

close succession. The fourth, or Pas, is between two and three miles above the Gros Roche, and the fifth, or Terre Blanche, about five and a-half above the Pas. They are all within a space of about nine miles.

Cascade Rapid. Pas Rapid. The rock at the Cascade Rapid is a thickly bedded, hard, yellowish-grey limestone, with a bituminous odor on fresh fracture. At the Pas Rapid, and in the valley of the river above, and to the north of it, much rock is exposed. It consists of a porous or spongy-grey, bituminous limestone. Free petroleum. One bed in the vicinity of the rapid was stained with free petroleum. Islands and pillars of the limestone stand in the river at the rapid, and in the sand which covers the bottom of the valley in the neighborhood. Sand. In some places the limestone is cavernous, and all the exposures are much decayed and eroded. The valley itself appears to be of pre-glacial origin. It is between 500 and 600 feet deep, and its banks, towards the top, are very steep. In the neighborhood of the rapids they expose bare spots of light-coloured, gravelly-clay. On the north slope of the valley, between the Pas and Terre Blanche Rapids, at about two miles below the latter, a cliff of thickly bedded or massive light-grey limestone was found. Porous limestone. It is of a porous character, and the weathered surface shows numerous holes, resembling the burrows of swallows in a sand cliff. A cave has been worn out in one part of the cliff. Terre Blanche Rapid. At the Terre Blanche Rapid, the river passes down amongst the high islands and points of grey limestone, which is much shattered on the surface by the weather, but otherwise it appears to be mostly of a massive character. No fossils were observed in the rocks at any of the rapids, and they appear to belong to a part of the Devonian system, somewhat lower than the fossiliferous beds immediately underlying the Cretaceous further west.

Mineral springs. Numerous streams of mineral water flow into the Clearwater from springs on the slopes on either side, all the way from The Forks to the rapids. They deposit a bluish-white, flocculent precipitate along their course, and have a slight odor of sulphuretted hydrogen. The most notable group of these springs occurs on the north side, about four miles below the first, or Cascade Rapid, and the locality is known as The Mineral Springs. Here the springs are very copious, issuing from the bank in a number of places, for a space of 300 yards in length. The largest single spring forms a small brook itself, and the addition of these and all the other mineral springs which flow in further down, must increase considerably the soluble salts in the water of the whole river. The uppermost spring of the group is not seen from the river, but flows out among masses of the limestone, and falls into a small brook. From a large spring near the mouth of this brook, five and a-half quarts of the water were taken and boiled down. This yielded 1.36 ounces (avoirdupois) of crude salt, and from one-fifth to one-fourth more adhered to the large kettle, which was used in evaporating the water. Mr. Hoffmann finds this salt to contain potash, soda, magnesia and lime, all in considerable quantity as sulphates, chlorides and carbonates. The water of this spring, (and all the other springs) is very clear and bright, and has a pleasant saline, and slightly alkaline and sulphurous taste. These springs have, no doubt, valuable medicinal properties, and being situated in a picturesque locality, they may at some future time become resorts for invalids, when this part of the North-west Territory shall have been opened up by railways and peopled. The composition of the water is more particularly described in Report MM. by Mr. Hoffmann. Composition of the water.

The Methy, or Long Portage, crosses the height-of-land, which divides the waters flowing into the Arctic Sea, by way of the Mackenzie River, from those flowing into Hudson's Bay by way of the Churchill. It is nearly twelve miles in length, and connects the Clearwater River with the head of the Methy (Dogfish) Lake. The Clearwater, as already stated, runs in a deep valley, excavated principally out of drift, but exposing, towards the bottom, Cretaceous sand with petroleum, Devonian limestone as up far as the rapids, and it is said, red sandstone at the second fall about twelve miles above the Methy Portage. The brink of the bank on the south side, on the portage trail, is a mile and a-half from the Clearwater, and it was found by the barometer to have an elevation of 540 feet above it. The bank here consists of a stiff, pebbly-grey clay. From this point to the Methy Lake, the trail, for the most part, passes over white sand mingled with stones, which are principally fine-grained, white quartzite with some of gneiss. Methy Portage. Deep valley. White quartzite stones.

No geological facts worthy of special notice were ascertained on the journey from Methy Lake to Isle a la Crosse Lake. The latter lake is the meeting place of the waters from all directions, and the surrounding country is low, sandy and swampy. Rocks, *in situ*, were not observed, but a small exposure of limestone is said to exist in a cove on the west side of the arm leading from Clear Lake, a few miles from the Hudson's Bay Company's post. Mr. Walter Francklyn, of this establishment, has sent me a perfect specimen of *Orthis subquadrata* (Hall), which had been found at the lake. This species would indicate the horizon of the Trenton formation or thereabouts. Ile-a-la-Crosse Lake.

The Beaver River, for twenty-five miles from its mouth (in Ile-a-la-Crosse Lake), flows through a flat country, and is filled with long, narrow, marshy islands, which form a singular feature of this part of its course. The soil on either side, like that around Isle-a-la-Crosse Lake, continues sandy and poor until reaching the Grand Rapid, above which a great improvement takes place, and the country generally continues to be much better all the way southward to the North Saskatchewan River. At the Grand Rapid, which is about two miles in length, the bed of the Beaver River.

river is full of boulders, over which the water flows, but in the banks a dark, slate-coloured marl makes its appearance, and although the stratification has been disturbed by the pressure of the ancient glacial ice; it is evidently the rock of the country, and is considered to be the commencement of the Cretaceous area. The change in the nature of the surface deposits, which become clayey from this point southward, would lead to the same conclusion, the direction of the drift having been from the north-eastward.

Cretaceous area begins.

Surface Geology.

Glacial striæ.

Nearly the whole of the country examined during the season being covered by drift or soft Cretaceous rocks, the glacial striæ were seldom seen. At the foot of the Mountain Rapid, on the Athabasca, seven miles above The Forks, these striæ are well seen on a smooth surface of limestone, running S. 80° E. and N. 80° W. (mag.) Near the edge of the water, at the same place, scratches produced on the limestone by the passing of the river ice, run at right angles to the ancient striæ. At Fort Chipewyan, and again at the Roman Catholic Mission, about a mile to the west of it, the striæ are well marked upon the gneiss. Their course varies from S. 55° W. to S. 60° W. (mag.). On the island at the outlet of Lake Mammawee the striæ on the gneiss run S. 55° W. (mag.)

Drift at Fort Chipewyan.

As elsewhere stated, the boulders about Fort Chipewyan are mostly of red sandstone, containing white quartz pebbles. The gravel and sand are also derived from the same sandstone. As this rock is known to occur largely at the east end of the lake and beyond it, and as the course of the glacial striæ corresponds with that of the length of Athabasca Lake, there is no doubt the material of the drift at this locality has been scooped out of the lake basin.

Quartzite pebbles and boulders.

An interesting point in reference to the drift in the North-West Territory is the distribution of quartzite pebbles and boulders, which are always thoroughly rounded, very smooth, and usually the boulders are of small size. In going northward from Fort Pitt to Lac la Biche cobblestones, mostly of hard grey and reddish-grey sandstone or quartzite, become abundant at Gull Lake, between the crossing of the Beaver River and Lac la Biche. Along with these are some of gneiss. Quartzite pebbles and small boulders are met with all along the Athabasca from the Biche River to the Great Bend, being in this section probably the most abundant of the travelled constitutents of the drift. On the Methy Portage the commonest stones consist of a fine-grained quartzite, which is pure white, thus differing from the grey and reddish-grey and banded quartzite of the cobblestones and gravel further west. They are generally also somewhat angular or only partly rounded, which is another evidence of difference. The uneven surface of some of them are smoothed as if by the blowing of the sand on which they lie. Here, as everywhere in the country traversed during the season, there is a certain proportion of stones of gneiss. Pebbles and cobblestones of light grey quartzite extended southward on our homeward route for 25 miles south of the southern extremity of Green Lake.

Specimens of quartzite of various shades of grey and one of a deep green color, broken from the rocks *in situ*, were sent me by Captain H. P. Dawson, R.A., from the vicinity of Fort Rae, on the deep northern bay of Great Slave Lake. I have also received frem Mr. G. McTavish a specimen of white quartzite from Marble Island, in the north-western part of Hudson's Bay, which is said to represent a common rock there. The island may have derived its name from the circumstance that this rock bears a close resemblance to white marble. Mr. Roderick Ross, of the Hudson's Bay Company, who has travelled much in the country about Lake Athabasca, informed me that boulders and fragments of a similar rock are to be found all through the country from that lake to Hudson's Bay. The Rev. Father Petitot has brought pebbles of white quartzite from the bed of the main Mackenzie River; and quartzite of various colors have been found in the Rocky Mountains about the head-waters of the South Saskatchewan. Similar rocks may also occur in many regions in the north, north-east and north-west, which have not yet been explored and may not be examined for many years to come. Until we have the means of distinguishing with certainty all the quartzites of this great northern region, the mere occurrence of quartzite *debris* in the drift proves nothing as to its source or origin. Not much information can be derived from the direction of the glacial striæ. At Fort Chipewyan it is S. 55° to 60° W. by compass, or only a few degrees south of true west, and at the Mountain Portage on the Athabasca, seven miles above The Forks, it is S. 80° E. magnetic, or S. 54° E. astronomically, so that these two courses would intersect each other at an angle of upwards of 40°.

Slave Lake.

Marble Island.

Mackenzie River.

Lac la Biche is situated just northward of the Height-of-Land, and it lies in a shallow basin excavated in stratified clay and sandy loam of Post-tertiary age. These deposits appear to extend for many miles in all directions from the lake, and where the country is not too swampy the soil is excellent, as proved at the farms of the Hudson's Bay Company and the Roman Catholic Mission, as well as at the gardens of the numerous half-breed settlers around the lake. On the north-east side of the point between the Hudson's Bay Company's post and the Mission a section of the bank was seen to consist of 8 feet of stratified dark colored clay on top of 25 feet of yellowish-grey, fine, sandy clay.

Basin of Lac la Biche.

Excellent soil.

Composition of shingle.

At the Company's post, which is at the south-east end of the lake, the banks are composed of brownish clay. Here the pebbles of the beach consist principally of grey and reddish-grey quartzite, mostly fine-grained and compact; some are ribboned and translucent, others opaque. There are also pebbles of whitish chert, decomposing silicious material, purplish amygdaloid, in which the spots are small and white, black chert with fine white bands, felspar, gneiss, &c. One pebble of handsome yellow chalcedony was also found. There is here a row of gneiss boulders in the water, a few feet from the present shore, which has probably been formed by the shoving of the ice. Lac la Biche is said to be nowhere more than about twenty feet deep. Its level was found by the barometer to be 186 feet above the junction of its outlet with the Athabasca River. Its waters abound in the finest whitefish which supply a large part of the food of the settlers.

Height of lake.

Origin of valleys.

The valleys of both the Athabasca and Clearwater, as far as they are excavated in the Cretaceous and Devonian strata, may be of pre-glacial origin. There appears to be no evidence that these rivers themselves removed so large an amount of rock; and drift materials, similar to those of the higher levels, are deposited equally below the more ancient walls. On the east side of the Athabasca, about five miles below the junction of the Pelican River, a large patch of the dark Cretaceous marl from the upper part of the bank has slipped over and rests upon a considerable thickness of shingle. At Pointe Brulé, nearly opposite the mouth of the Little Buffalo River, a considerable quantity of similar shingle and boulders rests on top of the sandstone cliffs about 200 feet high. The banks of the Clearwater, which, except near the mouth, are from 500 to 600 feet high, consist principally of pebbly drift clays, with Cretaceous and Devonian rocks towards the base in some places, as already mentioned. The sandy banks of the Athabasca, towards the head of the delta, have been referred to in describing the river in a previous part of this report.

Economic minerals.

Economic Minerals.

My attention was constantly directed to the discovery of economic minerals and to all the circumstances connected with those already known to exist in the region examined.

Gold.

Gold in the form of fine dust was said to have been found by passing miners and explorers on both the Athabasca and the Clearwater, but I did not succeed in detecting its presence, although it was diligently looked for along both streams.

Iron.

Iron. As stated in the description of the Biche River, nodules and thin interrupted beds of clay-ironstone occur in the dark marls of the lowest stretch. The large concretions of low grade ore of the same kind which are derived from the indigo-colored marls of the Athabasca, above the Pelican River, have been fully described. Thin beds, containing a considerable percentage of carbonate of iron, were found among the Devonian limestones on this river below the Clearwater, and as clay-ironstone in workable quantities occurs elsewhere in the Devonian rocks, the possibility of finding larger deposits in this region should be kept in view. In 1881 Mr. Cochrane obtained small quantities of red hæmatite at Fond du Lac, on the northern shore of Lake Athabasca, and requested the gentleman in charge to enquire and search for iron ores in larger quantity. In consequence of this, a short time before my arrival at Fort Chipewyan, he had brought to that establishment a large freshly broken specimen of fine magnetic ore, said to have been obtained near the entrance of Black Bay, on the same side of the lake.

Clay ironstone.

Red hæmatite,

Magnetic iron.

Lignite. Seams of lignite, sometimes thick enough to be worked, have already been described as occurring amongst the Cretaceous sandstones and marls on the Athabasca, between the Grand Rapid and the junction of the Clearwater, and a seam three or four feet thick was noticed in the petroleum-bearing sand on the east side, about twelve miles below The Forks. Indications of lignite were also found at other localities in these rocks, but, owing to the general black color, of the banks a seam of the lignite might easily escape observation.

Lignite.

Ochre. A considerable patch of reddish ochre, or marl, was observed on the west bank of the Athabasca, about three miles above the Big-mouth Brook, and a deposit of brown ochre, which appeared to be large enough to be of economic value, occurs on the same side on top of a bank of drift about half-a-mile below the Pelican River.

Ochre.

Clays suitable for brick-making, puddling, etc., were seen in the banks of streams, etc., at various places between Fort Pitt and Lac la Biche, and some of the beds of clay around this lake would answer the same purpose. The stiff, dark-colored marly clays of the Athabasca, between the Biche and the Pelican rivers, where they have been exposed to the action of the weather, would probably make good bricks.

Clays.

Marls. The bottom of Lac la Biche, near the outlet, is said to be covered with white shell-marl, and the same substance is reported as occurring in other lakes. A light greenish-blue marl is obtained among the Devonian strata near The Forks of the Athabasca, which is highly prized as a wash for the inside of houses.

Marls.

Limestone. Some of the Devonian limestones along the Athabasca would be suitable for burning into lime, and at the rapids of the Clearwater any quantity of a superior quality for this purpose can be obtained. Many of the beds in this neighborhood would make excel-

Limestone.

lent building stones. Mr. Cochrane found impure limestones among the Huronian rocks on the north shore of Lake Athabasca.

Moulding sand. *Moulding Sand.* A fine loamy sand, apparently suitable for moulding, was observed at a few points along the Athabasca, between the Grand Rapid and The Forks.

Sand for glass-making. *Sand for Glass-making.* In the valley of the Clearwater, at the Bonne Portage, and again at the Terre Blanche Portage, large quantities of fine pure white sand occur, which, to all appearance, would serve for making good glass. The white sand of the Methy Portage would also answer for the same purpose.

Graphite. *Graphite.* Worn pieces of fine-grained graphite are fonnd on the north shore of Lake Athabasca, near Fond du Lac, and the natives were requested by Mr. Cochrane to try to find it in the solid rock.

Salt. *Salt.* At the locality known as La Saline, about half-a-mile east of the Athabasca and twenty-five miles below The Forks, a white incrustation of salt is deposited from water flowing over a bank of the black petroleum-bearing sand. The salt used in the Athabasca district is, however, brought from Salt River, a small western branch of the Slave River, where it is found of excellent quality on the surface of the ground in crystals about the size of those of Liverpool salt, and is shoveled directly into the bags in which it is transported. Gypsum is said to occur in economic quantities near the salt. The numerous and copious mineral springs along the Clearwater River, which have been already described, are perhaps destined to become of value in the future.

Salt River.

Gypsum.

Petroleum and asphalt. *Petroleum and Asphalt* were the most important substances which came under my notice during the season. Their mode of occurrence along the Athabasca, both above and below The Forks and on the Clearwater, has been described in a previous part of this report. These deposits have been referred to by the earlier travellers, especially Sir John Richardson, who described this part of the Athabasca in 1823; but in those days the science of geology was in its infancy, and no attention had been paid to the geological relations of petroleum, which was not at that time considered of any commercial value. The asphalt and "tar" of the Athabasca region were, therefore, referred to as natural curiosities rather than from any appreciation of their possible future use. Now, however, they may be regarded as of great scientific interest and economic importance, notwithstanding the distance of the locality from present railways. The enormous quantity of asphalt, or thickened petroleum, in such a depth and extent of sand indicates an abundant origin. It is hardly likely that the source from whence it came is exhausted. The whole of the liquid petroleum may have escaped in some parts of the area below the sandstone, while in others it is probably still imprisoned in great quantities and may be found by boring. The thickened and blackened residue, which now saturates the sand and renders it plastic, has resulted from the escape of the more volatile hydrocarbons and the simultaneous oxidation of those remaining. This itself may have, in the course of time, prevented any further escape of the petroleum from the limestone below. In some places argillaceous beds in the sandstone or amongst the limestones may have held down the oil. The attitude and conditions of the strata are favorable for the accumulation of the oil amongst the limestones themselves, and it is therefore to be expected that productive wells will be found by boring into these rocks along the part of the Athabasca where they may be reached. The petroleum, in regions which have been worked, is believed to be most abundant near the crowns of low anticlinals or domes (as might have been expected), where it has been prevented from escaping upward by impervious strata. It may therefore be found in great quantity where the surface indications are faint. Conspicuous surface indications do not always indicate the largest stores of oil below, since it may have escaped so freely as to have left but little behind. It has been stated that the Devonian limestones along the Athabasca are, on an average, nearly horizontal, but that they undulate slightly or dip locally in various directions. The majority of the dips appear to indicate a tendency to form slight anticlinals and synclinals running in an easterly and westerly direction. The question of the best sites on which to bore for oil would be partly determined by a consideration of these facts. The subterranean accumulations of oil may be expected to be found on the principal anticlinals or domes in the limestones without reference to the attitude of the unconformably overlying Cretaceous sands. A point might be selected on one of these where the surface tar or naptha was least profuse, care being taken to avoid surface water, quicksands, boulders, &c. The indications of petroleum in the Cretaceous sand were wanting, or only slight, at two or three places. One of these might be a promising spot for a trial well, provided it was found that the absence of petroleum was not due to the spot being situated over a synclinal axis in the limestone formation.

Boring.

Petroleum retained.

Anticlinals.

The pitchy sand may itself be found useful for a variety of purposes. When chopped out of the bank in lumps like coal it was found to burn freely with a strong smoky flame, if supported in such a way as to admit of the free access of air. As the bitumen became exhausted, the fine sand fell to the bottom. A furnace or stove might be contrived so as to burn this material. Perhaps a grate constructed on the plan adopted for burning sawdust, with an additional contrivance for

Possible substitute for coal.

removing the sand, would be found to succeed, and, if so, the banks of the Athabasca would furnish an inexhaustible supply of fuel.

Other uses.

This fine asphaltic sand might also be utilized, with little or no treatment, for pavements, roofing, the manufacture of drain tiles, etc. etc., and also for insulating electric wires.

Lubricating Oil.

A very superior lubricating oil may be manufactured from it. Mr. Hoffmann, of this Survey, Mr. Isaac Waterman, the well-known petroleum refiner of London, Ont., and Lieut. Cochrane, instructor in practical chemistry at the Military College, Kingston, have found it to

Percentage.

contain from 12 to 15 per cent. of bitumen. Although this proportion may appear small, yet the material occurs in such enormous quantities

Methods of extraction.

that a profitable means of extracting the oil and paraffin which it contains may be found. The high banks of the river and its branches offer an easy means of excavating it; and, as it burns readily, one part might be consumed to extract the oil from another, there being practically no limit to the quantity which may be obtained for the digging. Dr. Hunt suggests that the lighter and less valuable oils, obtained in the process of distilling, might be used to percolate through or lixiviate large masses of the crude material, and that in this way a large proportion of the better part of the oil which it contains might be cheaply obtained on a large scale. Mr. Hoffmann found that, in the sample he tried, 69.26 per cent. of the bitumen was removed by boiling or macerating in hot water, the extracted bitumen containing 50.1 per cent. of sand.* This might be found to be a good method of reducing the bulk of the material to be distilled for oil or for the purpose of making gas. The natural "tar," which has been already referred to, may be found to be in sufficient quantities to be available for the manufacture of oil. Mr. Waterman informed me that the

Paraffine.

proportion of paraffine in the bitumen of the sample submitted to him appeared to be large, and it is possible that this substance might be profitably extracted for export from the deposits which have been described.

Transportation of the oil.

The principal obstacle in the way of a speedy development of the oil-fields of the Athabasca is their distance from a sufficient market. There is, however, a near prospect of this difficulty being removed by the construction of one or another of the projected railways into the region, for which charters have been granted. A beginning might, in the meantime, be made for the supply of the Northwest Territories themselves, where the price of mineral oil is excessively high. Independent of railway construction, an outlet for the oil to foreign markets might be found by conveying it by steamers, for which there is

* See analyses and reports by Mr. Hoffmann, Geological Survey Reports for '80, '81, '82, pp. 3 to 5 H.

uninterrupted navigation, from the Athabasca River to the eastern extremity of the lake of the same name, and thence by a pipe to Churchill Harbor on Hudson's Bay.

As complete a collection as possible of the Lepidoptera of the region traversed was made, and the specimens were sent to Mr. H. H. Lyman, of Montreal, a well-known entomologist, who has kindly determined the species, and furnished us with the list which is given as an appendix to this report. A few specimens, about which Mr. Lyman had doubts, were submitted by him to the principal authorities on the Lepidoptera in the United States. Where more than one specimen of any species was taken at the same locality, the number is given after the name.

Lepidoptera.

List.

Authorities.

APPENDIX.

LIST OF LEPIDOPTERA COLLECTED IN THE NORTHWEST TERRITORIES BY DR. ROBERT BELL IN 1882.

Lac la Biche, June and July.—*Papilio turnus*, L.

Near Flat Creek, July.—*Satyrus nephele*, Kirby, 2.

Camp between Fifth Siding of the C. P. Ry. and West Creek, July 22nd.—*Hepialus quadriguttatus*, Grote.

Fort Qu'Appelle, July 24th and 25th.—*Colias christina*, Edw. *Argynnis lais*, Edw. *Phyciodes tharos*, Drury. *Cœnonympha pamphiloides*, Peak. *Satyrus nephele*, Kirby, 4. *Hypoprepia fucosa*, Hubner.

Between Fort Qu'Appelle and Touchwood Hills, July 25th and 26th.—*Argynnis lais*, Edw., Kirby, 2.

Touchwood Hills, July 26th to 31st.—*Colias christina*, Edw., 5. *Argynnis lais*, Edw., 5. *Argynnis myrina*, Cram. *Phyciodes tharos*, Drury, 6. *Vanessa antiopa*, L. *Limenitis arthemis*, Drury. *Limenitis disippus*, Godt. *Satyrus nephele*, Kirby, 4. *Lycæna sæpiolus*, Boisd, 2. *Pamphila mystic*, Edw. *Plusia simplex*, Green.

White Sand River, July 28th to 29th.—*Colias christina*, Edw. *Argynnis cybele*, F. *Argynnis lais*, Edw. *Limenitis arthemis*, Drury. *Limenitis disippus*, Godt. *Satyrus nephele*, Kirby, 2. *Lycæna sæpiolus*, Boisd.

Round Plain, July 30th.—*Argynnis lais*, Edw. *Limenitis arthemis*, Drury. *Satyrus nephele*, Kirby, 2. *Lycæna sæpiolus*, Boisd. *Hadena devastator*, Brace.

Salt Plain, August 2nd and 3rd.—*Colias christina*, Edw. *Argynnis lais*, Edw. *Phyciodes tharos*, Drury. *Cœnonympha pamphiloides*, Peak. *Satyrus nephele*, Kirby, 2. *Lycæna sæpiolus*, Boisd.

Humboldt, August 3rd and 4th.—*Colias christina*, Edw., 2. *Argynnis cybele*, F., 2. *Argynnis lais*, Edw., 2. *Phyciodes tharos*, Drury, 2. *Vanessa antiopa*, L. *Satyrus nephele*, Kirby, 2. *Lycæna sæpiolus*, Boisd. *Hadena devastator*, Brace, 2. *Crambus*.

Vermilion Lake, August 4th.—*Colias christina*. Edw. *Argynnis cybele*, F. *Argynnis lais*, Edw. *Phyciodes tharos*, Drury, 2. *Satyrus nephele*, Kirby. *Lycæna sæpiolus*, Boisd., 3. *Hypoprepia fucosa*, Hubner.

Gabriel's Crossing (South Saskatchewan River), August 5th.—*Colias christina*, Edw. *Argynnis lais*, Edw. *Phyciodes tharos*, Drury, 2. *Satyrus nephele*, Kirby, 2.

Duck Lake, August 6th.—*Colias christina*, Edw. *Argynnis cybele*, F. *Argynnis lais*, Edw. *Phyciodes tharos*, Drury, 2. *Satyrus nephele*, Kirby, 2. *Plusia simplex*, Guen.

Camp near Fort Carleton, August 7th.—*Colias hagenii*, Edw. *Argynnis lais*, Edw., 2. *Phyciodes tharos*, Drury, 4. *Satyrus nephele*, Kirby, 2. *Lycæna sæpiolus*, Boisd. *Pamphile cernes*, (Bd.) Lec. *Plusia simplex*, Guen.

Near Fort Pitt, August 15th and 18th.—*Phyciodes tharos*, Drury. *Vanessa antiopa*, L. *Petrophora truncata*, Hubner.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

OF

GEOLOGICAL OBSERVATIONS

IN THE

SAGUENAY REGION.

BY

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MONTREAL.
DAWSON BROTHERS.
1884.

To A. R. C. Selwyn, LL.D., F.R.S., F.G.S., &c.

Director Geological and Natural History Survey of Canada.

Sir,—In your instructions respecting the geological researches to be made in the region of the Saguenay, you wished me to pay particular attention to the limestones of the Cambro-Silurian, to the bands of crystalline limestone of the Laurentian, to the deposits of titanic iron ore, and in general to all important geological facts which I might be able to observe. I believe that I am in a position to submit to you some new observations on various points, which will to some extent modify the geological map of the Saguenay region as published by Sir William Logan in 1863.

These observations are, perhaps, not as precise nor as detailed as they might have been had I had more time at my disposal. Moreover, the difficulties which attend such researches in thick forests where the measures are not only covered with dead and live vegetation but also in the majority of instances hidden beneath considerable masses of glacial *detritus*, must necessarily take away from the clearness and precision of a work of observation.

I have the honour to be,

Sir,

Your obedient servant,

Abbé J. C. K. LAFLAMME.

Quebec, December, 1883.

REPORT

OF

GEOLOGICAL OBSERVATIONS

IN

THE SAGUENAY REGION.

Physiographical Sketch.

The region which I have more particularly studied is that situated to the north-east of the Saguenay, from Chicoutimi to Lake St. John. Then I examined in detail the level country lying east of the lake, bounded on the north by the small outlet (*petite Décharge*), and on the south by the granitic hills which lie near the centre of Labarre Township, then by the elevated land which runs uninterruptedly and in a straight line from the west end of Lake Kénogami to Lake St. John where the Metabetchouan River empties into the lake.

The portion situated to the north-east of the Saguenay is, to a great extent, limited in that direction, and to the south-west, by two small slightly elevated chains of Laurentian hills, distant at various points from four to five leagues. This kind of basin-like area widens out, however, going up the *Décharge* until it merges in the vast swamps which reach Lake Tshistagama and river Péribonka. This flat country is everywhere covered with a thick layer of quaternary deposits. Taken as a whole, it is eminently suited for agricultural purposes. Besides, as numerous rivers traverse it and flow into the Saguenay, it is one of those districts where lumbering is carried out on a large scale.

The similar plain which lies to the eastward of the lake is already settled and cultivated to a large extent. The general surface would be quite level were it not for those tortuous and deep ravines which the rivers as well as the small brooks have worn out in all directions. A few outcrops of Laurentian rocks are also seen therein, outcrops which moreover, are always marked by slight elevations. This level tract resembles closely that occupied by the townships of Chicoutimi, Bagot and Laterrière, where the generally level surface is again only broken by the ravines made by the flowing waters, and its borders are occupied by ranges of Laurentian hills.

Laurentian.—A.

The Laurentian in the area explored may be divided into two very distinct series. First, the hornblendic and micaceous gneisses, the granites, and the syenites, which are seen at Chicoutimi and Ste. Anne, along Lake Kénogami and on a portion of the shores of Lake St. John; and second, those extensive labradoritic masses which lie along the *Décharge* and on the eastern shore of Lake St. John.

I. *Gneissic Series.*—Gneisses predominate everywhere, whilst true granites and syenites are comparatively rare. At Ste. Anne, the rocks contain many hornblendic minerals. They are associated with a large number of quartzose and felspathic beds or bands which strike generally at right angles to the Saguenay River.

These bands probably indicate the original stratification, notwithstanding the fact that in certain cases they are strongly contorted and appear rather like veins or dykes. Yet, they are evidently contemporaneous with the associated rocks which hold them.

These indications of stratification are well exposed over the whole ridge which separates Ste. Anne from the *Terres rompues.*

A few indications of foldings can also be recognized. Moreover, similar beds can be traced to the mouth of the Saguenay, following essentially the same strike. A little above Shipshaw, the gneissic series is interrupted by a large band of labradorite. It reappears further, but sensibly changed as to its nature and appearance.

The felspar predominates, and the rocks, being more readily disintegrated, are more deeply attacked by the atmosphere. At la Dalle the rocky beds which form the shore of the Rivière des Aulnets, are rich in common garnets.

About five miles above the mouth of the Rivière des Aulnets on the Saguenay, the gneiss disappears completely and is replaced by nearly pure labradorite.

Unequal decomposition by atmospheric action since the glacial period on these Laurentian rocks is very marked ; many of the rounded and polished surfaces have become quite rugged. Layers of quartz and other minerals, rich in silica are left in relief, whilst those more easily decomposed have been removed to greater or lesser depths.

I must point out a very remarkable fact with regard to the erosion by the ice. As might be expected, the northern slopes of the rocky hills have been more effectively attacked than the southern. The crests of those which crop out from beneath the quaternary clays are worn and rounded on the northern slopes, whilst the opposite slope is still often abrupt and rugged, indicating that the course of the glacial current was from the north and north-west.

II. *Labradorite series.*—It is a difficult matter to locate precisely the first appearance of beds of labradorite along the Saguenay. Still it is only in the neighborhood of Shipshaw river that such beds can be said to acquire considerable development, on the north-eastern border of the *Décharge.* They are here intermingled with a certain number of beds of gneiss, such as we referred to above, and are consequently parallel to them. But at the Cran-serré, a little above the Duclos River, labradorite composes almost exclusively the rocks of the hills.

The colour of this labradorite is very dark brown with a tinge of blue in it. From exposure to the atmosphere, it crumbles into a greyish powdery material, and the rocky hills consequently assume a smoky hue which causes a singular contrast with the non-decomposed portions.

The rock is compact, with an eminent crystalline fracture and exhibits large crystals with faces marked by the characteristic striæ of the plagioclase felspars.

In certain places these labradorite rocks have a cellular structure. This phenomenon arises from the decomposition of small patches of foreign minerals, originally imbedded in the labradorite and slowly dissolved by atmospheric agencies. This decomposition, commencing at the surface of these isolated patches, has extended by degrees to the centre, forming a number of chloritic leaflets, in clusters radiating around a central point. This peculiar leaf-like decomposition is due to an original concentric structure, developed by the action of frost and snow on the glacial surface. It is not rareto meet some *roches moutonnées* labradoritic in composition, the summit of which is covered with leaflets neatly separated. Their thickness varies from a few lines to a few inches. This exfoliation is much better marked on the surface of the labradorite rocks than on any other. These various disintegrating actions were doubtless at work previous to the glacial epoch as well as subsequently, and the labradorite rocks must have been decomposed to a greater depth than the granitic rocks at the time when ice invaded the country. Whence it follows that these rocks have been more deeply eroded during the glacial epoch, and this would perhaps explain the fact that the labradorite hills of the Saguenay are, as a general rule, lower than the granitic or those of gneiss or syenite. At first sight it seems as if the surface of the country occupied by the labradorite had undergone a kind of a depression, whilst in reality this appearance may more likely be solely due to greater erosion.

To sum up my observations on these developments of labradorite, I shall state that these rocks occupy a pretty extensive area on the eastern shore of the Saguenay. They begin at the Shipshaw River, follow the Aulnets as far as the sixth or seventh ranges of Bourget, without reaching lakes Chabot, Thomy and des Brochets, then are exposed on the northern shore of Lake St. John, from the *Décharge* to to the Rivière au Cochon.

This formation probably extends further north, perhaps reaching Péribonka River. However, the extensive swamps between the Lac des Brochets and that river would render observations extremely difficult.

The island of Alma itself is composed solely of labradorite with a few beds of interstratified gneiss.

To the south shore of the outlet, similar labradorite masses are visible east of the Church of St. Dominique, and again continually on the right bank of the river as far as the lake. Finally they compose almost entirely the hills found between St. Gédéon and the *Petite Décharge.*

Amongst the most important minerals which this formation holds, titanic iron ore may be mentioned first.

The labradorite pebbles which are found in the neighborhood of Shipshaw often enclose this mineral, and it appears to occupy a position analogous to that which hornblende occupies in syenite, to such an extent that at first sight these rocks might be mistaken for ordinary syenitic fragments.

The mass which I was able to study most thoroughly is found on the first range of Bourget, at a short distance from Taché township. This mass is about two arpents wide and four or five long; but it is found again in different places on the same direction, at a considerable distance from the Saguenay. The mass in Bourget forms a regular hill, 150 feet high, composed almost exclusively of titanic iron. Felspathic veins with strange configuration are, however, found in the same. They remind me, remotely perhaps, of Prince Rupert's drops with this difference that they are much more irregular. Large crystals of labradorite are likewise often met with.

At first sight, the structure of these ferruginous masses is so disturbed that an igneous origin is suggested.

The action of the quaternary glacier was remarkably exemplified in the case of these minerals, large surfaces being found which have still preserved the original polishing. Others have become rugged, and cellular, by the decomposition of foreign substances originally mingled with the titanic iron.

The occurrence of ilmenite in several places which Sir W. Logan does not mention in the Geology of Canada, 1863, has also been noted. The principal ones are: At Jervais River, on the banks of Shipshaw, on the second range of Jonquière and on the first range of St. Gédeon.

A word now about the different veins which traverse the labradorite. At Trépannier Bay, on the island of Alma, thére is a very remarkable vein of orthoclase pretty nearly pure and crystalline. It runs north north-east from the bay and has a dip of about 70°. Analogous veins, two or three feet in thickness, are met with in various places on the islands of the *Petite Décharge.* Rather large dykes are also found composed of a kind of compact dolérite enclosing crystalline masses of hypersthene and ilmenite. These dykes can be seen again at the mouth of the *Grande Décharge* and on the shore in the vicinity of the *Petite Décharge* to the south. Their strike is nearly at right angles to that of the felspathic veins referred to above.

The Laurentian formations which I have examined hold several minerals which we will briefly cite here:

Mica is found abundantly. It is met with in large laminæ, capable of being utilized, at l'Anse à Caron, along the *Grande Décharge* and in the third range of Jonquière. From this latter place we had sheets of a mica, black in colour, about two feet square.

Sulphide of antimony was found in a very narrow vein crossing the Saguenay at the height of the broken lands (Terres Rompues) close to a remarkable development of titanic iron. On the eighth lot of the thirteenth range of Laterrière occurs a quartzo-felspathic vein running from north-west to south-east, enclosed in gneissoid rock. It contains a very small quantity of graphite disseminated throughout in small masses.

Another quartzose vein is found three miles from the Portage des Roches on the right bank of the Chicoutimi River. Its thickness is from eight to ten feet and direction north to south. It is rich in iron pyrites. Gold was thought to have been present, but the analysis has shown that the pyrite was not auriferous.

In the township of Jonquière, on the north range of the road leading to Kaskouia there is a curious agglomeration of precious minerals, specially garnets and emerald. The garnets are rarely transparent, save those surrounded by masses of mica, but then they are unfortunately very small. The emeralds belong to that variety called "aqua-marine." Crystals have been found reaching a diameter of three inches and more and a length of from twelve to fifteen inches.

The crystalline limestones which are elsewhere characteristic of the Laurentian were not observed anywhere. The only calcareous rocks met with are a few narrow veins traversing the Laurentian hills invarious places. Such are, amongst others, the veins of Shipshaw, near the Grande Décharge.

However, I must especially mention a much more considerable mass of lime-rock examined on the second lot of the first range of Metabetchouan, quite close to the so-called Quebec road. On the side of a hill some one hundred feet in height and running north and south a mass of white limestone coarsely crystalline can be observed which is composed of rhombohedral crystals. This limestone rock may be seen more than fifty feet long and about twenty feet thick. It is surrounded by gneiss which is also found in all the adjoining hills. Unfortunately the mineral and vegetable detritus which cover the country render the examination extremely difficult, to such an extent that it is almost impossible to define the boundaries of the limestone in a precise manner. Whether it is a vein or a remnant of a large mass of crystalline Laurentian limestone could not be affirmed with certainty.

Cambro-Silurian.—D.

The examination of the Cambro-silurian formations was one of the principal parts of my programme, accordingly I have paid particular attention to the same.

In the Geology of Canada, 1863, Sir W. Logan mentions solely the limestones which occur on the island at the entrance to the *Petite Décharge* and those which border the southern shore of Lake St. John from Metabetchouan to Blue Point. I believe that I have discovered the boundaries of another large Cambro-silurian basin to the north-east of the Saguenay, not reckoning a goodly number of smaller areas, which, although isolated, can however be grouped so as to form minor, but perfectly characterized basins. As the first-mentioned and largest is for the most part in Ste. Anne parish, I shall call it the Ste. Anne Basin.

The strata which compose it are all limestone and referable to the Trenton Group. The following is a list of the localities where I have ascertained their occurrence with the leading characteristics which they offer in these different places:—

First, they are found on the third range of Tremblay, about 40 arpents from the Saguenay, and about 270 feet above the river. There they rest directly on the gneiss, and their thickness is so slight, at least on the border of the formation, that the undulations of the gneiss are brought to light through their edge The absolute horizontality of the Trenton beds prevails over the whole of the Ste. Anne basin. The road crosses this calcareous series, almost at right angles to the strike of the strata, which is south-west. It here forms a hill about 40 feet high. To the south-west it abuts against Laurentian masses. To the north-east it dips below the deposits of quaternary clays. It has in that locality a width of about 30 *arpents*. The quaternary clays which begin here, form an extensive plain stretching to the limits of the townships of Tremblay and Simard. The general surface is quite regular, except in those places where brooks and rivers run, whose beds are always worn deep. The soil is very fertile, and already a fair portion of it is being cultivated.

Towards the boundaries of the township mentioned above, the surface rises sensibly, and between Lakes Caribou and Charles another limestone band is seen to crop out quite like the limestones of the third range of Tremblay. The gneiss hills begin again beyond and continue as far as the Valin Mountains which separate the waters of Saguenay from those of the Betsiamits River. This band of limestone is somewhat thicker than the one already described. It is also longer, for it is found again between Lake Tortu and River Shipshaw, a very good natural section of it being there exposed. The Shipshaw River itself runs more than a mile upon these limestone beds, the Ours River, which flows about a league west of the Shipshaw, does the same.

On the eastern side, at the boundaries of Tremblay township, the Valin River has likewise worn its bed in the limestones, and that to a considerable extent.

From all these observations it can be affirmed that to the north of Tremblay and Simard townships, there exists a great band of Trenton limestone running almost parallel with the boundaries of those townships.

The limestone band first referred to also extends in a direction from east to west, being found again at Riviere aux Vases and Caribou River. In both places the beds are overlaid by very extensive deposits of clay, but these are cut through by both rivers down to the limestone.

Apparently the two bands of limestone are only parts of the rim of a large basin, its central portion being covered and concealed by the alluvial deposits referred to; as on the eighth range of Simard, between the 11th and 21st lot, the limestone is only a few feet below the surface over a breadth of about twenty arpents. This is also the case in the sixth range of the same township, where the soil is literally covered with pebbles of limestone. In this last mentioned locality an abundant sulphurous spring occurs.

To sum up, I have ascertained the presence of limestone over an area about ten miles broad and seventeen miles long. In the whole of this area there is not a single outcrop of the gneissic series. It is an extensive wooded or cultivated plain. This Cambro-silurian basin is, as stated, limited to the north and south by the limestone bands just described, but it is not so to the east and west. Time did not allow me to examine the eastern boundary. As to the limits of the basin to the north-west I believe it to be very difficult to determine, seeing that from the River Ours to Péribonka and to Lake Tshistagama, the surface of the country is only a vast plain often covered with swamps and where no rock outcrops have been seen. This remark, however, applies only to that portion which lies beyond the surveyed townships, for the contrary is the case in these latter. In fact the Aulnets River, which crosses Bourget township, in no place flows over limestone beds. Lakes Chabot, Thomy, and des Brochets have gneiss or labradorite shores, the same is the case with the Mistouc River. The limestone basin of Ste. Anne is, therefore, clearly limited on that side.

There is no doubt that these limestone formations were originallv more extensive, and that they were reduced to their present dimensions by glacial erosion, which has left too extensive traces on the granite hills of the Saguenay not to have affected considerably the comparatively soft surfaces of the adjacent palæozoic rocks.

The limestone beds are everywhere crossed by numerous joints belonging to two systems nearly at right angles. The lower beds, those which are in close contact with the granite, are compact, dark in colour, with a light tinge of blue. Fossil remains are abundant. They are found crowded together, especially in certain beds. However, it is difficult to find perfect specimens. They are naught but fragments accumulated in such a way as to make identification almost impossible.

Besides the fossils, there are seen in the mass of the rock small crystalline grains, such as are found in the Bird's Eye formation.

In the upper beds of the same basin, the fossils are more abundant. A few layers appear to be almost exclusively composed of crinoid stems. Tombstones obtained from these beds present specimens of pretty palæozoic algæ. Let us also add that these beds are crystalline and resemble pretty closely the limestones of Deschambault.

Petroleum is not rare throughout this whole area of Cambro-Silurian rocks. Sometimes it exudes spontaneously from the cavities of the rock, and when the rock is heated it gives forth a very marked bituminous odour. All the limestones of the Saguenay are also bituminous, which establishes clearly their relation to the Trenton group.

To complete the study of Ste. Anne basin, it would be necessary to find out the eastern and western limits, and also ascertain besides other facts, whether there are not between Valin Mountains and Betsiamits River deposits which belong to the same horizon. The guides certify that rounded pebbles of limestone are found throughout that whole region.

Lake St. John Basin.—In the Geology of Canada, 1863, Sir W. Logan states that the limestone formations must probably nearly cover the bottom of Lake St. John, though it is seen only in two places. As regards the boundaries of these two limestone areas, as laid down by Sir William, I shall point out that the first one does not begin at the mouth of the Metabetchouan, but about a mile and a half farther west. The formation attains almost immediately a thickness of about one hundred feet, always in horizontal beds except near the lake, where they dip towards it. It is, moreover, singular that the beds of this whole limestone area, which are near the lake, always dip towards it.

At the point where these limestones first appear, black bituminous beds of Utica slate are found resting unconformably against the limestone; a phenomenon probably due to a fault. These beds hold such a quantity of bitumen as to have caused the farmers to mistake them for coal, finding that they burnt with a flame.

At Ouiatchouan River, the Utica shales rest conformably on the limestones, being directly superimposed. Here they are but slightly developed, and disappear beneath huge masses of clay. At Ouiatchouanish River the limestones rest immediately upon the granite. Fifteen arpents west of Point Blue, the Utica argilites reappear, resting conformably on the limestones. They dip considerably towards the lake.

The Cambro-Silurian band along the north-western shores of Lake St. John is relatively narrow. It scarcely extends beyond the second range of the Metabetchouan and Chambord and the first range of Roberval. Farther south the granitoid Laurentian hills begin. These limits are only approximate, seeing that I had not an opportunity of studying them in detail. It would be very interesting to ascertain exactly that line of demarcation, also to make sure whether the limestone band around Pointe Bleue is continuous over the vast basin where the Ashouapmouchouan and its various tributaries flow. There is every reason to believe that another palæozoic basin, equally developed, may be found there.

The limestone island referred to by Sir William Logan, which is situated at the mouth of the *Petite Décharge* is very large. When the water is low its exposed length is from three to four miles and its breadth two. The limestone may even be traced beneath the waters at a good distance from the island. This island is itself but little elevated, and when the water is high, is completely submerged except the tops of the trees which cover its surface; the beds, always horizontal, abound in fossils: corals, brachiopods, gasteropods, cephalopods, &c.

It is natural to suppose that this limestone island is one of the sources of the pebbles of limestone which are found quite often on the shores of the outlet of Lake St. John, and also in places apparently very remote, from limestone formations. In this light I have noticed such pebbles at the Grand Remoux, at Jervais Rapids and in various places along the *Petite Décharge.*

They are torn up by the ice and transported here and there during high waters.

I have further found limestone beds in many other localities at the eastern extremity of Lake St. John, to such an extent that formerly this formation must have covered the whole of that portion of the country in which are now the parishes of St. Jerôme, Hébertville, Grammont and Alma, except perhaps a few Laurentian islets. It was subsequently removed by successive denuding agencies. The limestone pebbles, however, still lie around to such an extent sometimes as to allow the erection of lime-kilns. Among such places may be mentioned, the 30th lot of the eighth range of Signay, the 7th and 8th lots of the first range of Alma, different lots situated at a short distance to the north-east of Grammont church, and near St. Jerôme church, moreover, there are others where the limestones are still *in situ.**

On the Island of Alma, twenty arpents to the east of Trepannier Bay, there is an outcrop of limestone resting directly upon the Laurentian rock. As the exception, these beds are highly inclined toward the north-east.

On the other side of Alma Island on the right bank of the *Grande Décharge* we find a similar limestone formation. The same is the case on the 25th lot of the eighth range of Signay, where horizontal limestone beds are, as it were, imbedded in a nest of granite. At that point where the road of the third range of Caron crosses the river Koushpaganish, it flows over limestone beds slightly inclined to the north, and

* These Trenton limestone outliers are economically important as a source of lime, and they are also geologically of great interest as indicating the area once covered by the Cambro-silurian ocean. The discovery of more such outliers, in the great unexplored Laurentian region between Hudson's Bay and the St. Lawrence, may yet prove that the Laurentian Continental nucleus was wholly, or in great part submerged, perhaps more than once in early palæozoic ages. Such repeated oscillations and the great denudation resulting from these may easily have destroyed all traces of formations once superincumbent to the Laurentian. It is therefore in a modified sense only that the present extent of these palæozoic outliers can be ascribed to glacial erosion which was one of the latest only of the denuding agencies which have taken part in producing the existing physical outlines.—A. R. C. S.

covered above with more than 100 feet of clay. Further to the west limestones again crop out, on the 7th and 8th lots of the fifth range of Metabetchouan. The dip is 30° to the north, and their visible thickness about 40 feet. The beds are thick and would afford good building-stone. Their extent is from twelve to fifteen arpents in length and five or six in breadth. Travelling towards Hebertville similar beds present themselves near Lac à la Croix, in a small Laurentian depression which preserved them from glacial erosion.

A noteworthy fact is that in all the points of contact which I have been able to observe between the Laurentian and the Trenton, the latter rests directly upon the former, no traces of the Potsdam Calciferous or Chazy being seen. Moreover, whilst the Utica formation is present only in a few instances, still *debris* from it are found on the shores of the lake and very often inland to such an extent that we are forced to conclude that the whole area of the Trenton was formerly covered with this formation. I have pointed out in the course of these remarks the fact that the limestones are often enough found in nests or outliers amongst the granites. Therefore, these depressions and hills of Laurentian age must necessarily have existed at the bottom of the palæozoic ocean where the limestone beds were being deposited. Consequently, even previous to Cambro-silurian times, erosion had already strongly attacked the gneisses, however hard they were, and to a considerable extent modified their surface features.

There remains to be pointed out another limestone deposit on the 3rd and 4th lots of the third range of Bagot, near the fourth range. The limestone is visible upon a surface of three or four arpents. Elsewhere it is completely covered with the quaternary clay. Here again, as throughout the whole Saguenay region, the limestone rests distinctly and immediately upon the granite. Fossils are not rare in this limestone, and cavities filled with petroleum are also found therein. In the large plain which includes the parishes of Chicoutimi, Grand Brûlé, St. Alphonse and St. Alexis, I have not found any limestone except where mentioned above. However, it is quite probable that it should be met with beneath the clay in many localities. In fact, these parishes form a large basin similar to that of Ste. Anne. The Laurentian outcrops are few and but slightly elevated. The general surface of the country is level enough except the ravines worn out by the rivers and brooks. Further, but a few years ago, limestone beds were blasted near the spot called "*les battures*," on the right bank of the Saguenay, about on the same level with the limestones of Bagot. It is then not impossible that we have there again another palæozoic basin in which erosion first, and the accumulation or heaping up of the detritus of glaciers next, have destroyed or concealed the greater portion of these deposits.

To recapitulate, I must say that besides the Cambro-Silurian formations pointed out by Sir William Logan, the region of the Saguenay comprises others situated in the Ste. Anne parish, various small outcrops east of Lake St. John, and less extensive deposits in Grande Baie plain, to such an extent that the palæozoic ocean must have been there co-extensive with that of the quaternary age.

Post-Tertiary.—M.

The Post-tertiary deposits of the Saguenay are clearly divisible into two groups just as Dr. Dawson's study published in the Geology of Canada, 1863, indicates. The lower group comprises the boulder clay, overlaid by a more or less thick deposit of stratified clay. The upper group consists almost exclusively in beds of sand holding at times pebbles of goodly size evenly rounded. This sandy group is never very thick. The brooks and rivers have worn out their beds in these easily moveable formations into ravines of great depth with steep sides.

The palæozoic basin of Ste. Anne is covered with a thick bed of clay. The sandy deposits are only met with in the western portion near Aux Vases River (Mud River.) It is a curious fact that we frequently find the sandy surfaces of the terraces entirely or in part occupied by swamps. Such is the case, amongst others, near the Aux Vases River, in the neighborhood of Lake des Brochets and between Chicoutimi and the Grand Brûlé.

Little by little the water of the swamp permeates through the whole sandy mass and reaches the surface of the clay. It then follows the impermeable surface of the clay in the direction of the greatest slope and comes forth in the shape of abundant springs in the worn out ravines. The springs always come from the line of junction of the sand with the clay.

At this exit a quite remarkable chemical action takes place at times. The ferruginous material of the clay and sand is decomposed. A more or less abundant formation of yellow ochre results, and is carried away by the spring-waters. The numerous bog-plants which grow abundantly in these places undoubtedly have a great deal to do with these chemical actions.

This formation of *limonite* is particularly noticeable in the upper portion of Mistouc River, along the Rivière des Aulnets and also along Bear River. But the most remarkable place in this respect is at the source of one of the tributaries of the Aux Vases River, where there is a small vale surrounded on three sides by sandy swamps. Water rises in abundant springs, escaping in several small brooks, the union of which constitutes one of the principal tributaries of the Aux Vases

River. The ochre formed on the brow of the hill is carried away by the water and is deposited in the lower portion. There is then a deposit of oxide of iron the thickness of which varies from three to twelve feet in an area of more than twelve arpents in length and five or six in breadth. The surface portions are of a rusty yellow colour, but this colour disappears at a certain depth and assumes a greenish-brown hue. This ochre holds but little silica and could be obtained with great facility.

From the Terres Rompues going up the Saguenay, the clay deposits have no longer that uniform evenness found below. However, they remain stratified throughout, but have been ploughed and denuded by the waters to such an extent that their primitive surface is entirely gone. They are only argillaceous or arenaceous hillocks inserted between Laurentian hills. At Gervais Rapids the general surface becomes regular and remains so to Lake St. John. However, the immediate neighbourhood of the *Décharge* and Lake Kenogami is always more disturbed than the remote districts, which proves that the waters extended over the country in large volume when the lake basin was narrowing in at the close of the Champlain epoch.

When all the terraces of Lake St. John are examined together, a fact immediately strikes the observer. It is that these terraces are much more elevated on the south-eastern shore of the lake than in any other place. At Héberville, for instance, they are nearly 200 feet above the level of the lake. From this, as a central point, their level lowers usually almost imperceptibly as far as St. Prime on one side and Grammont on the other.

This fact appears to me to be capable of interpretation in two ways. It may be that the elevation which marked the close of the glacial inundation was felt to a greater extent in that part of the shore than elsewhere. Or else, the phenomena of erosion may have been felt more, near the *Décharge* and at the opposite extremity, near the Ashuapmouchouan, so as to remove the greater portion of the areno-argillaceous terraces. The former explanation seems to me to be preferable, inasmuch as there is not seen at the surface of the terraces of the Grammont, the *Décharge* and Riviere à la Pipe that deep ravine-cutting which ought to have taken place there as they did lower down, along the *Décharge*, where the waters have acted powerfully. The north-eastern shore of the lake between the *Décharge* and Péribonka should, however, be examined in detail before adopting this conclusion as final.

The rivers which flow into Lake St. John from the north carry with them a great quantity of sand, produced by the rapid decomposition of the hills which border their upper portions. These sands are first spread out in the lake and tend to fill it continually. They are very different from the quaternary sands proper, seeing that they contain a considerable quantity of garnets and of magnetite.

The sandy masses are still accumulating into narrow ridges upon the shore of Cochon River as far as St. Jerome. The wind which plays the principal part in the formation of these, acts as a sifter. The garnets and magnetite, which are very heavy, remain near the water, whilst the lighter quartzose grains are driven into the interior, toward the summit of those ridges or *dunes.* These reach a height of 190 feet in some instances. Beyond these arid hills the soil is argillaceous and fertile, being part of the ordinary quaternary terraces.

J. C. K. LAFLAMME.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

OBSERVATIONS

ON THE

GEOLOGY, MINERALOGY, ZOOLOGY AND BOTANY

OF THE

LABRADOR COAST, HUDSON'S STRAIT AND BAY.

BY

ROBERT BELL, M.D., LL.D., B.A.Sc., F.R.S.C.

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MONTREAL.
DAWSON BROTHERS.
1884.

OTTAWA, 24th November, 1884.

A. R. C. SELWYN, LL.D., F.R.S.

Sir,—Herewith I beg to submit my Report as Geologist and Naturalist on the Hudson's Bay Expedition, sent out by the Government of Canada during the present season.

I have the honour to be,

Sir,

Your obedient servant,

ROBERT BELL.

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The question of sending a party by sea into Hudson's Bay, for scientific purposes, at the expense of the Government, has been before the public of Canada for some years. Without entering into the subject of the various useful purposes which it was believed such a party might accomplish, it may be stated that the main object of the expedition, sent out by steamship the present season, was to establish six observatory stations on the shores of Hudson's Strait. The parties to be left in charge of these stations were to remain one year and to keep regular meteorological records, and to note all seasonal events, especially with regard to the condition of the strait itself in winter, the tidal phenomena, &c., all with a view to throw additional light on questions regarding the navigation of these waters. If time permitted, after having built the stations, the vessel was to visit certain parts of Hudson's Bay. Without interfering with the above mentioned objects, the expedition would afford an opportunity for obtaining much desirable information in regard to the geology and mineralogy and the zoology and botany of the places which might be visited. The writer, who had been on Hudson's Bay in previous years, and who had already passed through the strait (see Report of the Geological Survey for 1879-80), was selected for this duty, and also to act as medical officer to the expedition. I also acted as taxidermist and photographer for geological purposes, and provided myself with the instruments necessary for various methods of surveying, in case opportunities for using them should occur.

Objects of the expedition.

The expedition was essentially a meteorological one, and Lieut. A. R. Gordon, R.N., of this branch of the public service, was selected for the command; and the general management fell within the province of the Department of Marine. Notwithstanding that I had neither men nor boat at my command, I managed, while the stations were being built, or while the ship was taking in ballast, to get ashore with the boats that were passing backward and forward between the vessel and the land, and in some cases I had the use of a boat and the assistance of officers and men, both of the expedition and of the ship's company.

The following letter from the Deputy Minister of Marine, in reply to one from Dr. Selwyn, will best explain my position with regard to the facilities to be expected:

"Department of Marine and Fisheries,

"Ottawa, 20th June, 1884.

"Sir,—I have to acknowledge receipt of your letter of the 18th instant, making certain enquiries in regard to the Hudson's Bay Expedition and the employment of Dr. Bell, and in reply I am to inform you that the vessel will sail from Halifax about the 21st of next month. Nothing beyond board and berth accommodation can be given Dr. Bell, the vessel being chartered to the Department, and no special accommodation being guaranteed, but space will doubtless be provided sufficient for the storage of any specimens, &c., which Dr. Bell may collect or the stores provided for the preservation of the same. With reference to your enquiry as to what assistance, as regards men and boats, can be provided for Dr. Bell's work, I have to inform you that Dr. Bell will have the opportunity of landing at every place at which the vessel may call, and every facility will be given him which the officer in charge may consider he is able to afford without prejudicing the primary objects of the Expedition, but no special boat or crew can be furnished for Dr. Bell's use. I am also to inform you that it is the intention that the vessel shall return this fall, but it is impossible to state positively that she will. I am also to state that no charge will be made for Dr. Bell's maintenance while on board the vessel.

"I am, Sir,

"Your most obedient servant,

"W. SMITH,

"*Deputy Minister of Marine, &c.*"

A. R. C. Selwyn, Esq., LL.D., F.R.S.,
Director Geological and Natural History Survey.

Report of Lieut. Gordon.

The route followed by the expedition, in going out and returning home, together with a full narrative of occurrences, will no doubt be given in the report of Lieut. Gordon to the Minister of Marine; but in order to make the present report intelligible by itself, it will be necessary for me here to give a brief sketch of the round voyage.

The vessel which had been chartered by the Government for this service was the steamship "Neptune," belonging to the Messrs. Job Brothers, of St. John's, a wooden vessel of 684 tons burden, which had been built and fitted for the seal fishery. She was navigated by Captain William Sopp, as sailing master, and a competent staff of officers and men. We sailed from Halifax on the 22nd of July, our course lying between Cape North and Cape Ray, and through the Gulf of St. Lawrence and the Strait of Belle Ile. We anchored for an hour at Blanc Sablon, on the north shore, but did not land. On the way up the Labrador coast, we called at Ford's Harbour, Nain and Natchvak, for the purpose of engaging an Eskimo interpreter, which we succeeded in doing at the last named place.

Observatory stations, and routes followed.

The first station was built on the north-west point of the promontory between Ungava Bay and the Atlantic, or near Cape Chudleigh. The second station was to have been placed on the southern or western part of Resolution Island, but we did not succeed in finding a harbour on these shores, and could not land on account of the stormy weather; but we got a near view of the west coast of the island, and also of some of the Lower Savage Islands. We therefore proceeded to the locality which had been determined on for the third station, and found a suitable place on the south side of Big Island, which is just west of the Upper Savage Islands, at an inlet about two miles east of North Bluff. We next crossed the strait to Cape Prince of Wales, south south-west of North Bluff, and erected a station on the shore of the bay, inside of the cape, or on its eastern side. From this place we next made the south point of Nottingham Island, and established a fourth observatory. Again crossing the strait in a southerly direction, we passed close to Digges Island, and coasted down the eastern side of Mansfield Island, looking for a suitable place for another station, but without success. The south-east shore of Southampton Island was also coasted for some distance, after which we traversed the northern part of Hudson's Bay to the entrance of Chesterfield Inlet. We did not land in this neighbourhood, however, but turned south, and called at Marble Island, where we anchored and spent one day ashore. From this island we made Cape Churchill, and then entered the harbour of the same name, at the mouth of the Churchill River. A short visit was paid to York Factory, from which we recrossed Hudson's Bay to Digges Island, where a fifth station was built. On our homeward voyage through Hudson's Strait, we visited all the other stations in the reverse order in which they had been established. Another attempt was made to stop at Resolution Island, in order to build a station, but again without success. It was then decided to place the party intended for Resolution Island at Nachvak Inlet, and we called there for this purpose and to leave our Eskimo interpreter, on our way to St. John's, which we reached on the 11th of October, and immediately handed the ship over to her owners, four days before the date fixed for the expiration of the charter. On the morning of our arrival at St. John's, we happened to catch a steamer for Halifax, and so were enabled to continue our homeward journey without an hour's delay.

Nature of information obtained.

Before proceeding to give details of my special work, I may say that at every place we visited I obtained as full notes as my opportunities would permit in regard to the geology and mineralogy of the surrounding country. I also endeavoured to obtain from the natives information as to the occurrence of useful minerals, which, although not very definite, may in some cases lead to valuable discoveries. The Eskimo are intelligent and good observers, especially of such matters as affect their own mode of living and although rocks and minerals would not be expected to interest them much, still I found that in some instances they had taken notice of them. In order to facilitate enquiries, I had provided myself with a collection of all the ores, minerals and rocks which might be expected to occur in the regions we were to visit, and on allowing the natives to inspect them, they would point out those which they thought similar to certain kinds which they had noticed in their own districts. An interesting feature in the geological phenomena of these northern regions, is that a study of them will assist us in the elucidation of the superficial geology of the more southern portions of the Dominion, which forms so important a branch of the work of the Geological Survey.

Zoology.

In regard to zoology, efforts were constantly made to collect specimens in every class of animals and to obtain new information on all points with reference to them. Upwards of fifty specimens of mammals and birds were obtained, of which a portion were from Dr. Matthews, of York Factory. Some of these are rare and will prove to be very useful and interesting additions to our museum. Many notes were made on the habits and distribution of the mammals and birds. Attention was paid to the fishes and their food and to the subject of possible fisheries in these regions. A variety of molluscs and other invertebrates was secured by dredging. As we were living mostly on shipboard and in so cool a climate, but little could be done for the science of entomology. A small collection of butterflies and moths from the shores of Hudson's Strait have been identified by Mr. H. H. Lyman, a well known entomologist in Montreal. (Appendix V.) One of the missionaries on the Labrador coast has kindly promised to collect the Lepidoptera of that region and send them to me next year.

With regard to botany, as complete a collection of plants as possible was made at every place we touched at. These are in the hands of Professor Macoun and a catalogue of them will be found in Appendix I. Some new facts of interest in regard to the ranges of forest trees in the Labrador peninsula and the country west of Hudson's Bay were ascertained from persons acquainted with these regions. Botany. Forest trees.

In addition to the technical assistance already acknowledged above, I take this opportunity of mentioning that Professor C. Hart Merriam has kindly aided me in making out from my descriptions, the local names, &c., with which he is familiar, the list (Appendix II.) of the seals of Hudson's Bay and Strait. I may mention that Professor Merriam, who is justly regarded as a high authority on the Pinnapedia, has himself gone to the Newfoundland and Ladrador seal fishery, and travelled in the Gulf of St. Lawrence for the express purpose of studying these animals. It would appear from my observations that we have, in both Hudson's Bay and Strait, all the kinds of seals found at any season either in the gulf or on the coast of Newfoundland and Labrador; and from all that we could learn, both seals and walruses are abundant in the strait and the northern parts of the bay. But in order to obtain them in large numbers for commercial purposes, their various resorts and the course of their migrations at different seasons of the year would require to be studied. The gentlemen in charge of the observatory stations were instructed to attend to such matters, and their notes will probably throw some light on the subject in the particular localities at which they are stationed. In the list of fishes, I have included species which I had in previous years ascertained to exist in Hudson's Bay or the waters immediately connected with it. Mr. Lucien M. Turner, who has spent two years in the Ungava district in the interest of the Smithsonian Institution, has kindly determined some of the fishes which I collected, and added the names of others which he found in the district named. Assistance received from Professor H. Merriam. Seals. Mr. L. M. Turner.

I secured about sixty-five photographs of a uniform size of 8 by 5 inches. These are illustrative of subjects of interest in connection with the expedition, of the nature of the country and more especially of points bearing on its geology. Photographs.

I shall confine myself in the following pages to the subjects above referred to, as all others connected with the work of the expedition will probably be fully reported on by Lieut. Gordon. In regard to the arrangements to be adopted in this report, it has been considered best to state the facts and observations in the order in which they were noted, and in connection with them to give other information, bearing on the subjects referred to, which may have been gathered in previous years.

As already mentioned, we anchored for an hour at Blanc Sablon on the morning of the 26th of July. Here the horizontal strata of the Lower Silurian series form a conspicuous feature in the landscape. They are described at pages 287 and 288 of the *Geology of Canada* as consisting of 231 feet of red and grey sandstones and fine conglomerates forming the lower part of the section, with 143 feet of grey, reddish and greenish limestones resting upon them. In Forteau Bay, a short distance east of Blanc Sablon, a considerable collection of fossils was made in these limestones by the late Mr. James Richardson, which proves them to be equivalent to the Red Sand-rock of Vermont. The Laurentian gneiss may be seen cropping out from beneath these sandstones at and near the sea shore, while the hills of the same formation rise above the level of the summit of the horizontal strata all along in the interior.

Castle and Henley Islands.

At the entrance to Chateau Bay on the Labrador side of the Strait of Belle Ile, opposite to the northern extremity of Newfoundland, are two islands, called Castle and Henley's Islands, which are capped by flat basaltic summits, the former being 200 feet above the sea.† They form a striking contrast to the prevailing character of the shore rocks, which everywhere else in the neighbourhood appear to be of Laurentian gneiss. Later in the season I was informed that some men had been mining mica on the shore of this bay, and in the autumn had brought about one ton of the mineral to St. John's, on the way to Boston or New York, but that the plates did not exceed three by six inches in size, and that they were of a rather dark colour.

High mountain range.

After passing the Strait of Belle Ile, the Labrador coast continues high and rugged, and although there are some interruptions to the general rule, the elevation of the land near the coast may be said to increase gradually in going northward, until within seventy statute miles of Cape Chudleigh, where it has attained a height of about 6,000 feet above the sea. Beyond this, it again diminishes to this cape, where it is 1,500′. From what I have seen of the Labrador, and from what I have been able to learn through published accounts, Hudson's Bay Company's officers and the natives, and also judging from the indications afforded by the courses of the rivers and streams, the highest land of the peninsula lies near the coast all along, constituting, in fact, a regular range of mountains, parallel to the Atlantic sea-board. In a general way, this range becomes progressively narrower from Hamilton Inlet to Cape Chudleigh.

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† These are probably outlying remnants of extensive lava streams of Lower Cambrian age like those of Lake Superior, Lake Nepigon and the east coast of Hudson's Bay.—A. R. C. SELWYN.

The distance from the Strait of Belle Ile to Cape Chudleigh, along the Labrador coast, is 760 English statute miles. This is divided into three principal courses, as follows: From Belle Ile to Porcupine Bay, due north (true), 120 miles; from Porcupine Bay to Nain, north-west (true), 290 miles; from Nain to Cape Chudleigh, north north-west (true), 350 miles. The coast-line is everywhere indented by inlets or fjords, and fringed with islands of all sizes, from mere rocks up to some measuring twenty-five miles in length. Most of the fjords are narrow and about twenty-five miles long; several are thirty-five miles, and Hamilton Inlet runs in from the open sea a distance of 160 miles. The general bearing of the fjords is at right angles to the coast line in the neighbourhood. In a great many cases the islands are separated from one another, or from points on the mainland, by very narrow straits, with deep water, which have received the name of "tickles." With regard to the condition below the level of the sea, it is stated in the *Newfoundland Pilot*, published by the Admiralty, that the shores from Davis' Inlet to Nachvak are comparatively free from reefs and sunken rocks, but that from Nachvak to Cape Chudleigh they are fringed with inlets and rocks, to an average distance of five miles out. The coast of Resolution Island seems to be similarly studded with these impediments to navigation, and these circumstances appear to be connected with certain geological conditions, which will be referred to further on.

Belle Ile to Cape Chudleigh

Fjords.

In approaching Ford's Harbour, which is on the eastern point of Paul's Island, the islands near which we passed consisted of bare rock, and although usually high and steep, they had rounded or glaciated outlines. Numerous perched boulders lay about, either singly or in groups or rows, on the naked surface of the rock, wherever they could find a resting place. A short distance off the entrance of the harbour, we passed an island which, on the top and one side, was literally piled with rounded boulders. On this island I noticed a dyke of trap about 100 feet thick, cutting the gneiss in a west-north-westerly direction. On going ashore at Ford's Harbour, I found the gneiss to consist of common reddish and greyish varieties, some parts of it massive and others more finely and distinctly laminated. The average strike was south-east (true). The glacial striæ were quite distinct in many parts, but were best preserved near the shore. They run in two principal directions, S. 45° E., and S. 80° E. (mag.) Perched boulders were observed on all the surrounding hills. In going from Ford's Harbour to Nain we followed the channel on the north side of Paul's Island. The rock appeared to be dark, massive and crystalline.

Ford's Harbour and Nain.

Trap dyke.

Our stay at Nain was so short that I had only time to examine the high ridge or mountain to the north and north-west of the Mission Station. The first shoulder of this ridge, we were informed, has a height of 875 feet above the sea, but the summit, a short distance further inland, must be at least 200 feet higher. The rock here consists of a rather light grey gneiss, which strikes S. 45° E. (mag.) The glacial striæ, which were seen with greater or less distinctness, all the way to the summit, run S. 65° E. (mag.) or about parallel to the valley which extends inland from the head of the fjord up which we had sailed to Nain, and with the same general bearing. Well rounded boulders were scattered over the flanks and summit of this high ridge; and they were quite prominent on the high bare hills on both sides of the inlet, all the way from Ford's Harbour. The appearance of the top of this mountain, with the boulders resting on the bare, sloping rock, is shown in one of the photographs taken at this spot. Mountains of equal and greater height were seen in all directions from this summit, except towards the eastward, where they die down to the sea level in the distance. On the next hill to the north-west, the weathered surface of the rock showed a rusty belt of a brownish colour, and of considerable extent, which was supposed to be due to iron pyrites. I was informed by the Moravian missionaries at Nain that the labradorite of this part of the coast is to be found at different places on Paul's Island, and at a fresh-water lake called Nunaingok, which lies at no great distance inland from the head of a bay to the north-westward of Nain. They said it was also reported to occur on a bay a short distance to the southward. I had not an opportunity of visiting any of these localities, but from specimens which I have seen, I have little doubt the mineral occurs as veinstones, in which there are also crystals of pyroxene, iron pyrites and magnetic iron. In this connection it may be mentioned that I have seen a large specimen of coarsely crystalline labradorite rock from Hamilton Inlet, in which some of the faces showed a blue iridescence. The rose-red variety of anorthosite, called latrobite by Gmelin, is stated to come from an island called Amitok, on the old charts of the Labrador coast, about forty-five miles northward from Nachvak. When at Nain I obtained specimens of amazon stone, which the Eskimo told me came from Port Manvers, and of paulite, a variety of pyroxene or hypersthene, which has also been called "Labrador hornblende" and "metalloidal diallage." It was said to have been brought from Paul's Island. Mr. John Ford informed me that yellow mica, in flakes about the size of one's hand, was found on this island, about two miles north-westward of Ford's Harbour. In regard to the rocks and minerals of the Labrador coast, the following notes may be here given: I have received specimens of copper pyrites in a dark slate, which were labelled as having come from Indian Island, on the north side of the entrance of Hamilton Inlet, and I have been otherwise informed that slates or schists occur in that neighbourhood. A

Labradorite.

Amazon stone and paulite.

man from Nova Scotia stated to me that he had been engaged, with others, two years ago, in mining copper and lead ores on Deadman's Island, which is situated a few miles north of Hamilton Inlet. They occurred in a vein between a rock like granite and a sort of sandstone or quartzite. Mr. King, the second mate of the "Neptune," said that copper ore was also found at Iron-bound Island or "Makoubik" (probably Makkovik of the chart) not far from Cape Harrison. One of the gentlemen we met at Nain informed me that he had heard of copper ore being found somewhere to the southward of that place, but was not aware of the locality. These circumstances point to the possible occurrence of deposits of copper in quantities of economic value on this coast. It is well known that productive mines of copper were in operation for a number of years on the adjacent coast of Newfoundland.

Ores of copper and lead.

At Nain I noticed some freshly split slabs of a grey felsitic slate, which were being used as flag stones, and, on inquiring, was informed that they had been brought from Ramah, in the bay next south of Nachvak, where there was said to be plenty of this rock in situ. The name of the bay is Nullataktok, or Slate Bay. Our Eskimo interpreter, Lane, who was well acquainted with this bay, afterwards informed me that slaty rocks were abundant there.

While at Ford's Harbour and Nain I collected as many plants as the limited time would permit, and Professor Macoun's list of them will be found in appendix I. The Rev. Dr. S. Weiz, who had long resided at Nain, had made a collection of the plants of the vicinity, which he had submitted to some of the leading botanists of Europe, who had attached the proper name to each specimen. He kindly allowed me to make a list of these and it is also given in appendix I., in one of the columns of the general list.

Plants collected at Ford's Harbour and Nain.

Although timber disappeared from the outer coast before reaching Nain, yet groves of trees may be seen in the valleys and on the more favourable slopes at the heads of the inlets, and we were informed that after going ten to twenty miles inland from Nain, or from the coast for a considerable distance north of it, the whole country may be said to be wooded as far as the condition of the surface will permit of the growth of trees, and that in favourable situations the spruce and tamarac attain a sufficient size to be sawn into lumber. At Nain, the trees consist of spruce, tamarac, and small willows, but at no great distance inland, balsam fir, poplar, white birch and rowan begin to make their appearance.

In the gardens at Nain I observed the following vegetables: potatoes (a variety with low, flat, spreading tops), turnips, carrots, beets, cabbage, scotch kail, a very rank variety of spinach, lettuce, peas, beans

Vegetables at Nain.

and onions. There was also a great variety of flowers. The peas and beans were arranged so that they could be protected by glass if requisite, and the potatoes were planted in narrow beds, arched over with bent rods, so that long sheets of coarse canvas could be thrown over them on frosty nights.

Nachvak Inlet. Leaving Nain, our next stopping place was the Inlet of Nachvak, about 140 miles south of Cape Chudleigh. This inlet or fjord, with an average breadth of from a mile to two miles, runs in from the open sea a distance of about forty statute miles. The water in it is very deep, and the mountains on either side immediately overlooking it rise to heights of from 1,500 to 3,400 feet, but a few miles inland, especially on the south side, they appear to attain an altitude of 5,000 to 6,000 feet, which would correspond with the height of The Four Peaks, near the outer coast-line, about midway between Nachvak and Cape Chudleigh. The mountains around Nachvak are steep, rough sided, peaked and serrated, and have no appearance of having been glaciated, excepting close to the sea-level. The rocks are softened, eroded and deeply decayed. On precipices and steep slopes the stratification is well brought out by the weathering, so that the dips may be distinctly seen. The mountains on the north side proved to be mostly Laurentian gneiss, notwithstanding their extraordinary appearance, so different from the smooth, solid and more or less rounded outlines of the hills composed of these rocks in most other parts of the Dominion. On the present occasion we stopped only at the Hudson's Bay Company's post, at a narrow part of the fjord, about twenty miles in from the open sea, and I had a few hours to examine the rocks, collect plants and take photographs in the neighbourhood. But in returning, in the month of October, we stayed for several days at a bight on the north side, a few miles from the entrance, where we placed a station, and named the place Skynner's Cove. This enabled me to extend my explorations of the neighbourhood, and I shall now state the results of my observations on both occasions.

On the south side of the inlet at the Hudson's Bay Company's post, an escarpment rises to a height of 3,400 feet, as ascertained by Commander J. G. Bolton, R. N., but I had not time to visit it to determine the nature of the rock. A brook, which gathers its waters from higher ground further back, but which is not visible from the post, precipitates itself from the top of this great precipice in an almost perpendicular fall. The rock on the north side at this place consists of reddish gneiss, somewhat contorted and occasionally interstratified with dark micaceous layers. Two or three miles east of the post a good sized brook falls, in several almost perpendicular leaps, a height of 300 or 400 feet over these rocks. The strike of the gneiss in the neighbourhood of the falls is S. 35° W. (true.)

British American Bank Note Co. Montreal

VIEW, S.W. FROM THE HUDSON'S BAY COMPANY'S POST IN NACHVAK INLET, LABRADOR.

At a point on the north side, estimated to be about nine miles from the open sea and eleven from the post, opposite to a bay on the south side, a mountain rises steeply to a height of 1,500 or 2,000 feet. It is composed of gneiss standing vertically and striking N. 25° W. (true), cut diagonally by a great many dykes of dark trap all underlying westward at an average angle of about 30° from the perpendicular. Some of them run together and others appear to die out in both directions on the cliff section. Some dykes of close-grained, almost black diorite, also cut the gneiss in the vicinity of Skynner's Cove. From the point above named to Skynner's Cove the rock along the north side appears to be all gneiss with a variable strike in different parts. Around this cove there is a variety of micaceous, and hornblendic schists passing into thinly bedded gneiss. The average strike is about S. W. (true). I was informed by our interpreter, whose home is on the south side of the inlet, that the Eskimo obtained a kind of soapstone for making their pots, in the vicinity of Skynner's Cove, before they were able to procure others of metal. Along the northern part of the entrance to the inlet or about North Head of the chart, the rock is a coarse, dull red, syenitic gneiss. At one place it encloses a mass, like a bed, of nearly white quartzite marbled with small elongated gray patches, but it appears to be cut off as it runs up the slope, although another exposure of white rock was seen some distance off in a north-easterly direction. Here the glacial striæ were seen on projecting points near the water, running with the axis of the inlet or about east. At Mount Razor-back, which forms the outer point on the north side of the Nachvak Inlet the stratification is well seen, the dip being to the southward. The angle of dip on the outer or eastern part of the mountain is almost 60°, but this diminishes to 45° and finally to less than 10°. in going to the south-westward. Several large but somewhat irregular dykes of black-looking rock cut the strata of the mountain side at right angles to the dip in its varying inclinations.

Soapstone.

Trap dykes.

On the opposite or south side of the entrance of Nachvak Inlet, the dip of the bedding is S.S.W. (true), and the inclination, generally from 35° to 40°, but at one part it is 60°. Dykes were seen all along, cutting the face of the mountain range and running in a south-easterly direction.

On the west shore of the first cove, from the entrance, on the south side of Nachvak inlet, the rocks consist of a coarse-grained slaty tufa or breccia, thickly studded with grains of quartz-opal. To the north, this passes into a sort of coarse cleavable grey syenite, which could be traced for two miles westward along the shore; while to the south of it is a coarse grey mica schist, running N. 25° W. (mag.) vertical. In this rock, and near the slaty breccia, a vein of quartz was found, from a foot to two feet in thickness, and holding patches of brown-weathering calcspar. The rocks in the mountain, overlooking the south side of the inlet, opposite Skynner's Cove, have a slaty appearance, with some great bands of a light color and more solid aspect, the outcrop running nearly horizontally for some distance. I was unable to visit these bands, but our interpreter brought me a specimen, which he said he had broken off one of them, and which proved to be a fine-grained light grey, silicious schist, which makes excellent hones. These and the other rocks on the south side of the inlet in this neighborhood, which have just been described, as well as a part of those on the north side, may belong to the Huronian series. Slaty rocks have been mentioned as occurring at Ramah, in the inlet, about twenty miles south of Nachvak. From the specimens which I have seen, these are probably of the same age, and they may be connected as one area with the supposed Huronian strata of Nachvak.

Huronian rocks.

We were informed, both by Mr. George Ford, the agent of the Hudson's Bay Company at Nachvak, and our Eskimo interpreter, that at a short distance beyond the more distant mountains, seen to the west of the company's post, the country falls rapidly on the inland side, and soon becomes comparatively level. This description agrees with other accounts of the interior of the Labrador in the Ungava district. A wide level tract embracing the country drained by the George, the Whale and the Koksok, South, Big or Ungava Rivers, is said to extend southward a long distance from Ungava Bay. The surface is said to be covered with a wet, peaty moss, growing upon barren sand, with the solid rock everywhere at a short depth beneath. The rivers and brooks are fringed with spruce and tamarac trees, but very little timber is to be met with between them. The mouth of the Ungava River is 155 miles south-west of Cape Chudleigh. In going by sea, from one to the other, Commander Bolton says, in the Newfoundland *Pilot*: "The highland of the Labrador shore could be seen towering above the scarcely discernible shore of Ungava Bay, for the first sixty or seventy miles." The Ungava River is navigable for sea-going vessels to a point three or four miles above the Hudson's Bay Company's post, Fort Chimo, and boats may ascend it for seventy or eighty miles. The river is from one-quarter of a mile to a mile and a-quarter in width. Its upward course is S. by E. (true), and it passes through a barren undulating country. Spring tides at Fort Chimo rise 38½ feet, and the rapid currents produce dangerous whirlpools. Salmon frequent the rivers of Ungava Bay in great numbers, and for some years the Hudson's Bay Company have annually sent a cargo of them, in a frozen state, by a small steamship, to the London market, in addition to a considerable quantity of the salted fish. Besides salmon, the trade of this post consists of furs, seal

Level country inland.

Tides.

and white porpoise oil, and deer skins, and is carried on with the Eskimo of the coasts, Cree Indians from the south-western interior, and Nascopie Indians from the south-eastward.

Spruce timber begins to be met with, according to all accounts, about thirty miles to the south-west of the Hudson's Bay Company's post at Nachvak. The tamarac follows a short distance further south. To the westward of Nachvak, the northern limit of the spruce, according to Capt. William Kennedy, reaches the shore of Ungava Bay, north of the George River. On the western side of this bay the Eskimo informed me it begins to be found in the neighbourhood of Bay of Hope's Advance, or five days' journey south-eastward of Cape Prince of Wales, on the south side of Hudson's Strait, and that in this neighbourhood it was found further north in the interior than on the coast. In addition to spruce and tamarac, balsam-fir, canoe-birch, aspen and balsam poplar are reported, on good authority, to exist in the interior of northern Labrador, but at some distance further from the coasts of the Atlantic and the strait than the first mentioned. Spruce timber.

On the East-main coast of Hudson's Bay the northern limit of the spruce was found to be a few miles north of Richmond Gulf, but it was reported to extend much further north at a distance inland from this coast. On the west side of the Bay it was seen in considerable quantities all along the coast, from Cape Churchill to Button's Bay, and Mr. George McTavish, who has made several coasting voyages to the north, and who, at my request, has kindly made observations and collected information from the natives in regard to the distribution of timber, informs me that it leaves the shore about twenty miles beyond Seal River. He was told by the Eskimo of these parts, who travel a good deal in the interior, that spruce timber begins to be met with at two days (say fifty-five miles,) west of the mouth of Big River, and that it is considerably further inland, opposite to Eskimo Point, which is about in latitude 61° 40′. From this neighbourhood it runs west-north-westward and crosses the Coppermine River about twenty miles from its mouth, and thence reaches nearly to the mouth of the Mackenzie River.

On leaving Nachvak, we sailed up the coast, passed round Cape Chudleigh, through Gray's Strait, which is between it and the Button Islands, and entered Ungava Bay. According to the chart and the *Newfoundland Pilot*, the cape rises to a height of 1,500 feet above the sea, and the highest point of the Button Islands has an equal elevation. The outlines of these islands and of the southern shore of Gray's Strait, although bold and steep, are rounded, as if they had been glaciated. At the west end of the south-eastern island of the Button group a great rock has been excavated into the form of a half arch, which rises out of the water and rests, at its summit, against the cliff Cape Chudleigh.

which forms the extremity of the island. The rocks of the islands and the south side of the strait appear to be all gneiss.

On the Ungava Bay side of Cape Chudleigh we entered an inlet about ten miles southward of the extremity of the land, and discovered a harbour on its north side, which we named Port Burwell, after Mr. H. W. Burwell, the gentleman who was left in charge of the station (No. 1) which we built here. The hills, for a few miles around Port Burwell, are only moderately high and are not generally steep. Their outlines are rounded and their rocky surfaces have scattered upon them numerous boulders as well as finer rocky *débris*. The rock everywhere consists of ordinary varieties of gneiss, the commonest of which are massive reddish and dark hornblendic and micaceous. The strike at the Port varies from N. 20° E. to N. 40° E. (mag.) The glacial striæ at the observatory station run S. 35° E. (mag.), but among the hills in the neighbourhood they were observed to follow the trends of the valleys with a general south-eastward course by the compass. A short distance south of the station, a vein, varying from 8 to 13 inches in width, occurs in the gneiss. Its direction corresponds nearly with the strike, which is here N. 20° E., running with the stratification for a short distance, breaking across to other beds, following them for a short distance and then jogging off to others. It consists of light grey dolomite and white quartz, holding a little iron pyrites and some crystals of quartz, rendered ruby-coloured by a layer of oxide of iron under the faces.

Port Burwell.

Mineral vein.

From Port Burwell I explored the inlet to the south-eastward, and found it to be a strait dividing into two branches at five miles from the Port, the northern of which was ascertained to run through to the Atlantic. The Eskimo whom we met in this strait informed us (through our interpreter) that the southern branch also continued through to the ocean. They also told us that there was no other channel to the south of this between Ungava Bay and the sea to the east. We named this newly found channel McLelan's Strait, in honour of the Minister of Marine and Fisheries, and the north-west point of the mainland, Cape William Smith, in honour of the Deputy Minister. At six miles from Port Burwell, the northern part of McLelan's Strait has contracted to half a mile in width, and has become flanked by high and steep hills, rising from either side. The tides, which at springs have here a rise and fall of upwards of twenty feet, run with great velocity through this narrow part. The locality is called Nunaingok by the Eskimo, which means the "hidden place," and the same name is applied to one or two other localities on the Labrador coast. In proceeding from Port Burwell to Nunaingok, our course was S. 5° E. (mag.) or S. 55° E. (true), and the country on

McLelan Strait.

either side of McLelan's Strait showed less and less evidence of glaciation. Even close to the shore, in approaching the higher hills which begin at Nunaingok, the gneiss is deeply decayed, the softening process having extended, particularly along the joints which run both vertically and horizontally, leaving only hard kernels with a more or less rounded outline, between them. Nunaingok is situated on an alluvial flat, extending between the two branches of the strait. The hill which rises steeply on the south side of it is about 700 feet high; but further in, between the branches and on either side of them, the mountains are from 1,500 to 2,500 feet high, and have rugged tops and sides. Rounded boulders were found scattered all over the side and top of the hill just referred to; but although it had probably been somewhat glaciated, it had not been planed down to hard surfaces, but had an irregular outline, and the rocks were much disintegrated. Among the transported boulders and pebbles scattered over its surface, some of brecciated drab limestone with clear quartz grains, pinkish red sandstone, red jasper and magnetic iron, were noticed. Fragments of grey, drab and yellowish limestone, with obscure fossils, were common around the base of the hill. The glacial striæ were well seen on the southern side of the hill referred to, where, in one case, they were observed to groove longitudinally a vertical wall, and even the under side of an overhanging shelf of rock. The general direction was S. 25° E., or with the course of the south branch of the strait.

Fossiliferous Limestone fragments

The fixed rocks around Nunaingok, as far as I had the opportunity to examine them, were all gneiss, the average strike of which was N. W. (true.) On one of the mountains on the north side of the northern channel a wide belt of brown, iron-stained rock runs diagonally through the ridge, the colour being probably due to the decomposition of iron pyrites, but I had not time to visit the place.

Eskimo village

At Nunaingok, on top of a bank of sandy earth, are the remains of an old Eskimo village. The roofs of most of the underground houses had fallen in, leaving only large circular pits. Some of these had become partially filled up, showing great antiquity. A few of the newest of them had been inhabited within a year. Some Eskimo camped in the vicinity informed us, through our interpreter, that this had once been a comparatively populous village, and a resort of their people as far back as their traditions extend. It is their custom to live in the underground houses from the commencement of winter, some time in November, till January, after which they leave them and spend the rest of the winter in igloes or snow houses. The water in the north branch of McLelan's Strait, they informed us, is open all winter at this point, and is much frequented by seals, which afford them a reliable supply of food. These animals they kill either from their kyaks or by spearing them from hiding places which they have built of stones on every ledge and point of rock past which the seals are accustomed to swim. Great numbers of bones of seals, walruses, reindeer, foxes, hares, birds, &c., lie scattered about on the surface and mixed with the earth around the old dwellings. The remains of stone pots and implements near others of European manufacture showed a transition from the barbarous to a civilized condition. I was told by one of the Labrador missionaries, who had had a long experience of these people, that the comforts and conveniences of civilization rendered the Eskimo less vigorous and healthy, and, as a consequence, their numbers are diminishing.

The "Neptune" was anchored in 15 fathoms at low tide in Port Burwell. The bottom was a sandy mud, and was found, by dredging, to abound with shellfish, echinoderms and crustaceans. During our stay, from the 5th to the 8th of August, the water teemed with fine cod, which were taken in great numbers by jigging. Many of them were tolerably large, and they were of excellent quality, contrasting, in this respect, with the cod we had got at Nachvak, Ford's Harbour, and a fishing station on some islets we had passed to the south-east of it. Most of our crew had had more or less experience of the Labrador fisheries in previous years, and the superior quality of the Port Burwell cod was a subject of general remark among them. On our return to Port Burwell we found the fish still abundant on the 27th and 28th of September, and the party in charge of the station informed us that they could catch them any time they chose in the interval. At Nachvak the fishermen began to take cod on the 17th of July, and they were catching them in great numbers at the end of the month. During our stay in Skynner's Cove, in the inlet, from the 30th of September till the 6th of October, we caught as many as desired, by jigging from the ship's deck. From all that I could learn by enquiries along the Labrador coast and from our crew, it would appear that although the dates vary in different years and at different places, the average time for the cod to strike the shores is the middle of July, and that the particular time at any locality depends more on the presence or absence of ice than on its latitude. If this condition happened to be the same all along, the fish would appear at the same time at every part of the coast. This would be the natural inference, since there appears to be no other difference in the conditions which would affect the cod along the whole coast. Bait is used as far north as Cape Harrison, but beyond that the fish are so numerous and voracious that the naked jigger alone is required. The fish are dried on flakes as far as Indian Harbor, but on the more northern parts of the coast they are spread upon the shingle or the smooth, rounded rocks.

Fisheries.

Dates at which codfish arrive on the coast.

Station No. 2 was intended to be placed on Resolution Island, or one of the Lower Savage Islands to the north-westward of it; but after spending part of two days in endeavouring to find an anchorage or a harbour on these islands, the attempt was abandoned until we should be returning after establishing the remaining stations. A near view of Resolution Island was not obtained on this occasion, but the southern shores of the Lower Savages were seen closely enough to determine the rocks to be massive gneiss, of which the prevailing color was red. The iron bound shores of these islands rose abruptly several hundred feet above the sea.

On leaving the Lower Savages we proceeded by the strait to the vicinity of North Bluff, but a long distance from shore, until we came directly opposite to it. We anchored in a bay two miles east of the bluff, which we called Ashe's Inlet, after Mr. W. A. Ashe, D.T.S., who was to have charge of the observatory station (No. 3) which we proceeded to erect on the southern side of the bay.

Rocks of Ashe's Inlet,

The rocks on the west side of Ashe's Inlet consist of dark grey gneiss, composed principally of quartz and felspar in even beds. The general strike, which is pretty uniform, is east and west (true), and the dip, north at an angle of 40.° On the higher levels the surface of the rock is decayed into half isolated boulder-like masses. In the vicinity of the station, on the east side, a common variety of gray micaceous gneiss is met with, striking with regularity to the N.W. (true). A mile to the northward, however, on this side of the inlet, it has become east and west (true), corresponding with the strike on the west side. The country was examined for several miles inland, or what I judge to be about the centre of the (Big) island, and found to consist entirely of common varieties of gneiss, with a prevailing westerly strike. It contains many veins of "hungry" or barren milk quartz. Some of them contain felspar and black mica, giving them a somewhat granitic character. In one of them the felspar, which was white, was observed to be striated. The hills have a rounded sweeping outline, and their summits are a considerable distance apart. The wide even spaces between them hold shallow lakes, surrounded with green meadow-like flats and mossy slopes. Numerous rivulets and brooks run down the hills and discharge the waters of one lake into another. The general aspect of the landscape reminds one of some parts of the Highlands of Scotland. A shallow looking lake, with many stony points, begins about three miles northward of our anchorage, and has a length of three miles. It discharges south-westward into Ashe's Inlet by a wide, rapid and shallow stream, which we called Edith River. The Eskimo informed us that at certain seasons large trout were abundant in this lake and river.

Features of the country.

Around Ashe's Inlet the glacial striæ run about S. 65° E. (true). On the top of the hills the rocks are much weathered and only faint traces of the striæ remain. In these situations ridges of gneiss boulders, with an easterly direction, were occasionally met with. One of them, on a hill a short distance north of the observatory station, has evidently accumulated in the lee of a knob of rock which stands at its western extremity. Among the prevailing gneiss boulders, scattered on the hills and plains, were found several of grey dolomite like that of the Manitounuck group of rocks (Cambrian? See Geological Survey Report for 1877–78, p. 11 c.) and of the soft buff grey dolomite like that of the Churchill River. (See Geological Survey Report for 1878-79, p. 18, c.) I also found a large decomposed boulder which had been made up of coarse radiating crystals of greenish grey hornblende. A bed of the same rock was afterwards found interstratified with the gneiss at Cape Prince of Wales, on the south side of the strait, opposite to Ashe's Inlet. A small piece of greyish crystalline limestone was picked up near Ashe's Inlet, which bears a very close resemblance to a variety common in the Laurentian bands of the Ottawa valley.

Grey dolomite.

Ice in Ashe's Inlet.

Some heavy field ice had drifted into Ashe's Inlet before our arrival there. The Eskimo informed us that this was the first time in their knowledge that such a thing had occurred, and this circumstance afforded us another proof of the unusual abundance of this kind of ice the present summer. Several of the pieces or "pans" were upwards of 20 feet thick, and as the tide has here a rise and fall of more than 30 feet, some of them were left dry at low water and were found to consist of solid blue ice. The outlines of these pans, as seen floating in the sea, more frequently approach a quadrilateral form than any other. This kind of ice was afterwards seen in great quantities around Salisbury and Nottingham Islands in the mouth of Fox's Channel, down which, there appears to be no doubt, all the heavy ice of Hudson's Strait, comes. On reaching the strait, it projects towards the south shore and breaks off in fields of greater or less extent which float up and down with the tide, always working to the eastward, and part of it finally escapes into Davis' Strait. Hudson's Strait, however, being about 500 miles long, the tendency of the wind and tide is to drive much of it ashore, or to imprison it in bays and inlets. Once it has reached such situations, the lee afforded by the high lands often prevents it from being drifted out to deep water again. In this way, during the present season a large quantity of it became fixed in Ungava Bay and detained the Hudson's Bay Company's steamer "Labrador" for twenty-one days, being the first time, I understand, that any detention of the kind has taken place. Mr. L. M. Turner, of the Smithsonian Institution, who was at Fort Chimo at the time, informed us that the thickness of some of these

Source of pan-ice and its movements.

blocks of ice was measured, and in one case found to be as much as 42 feet. Mr. Burwell, at station No. 1, on the west side of Cape Chudleigh, reported that, during August and September, he observed these heavy pans floating south-westward into Ungava Bay, but never returning past his station. At Ashe's Inlet the observer reported that the ice always floated back or westward, a short distance, with each tide, but finally disappeared to the eastward. Some of the heavy ice was stranded about Cape Prince of Wales in the latter part of August and the first half of September, but it had all gone when we re-visited the station here on the 23rd September. At Nottingham Island we observed some of the heaviest "pans" stranded in six fathoms of water, and they would, consequently, be about 40 feet thick.

I tested the ice of the stranded pans in some places, and always found it fresh. This would be the case, notwithstanding that the ice formed in sea water, for most of the salt would be thrown out in the freezing, and what might remain would drain away near the surface on exposure to the mild air of summer. Owing to the somewhat poor heat-conducting power of ice, it is not possible that so great a thickness as 40 feet could form in one winter in Fox's Channel. It is probable that a good many years would be required. In regard to the quantity of ice which has been observed in Hudson's Strait, a study of the experience of the vessels which have navigated these waters, as well as that of the ships of the Moravian Brethren coming to the coast of Labrador, would seem to show that there is a succession of good and bad years, with a minimum, and maximum at perhaps seven or eight years apart, or in cycles of some fourteen or fifteen years; also that there may be a maximum intensity in these cycles themselves, so that perhaps every third one will be more favourable in the minimum of ice and more severe in the maximum than the two intervening ones.

Periodicity of the seasons.

The fact that most of the ice-pans of Hudson's Strait, when not covered with fresh snow, are colored with dust and earth, points to their formation near shore, and also to their remaining there during one summer at least, when the ground is bare of snow and the surface not frozen. The dust appeared to be in too great a quantity to be of cosmic origin. These pans sometimes carry gravel on their backs, a circumstance which was noted in the Geological Survey Report for 1879–80, p. 20 C. When at Ashe's Inlet, a fact was observed which may explain the last mentioned phenomenon. Some tolerably thick ice still remained attached to the shore at high tide mark. During the melting of the snow on the hills above it, torrents had carried a quantity of stones and earth out of an adjacent bank and deposited them upon the surface of the ice. The connection between this ice and the shore being sufficiently weakened, the next spring-tide would carry it out to

Dust, earth and gravel on ice-pans.

sea, as previous tides had already carried parts of the adjoining ice, similarly laden.

Icebergs of Hudson's Strait

The icebergs of Hudson's Strait are of comparatively small size and are or have been mostly flat-topped. The original appearance of some of them has been altered by foundering and canting, which have occasionally been repeated several times, the various positions which the berg has occupied being indicated by water-lines now standing at different angles to the surface. These small icebergs are most numerous along the northern side of the strait, and they have never been observed west of Fox's Channel, out of which they proceed. They are supposed to originate from glaciers on the shores of this channel, but it is possible that they may come through the passages which are believed to run into it from Baffin's Bay and Lancaster Sound, or through Fury and Hecla Straits, in all of which the current is known to set southward.

Frozen soil.

The soil or drift material of Hudson's Strait is probably permanently frozen at a certain depth below the surface, although our interpreter told me it was not so at Nachvak, nor does it appear to be the case at Nunaingok, in McLelan's Strait. On Nottingham and Digges Islands, when the gneiss has been glaciated and its hard surface exposed to the cold, it appears to have become so deeply chilled that its temperature does not rise above the freezing point in summer, except in the direct sunshine. Whenever water in small quantities had flowed over these rocks at night or in the shade during the day it had become frozen.

Mica, graphite and iron pyrites

While the "Neptune" was lying at Ashe's Inlet a party of Eskimo from the eastward came on board. They brought with them plates of good, light coloured mica and pieces of pure foliated graphite, also a small piece of iron pyrites, and one of amorphous graphite. In reply to questions, they stated that they came from a place called Kimnirook, about two days' journey by kyak, to the eastward, and that they had gathered these specimens in that vicinity. They further stated that there was plenty, both of the mica and the foliated graphite. Having assembled these visitors, and also the Eskimo of North Bay, who were already at the Inlet, a party of thirty-eight in all, I exhibited to them my collection of minerals, and passing them round, one at a time, enquired successively if any of them had ever seen a mineral like that. In return for any information which they might give, I offered them tobacco, ammunition, kettles, &c., all of which they coveted very much and might easily have invented stories as to the occurrence of minerals in these regions in order to gain the articles offered. But the only kinds they recognized, besides those of which they had brought the specimens above mentioned, were a bright red hæmatite occurring inland from Kimnirook, and a rather hard and inferior variety of soapstone, which they used for making pots before they obtained metal ones from the white men. At the western end of Big Island—in which this inlet and North Bluff are situated—they said they had observed plenty of hard white stones, like the quartz exhibited, in various localities, but no soft white ones such as the marble, gypsum, barytes, &c., the hardness of which they tested with their knives. Soapstone.

During our stay at Ashe's Inlet, the Eskimo killed two reindeer in the vicinity, and, judging from the numerous tracks of these animals they would appear to be common; but the natives informed us that they were much more abundant on the mainland to the north, where they are in the habit of hunting them most of the summer, coming again to the sea shore to live on seals and walruses during the winter. Three young harp seals were killed in the inlet during our visit, and as we steamed out of it we saw two walruses. One of our party obtained the tusk of a narwhal from the Eskimo who visited this inlet. Arctic hares were numerous on a small island, to which the foxes could not gain access. Gulls, gannets, guillemots, eider ducks and ptarmigan were the commonest birds. The young of the last named were about three parts grown on the 15th of August, and could fly with the adult birds. The Eskimo informed us that large trout were abundant, at certain seasons, in what we named Edith Lake and River, a few miles north of the observatory station. Reindeer. Arctic hares. Birds.

Driftwood, all spruce, of which a considerable quantity had been seen at Port Burwell and in McLelan Strait, was entirely absent at Ashe's Inlet, and Nottingham Island, and was scarce at Digges Island and Cape Prince of Wales.

We left Ashe's Inlet on the evening of the 16th August, and arrived at Cape Prince of Wales, on the opposite side of the strait, on the morning of the 17th, the distance being about 60 geographical miles, and the course about S. by W. (true). Prince of Wales Sound lies to the south-eastward of the cape, and appeared to be about 15 miles broad. We selected a place on the inner side of the cape for building the observatory station, and named it Stupart's Bay, after Mr. R. F. Stupart of Toronto, who was to have charge of it. The highest hill on the west side of the bay was ascertained to have a height, according to the barometer, of 340 feet, and the highest to the south of it to have a height of 180 feet. The rocks in the vicinity of the bay were found to consist entirely of Laurentian gneiss. In the hills on the west side of Stupart's Bay, the strike is from S. to S. 40° E (mag.), or nearly east and west (true). The gneiss in the hills, both to the south and west, is cut by numerous veins and bunches of milk-white quartz, Cape Prince of Wales. Quartz veins.

which in various parts are so conspicuous on the bare surface as to be seen from considerable distances. In one place on the eastward slope of the hill to the west a group of parallel veins of this mineral, varying from a foot to two feet in width, is traceable for some distance. Their course is slightly sinuous, but the average run is N. 55° W. (mag.). Red felspar occurs in some of these, and occasionally a little black mica. The top of this hill is rounded and striated. The glacial grooves are quite distinct. On the highest point their direction is S. 60° E. (mag.). A little below the summit, on the south side, they run S. 50° E., while at the observatory station, near the sea shore, their course is S. 40° E. (mag.).

Viewed from the top of the hill just referred to, the slopes and valleys to the north-eastward are full of ponds resting in basins of solid rock. Boulders are perched on the summits and slopes of all the hills around. Beaches of shingle, as fresh looking as those on the present sea shore, except that the stones are covered with lichens, may be seen at all levels, up to the tops of the highest hills in this vicinity. The long sloping hillside to the south of the observatory station, is covered with fields of shingle and small, round boulders, all blackened by the lichens. At the northern base of the ridge, to the north-west of the station, is a large, dry basin-like depression, with a notch on the outer side, through which it has formerly communicated with the sea. From the notch the shingle and mud are spread over the floor of the basin in a fanlike fashion, as if the tides had rushed violently in through this opening. The materials of the raised beaches above referred to consist principally of gneiss with milk quartz from the veins of the neighbourhood, together with a few fragments of yellowish grey dolomite, with obscure fossils, a hard and nearly black variety of silicious clay-slate, with an occasional boulder of dark, hard crystalline diorite.

Materials of the raised beaches.

Prince of Wales Sound has a breadth of, apparently, about fifteen miles, in a due S. E. bearing from Stupart's Station, on the inner side of Cape Prince of Wales, and of probably eight or ten miles in a southerly direction. A long arm, the north shore of which I reached at two and a half miles due S. W. from the station, runs due west from the western side of the sound. This appeared to be the favourite resort of the Eskimo, and I propose to name it, for convenience, Eskimo Inlet. A small rapid river was crossed between the station and the inlet. The Eskimo informed me that another river enters the head of this inlet, and that it passes through two good sized lakes not far from the sea. Some large trout, which they had brought to the ship, were stated to have been caught in this river. Salmon were said to be found in another river entering the sound at a point about south of Stupart's Bay.

Trout and salmon.

The hills of gneiss between Stupart's Station and Eskimo Inlet are pretty thoroughly glaciated. The ridges and hummocks, as a rule, present smooth gradual slopes to the west and abrupt craggy faces to the east, showing that the movement of the ancient ice was from the west. The striæ are well seen in many places on the hills, the average direction being S. 40° E., (mag.) or about due east, astronomically. On the shore of the inlet they run a little north of true east or parallel with the course of the inlet itself. Here I found a good many boulders of grey and yellowish limestone on the beach. Limestone boulders.

The gneiss along the northern shore of Eskimo Inlet is of the ordinary variety, and has an average strike of N. 20° W. (mag.) One of the veins of white quartz in this locality contains purplish red calcspar, in rather coarse crystals of a uniform size, both the color and texture closely resembling some varieties of the banded crystalline limestones of the Laurentian series in the county of Lanark. Dark crystals of epidote occur along with it. Light green amorphous epidote and a bright red felspar are associated in some of the quartz veins of the vicinity. One of the Eskimo had a small lamp made of a soft, grey variety of schistose mica rock, which he said occurred on an island in Prince of Wales Sound. Mica rock.

From a hill near Eskimo Inlet a view was obtained far inland to the west. The surface of the country in that direction appears in long sweeping outlines, terminating in mountain ranges in some of the higher parts, and resembles the landscapes in various parts of Newfoundland.

The Eskimo report reindeer to be plentiful around Prince of Wales' Sound at certain seasons, being most abundant, I understood, in the winter. During the interval between our two visits to the sound, the natives killed several, and a member of the observatory party shot one in the vicinity of Stupart's Bay. These people also told us that the polar bear was common on the southern shore of the strait, to the west, and that Ane-ugi, or Snow Island, about eight miles above Cape Prince of Wales, was a favourite place for them to land. The walrus is found at this cape at most seasons of the year. We saw several in going out and in with the "Neptune," and our interpreter killed one while we were lying in Stupart's Bay. Reindeer, Polar bear and walrus.

The Greenland, or harp seal, (*Phoca grœnlandica*, Fabricius) was the species on which the Eskimo were living during our visit to Prince of Wales' Sound, but they had in their possession the skins of a good many harbour and square flipper seals, (*Phoca vitulina*, Linné) and (*Erignathus barbatus*, Fabricius). Some of the last-mentioned were very large, stretching from the apex of a wigwam to the ground, and measuring 11 or 12 feet in length.

In reply to questions put to the Eskimo here, through our interpreter, they informed us that not only the strait itself, but even Prince of Wales' Sound, did not freeze over in the winter, but that the ice drifted up and down with the tides. They stated that ice formed in the coves and around the shoals and islands off the cape. The chief reason why they live in this vicinity is that Cape Prince of Wales being "a good place for ice" they are more certain of a steady supply of seals and walruses than elsewhere.

As to the supposed passage or channel between Bay of Hope's Advance and Mosquito Bay, they did not appear to have any positive knowledge. Our interpreter did not think it existed, but as he came from the eastern Labrador, he had no definite idea on the subject. Being an egotistical individual, and wishing his own opinion to prevail, it was impossible for me to get a fair expression of the views of these people on this important matter.

Nottingham Island.

We left Stupart's Bay at Cape Prince of Wales, on the evening of the 22nd of August, and arrived at the southern part of Nottingham Island on the morning of the 24th. In passing the south side of Salisbury Island, the hills of the western part were observed to have more even outlines than those of the eastern, as if the glacial force had come from the westward. We anchored in five fathoms of water, in an inlet a few miles east of the most southern part of Nottingham Island, and found a suitable place for the station close to our anchorage, and on the north side of the inlet, which we named Port DeBoucherville, after Mr. C. DeBoucherville, of Ottawa, who was to have charge of this observatory.

Clay bottom.

Around Port DeBoucherville, and for some distance to the westward, the country consists of island-like hummocks of rock, more or less separated from one another and surrounded by clayey mud. The lower parts of these muddy intervals are partly overflowed by the tide, rendering the water turbid in all the bays and inlets of this part of the island. The clay is mingled with boulders and gravel, and it extends below the bottom of the sea on the one hand, and up the valleys to a height of 50 to 100 feet. In preparing to leave the port, it was found difficult to start our anchor out of the mud, some of which came up on one of the flukes, and proved to be an exceedingly tough bluish-grey clay, containing grains of coarse sand disseminated through it.

Red syenite and gneiss of Nottingham Island.

I explored the country to a distance of about three miles in various directions from our anchorage, and found the rocks to consist of common varieties of gneiss, the only exceptions noticed being patches of a fine-grained red syenite on both sides of the inlet. The average direction of the strike is south-west (true) but there are numerous local variations which, however, seldom carry its course outside of the south-west quarter of the circle. The joints in the gneiss run about east, or nearly parallel with the glacial striæ, and this is also the direction of a number of long cuts and straight valleys or gorges in the gneiss, which have, therefore, an oblique angle to the strike. The bottoms of these depressions are filled with boulder-clay, which, on the surface, has a structural arrangement parallel with the walls, apparently due to a process of expansion and contraction and of heaving, on account of the intense frost of this region. In narrow cuts or gorges the heaving of the clay was the greatest along the sides, which had the effect of sorting out and throwing the boulders to the centre, where they formed rows as regular as if they had been placed artificially. Arrangement of boulders.

The direction of the joints in these rocks may also be that of dykes and veins, which, owing to decay and subsequent glacial action, would now be concealed in the bottoms of the depressions above referred to. At a projecting point on the one side of them, however, and running parallel to its walls, I found some straggling veins of hard grey dolomite, weathering brown and holding scales of mica. Veins of dolomite.

The rocks of the lower levels are well glaciated, and from upwards of twenty trials in various situations around Port DeBoucherville, the average course of the striæ across the south end of Nottingham Island was ascertained to be S. 80° E. (mag.), or only a few degrees southward of true east. That the direction of the glacial movement was towards the east is obvious from the contour of the *roches moutonnés*, the mode of the fluting of perpendicular walls and of channels cut in the rocks, as well as by the direction of the curves of the semi-circular lines across the larger grooves themselves. A valley, with a south-eastward bearing, enters the head of Port DeBoucherville, and along it the grooves partake of the same direction, showing that while the low southern portion of the island was swept by a great glacier from the west, others were traversing it from the north-west. Nearly half of the boulders, stones and gravel of the drift are grey limestone, like that of the Manitounuck (Cambrian) group, indicating the proximity of these rocks to the westward. The grey quartzite of this series is also well represented. One piece of this rock contained the characteristic spherical spots of a softer nature and lighter colour, which usually weather out into hollows on exposure. There are also fragments of black slate and red jasper, both of which have been found in the Manitounuck group. Two pieces of fine-grained white quartzite were noticed, which may have come either from rocks belonging to this group or to the Huronian series. A fragment of red sandstone conglomerate was also observed, of the same kind as that which underlies unconformably the Manitounuck rocks, and is so largely developed at Little Whale River and Richmond Gulf. (See Report of the Geo- Abundance of limestone fragments.

logical Survey for 1877-78, pp. 12 and 14 C.) No shells were found in the boulder-clay, but a few common species were abundant in a bank of stratified sand, having a height of about eight feet above high-water mark at the head of a bay.

Reindeer, hares, foxes and birds on Nottingham Island.

During the interval between our two visits to Nottingham Island, the observatory party saw a few reindeer, but the numerous tracks and droppings of these animals show that they exist in considerable numbers. Several of their shed antlers were found, and all of them had the upper tines curiously hooked and curved inwards—a peculiarity which would be incompatible with forest life. We saw a few walruses when first approaching the island, and while the station was building, but they were quite numerous upon the ice which we passed through to the south of it on our return on the 20th of September. These animals accompany the ice during the summer, and its unusual prevalence in this quarter the present season was shown by the blighted condition of even the Arctic vegetation of the island. Arctic hares and foxes were seen, and both appeared to be abundant.

Among the more noticeable birds which breed on Nottingham Island, are the Arctic loon (*Columbus arcticus*, Linn.), and the whistling swan (*Cygnus americanus*, Sharpless). We killed four old swans, all moulting, and two young ones, nearly full grown, on the 27th of August, and the male, female and young of the arctic loon.

Ancient Eskimo camp.

At Port DeBoucherville I found distinct remains of a very ancient Eskimo camp in the form of heaps and circles of stones, like those of the modern Eskimo, on a raised beach at the head of what had been a cove. From what I have seen of the situations, which the Eskimo, in various places in Hudson's Bay and Strait, choose for their camps, there appeared to be little doubt that they had lived here when the sea-level was twenty to thirty feet higher than it is at present. On the rocks facing the open strait, just south of the inlet, the more recent works of these people are well preserved, although they are probably upwards of 100 years old. Besides numerous rings of tent-stones and some shapeless heaps, there are here several rectangular walls a few feet high, and caches of a bee-hive form, each about six feet in height and seven feet in diameter. Two of the latter are nearly complete, and are adapted either for storing meat or as hiding places or "stands" from which to kill game. A good photograph of one of them was obtained.

Digges Island and Cape.

When we left Nottingham Island, it was proposed to place the next station on the south point of Mansfield Island, but the locality having been found unsuitable, the station was built on Digges Island, off Cape Wolstenholme, on our return voyage. As the geographical position of this station comes next in order, I shall now state the observations which were made during our visit to the locality. Heretofore the name Digges or Cape Digges has been applied on the sketch charts to several islands, represented as lying off Cape Wolstenholme. Our explorations went, however, to show that there is only one island from ten to fifteen miles in length. The bare hills of which it is composed are divided into several detached groups by straight, transverse valleys, cutting well down towards the sea-level, thus giving the appearance of separate islands, when viewed from a distance. The greatest length of the island lies about east and west (true). As this is also the commonest direction of the strike of the gneiss, most of which is red, and also of the glacial striæ, the island has become divided by longitudinal valleys, some of which, too, were traced in nearly straight courses for several miles.

We found a good harbour on the south side of the island, about a mile from its western extremity, well sheltered from all quarters except the south-west, with good holding ground and a convenient depth of water. The station was built on its south-east side, and placed in charge of Mr. A. N. Laperrière of Ottawa, after whom the harbour was called Port Laperrière. Only a narrow neck of land separates the head of the harbour from Hudson's Strait to the north. Between this and the western extremity of the island the hills have a rounded outline, and raised beaches, composed mostly of coarse shingle, form a prominent feature on their slopes, all the way from high tide mark to their summits, the highest of which is between 300 and 400 feet. Raised beaches

On the north side of Port Laperrière a light-colored quartzose band of gneiss contains numerous claret-colored garnets. Here the strike is N. 35° W. (mag.), but to the eastward of the harbour it is N. 45° W. (mag.), the bedding running in straight lines over a considerable area. At four miles east of the harbour, and towards the north side of the island, the gneiss strikes N. 50° W. (mag.). A well marked valley, with a chain of lakes along its bottom, comes to the south side of the island, about two miles east of Port Laperrière. It runs about east by north (true), and was explored for five or six miles without coming to the end of it. The general strike of the gneiss was parallel with the valley all along. Garnets.

The red gneiss, which rises from the shore on the north side of the valley, running eastward from the head of the harbour, is cut by two parallel fissures, only three or four feet apart, with well defined, slikensided walls, the intervening mass simulating a vein; but it is composed of red gneiss, all divided into small, sharp, angular pieces by a multitude of joints intersecting each other in all directions, and often lined with green epidote, which in this region very frequently accompanies veins and dislocations. These fissures run in a north-easterly direction, Red gneiss.

but curve about a good deal. They are accompanied by a small quantity of a handsome variety of red pegmatite, the quartz of which is blue, and the mass is occasionally streaked with bright green epidote.

Around the western part of Digges Island the course of the glacial striæ is from S. 70° E. to S. 75° E. (mag.); but in the interior it averages S. 55° E. (mag.), or with the general direction of the valleys.

We saw no Eskimo about Digges Island, but they appear to have visited Port Laperrière in recent years, as the remains of their camps were found in two or three places close to high tide mark. Some ancient camping places were also observed around this harbour, which, from their elevation above the present beach, the decayed nature of the larger bones lying about and the manner in which the circles of stones were embedded in the moss and overgrown with lichens, were supposed to be from 100 to 300 years old. Still more ancient works of the Eskimo were discovered in the valley which comes down to the head of the harbour. These consist of a row of stones lying in the vegetable matter at the surface, touching each other and running at right angles to the brook, at a contracted part of the bottom of the valley, which would be suitable for the Eskimo method of trout-fishing if the sea were 75 or 80 feet higher than it is at present. If the sea has receded as rapidly as seven feet a century, these works would be upwards of 1,000 years old, and if the rate has been less they must be even more ancient.

Ancient Eskimo works.

Polar bears and walruses.

The same day that we arrived at Port Laperrière (16th September) a she polar bear and her two cubs were killed in the interior of the island, about two miles from the ship. The cubs were somewhat larger than sheep, and were probably between seven and eight months old. Our party having approached them cautiously, one of them was observed sucking its mother. I examined the stomachs of all three, and found them to contain nothing but partially chewed grass. About four quarts of this were found in the stomach of the old bear and two and a half and one and a-half respectively in the cubs' stomachs. I had been informed by some Eskimo and Hudson's Bay Company's people that the polar bears sometimes eat grass, and I had occasionally seen along with their tracks, dung which could scarcely have been dropped by any other animal, and which was made up of the remains of comminuted grass and other vegetable matter. The three bears referred to were killed on a grassy spot where they had spent some time, apparently for the purpose of eating grass, and this was probably their only object in wandering away from the sea. The presence of the newly swallowed grass in such quantity in the stomachs of all three convinced me that these creatures live, to some extent, on vegetable food. On the 30th of August, while sailing down the east side of Mansfield Island, we saw a large polar bear and cub running along the rocks about a mile back from the shore. Walruses were numerous around Digges Island during our stay there. They were always in the water and were generally seen in groups of from three to seven or eight.

Mansfield Island.

We arrived at the eastern part of Mansfield Island, about mid-way down, on the morning of the 30th of August. Its even outline presented a remarkable contrast to the shores of Hudson's Strait. It resembled a gigantic ridge of gravel; but stratified rocks, in low horizontal ledges, appeared here and there, through the *dèbris*, at different levels. At one place, four or five miles inland, the island rises to an elevation of about 300 feet above the sea, and this was the highest point observed upon it. Small streams appear to run out upon the eastern shore, and narrow cañons are cut in the rock in a few places. The monotony of the eastern slope of the island is broken at one locality by the rocks projecting through the *dèbris* in a form resembling an old castle, with three towers on the left, and a wall broken through by embrasures on the right. A short distance to the south of this there is a cliff, with a distinct pillar on the left. These points are considered worth noting, as they have a bearing on questions as to the glacial phenomena of these regions. For many miles, the whole of the eastern slope of the island presents a succession of steps or small terraces, mostly too low to be distinctly counted, but there might be a hundred of them between the sea level and the highest parts of the island visible. These appeared to be partly ancient beaches, and partly the outcropping edges of nearly horizontal strata. I landed at a point about the middle of the eastern shore of the island, and found the shore very flat, with shallow water for a considerable distance out. The rock proved to be a fossiliferous grey limestone, in rather thin horizontal beds. The fossils are very obscure and scarce at the place referred to. Those collected, Mr. Whiteaves thinks, may possibly be Cambro-Silurian. The rocks themselves resemble the limestones of the Red and Nelson Rivers. I landed again near the south end of the island, and found the water very shallow in approaching the shore. No rock was detected *in situ* at this place; but a great extent of gravel and coarser shingle, derived from limestone like that found *in situ* further north was thrown into a succession of long, low ridges and terraces, all curving with the contour of the land. Behind most of the ridges I met with long ponds of clear, fresh water. A number of caches and "stands," built by the Eskimo, were seen along the shore of Mansfield Island, but none of these people were observed.

Fossiliferous limestone.

Southampton Island.

From the southern extremity of Mansfield Island we steamed to Cape Southampton, and thence coasted north-eastward, in the hope of finding a suitable site for building an observatory station, but without success; and after making about twenty or thirty miles in that direction, we returned to the cape and passed round it to the westward, shaping our course thence for the opposite side of Hudson's Bay. The general character of this island, and the part of its shore which we examined, are quite like the eastern side of Mansfield Island. It has rather more vegetation upon it than the last named island, and much of the surface has a brown colour in consequence. Shallow water, having a light green colour, extends some distance out all along. The island slopes gradually up from the beach and is thrown into a great many small terraces. The highest point seen did not exceed 200 feet above the sea. I noted that the limestone is evidently exactly the same as that of Mansfield Island. Low cliffs in the upper levels break through the decayed mass and the *débris*, and horizontal ledges also make their appearance through the loose materials near the sea beach.

Horizontal strata of limestone.

We did not observe any natives on the part of the island which we saw, but at four miles north-east of Cape Southampton there were three fresh houses of the Eskimo, covered completely with sods and moss, and having the doors built round with stones. About three-quarters of a mile to the north-eastward of these were five old Eskimo houses, built of stones and sods, with some sticks and bones lying on their tops.

Coast between Chesterfield Inlet and Marble Island.

Our first landing place on the western side of Hudson's Bay was Marble Island, but we had a distinct view of the land between it and Chesterfield Inlet. Judging from specimens which I have received through the kindness of Mr. George McTavish, of the Hudson's Bay Company, a portion of this coast is occupied by rocks, which may be referred to the Huronian series, among them being diorites, hornblende-schists and glossy mica-schists characterized by numerous cubes of iron pyrites. On the coast opposite to Marble Island, the last named rock appears to contain the veins of granular iron pyrites, an assay of a specimen from one of which, from Inari, was made by Mr. Hoffmann in 1879. (See p. 23 H., Report Geological Survey, 1878–79). These glossy mica-schists were found on Deadman's Island, near the west end of Marble Island. From all that I have been able to learn on the subject, a set of rocks, very like those of the township of Ascot, in the province of Quebec, and holding similar pyrites veins, which are of great economic value, will be found in this part of the western coast of Hudson's Bay.

Huronian schists.

Marble and Deadman's Islands.

The harbour on Marble Island, which is resorted to by the American whalers, and in which we also anchored, is situated on the south side of the island, about two and a-half miles from the western extremity. The outer harbour is formed by Deadman's Island, about a quarter of a mile long, lying across the front of a small bay. The inner harbour is a basin, which connects with this through a narrow gap in the rock with only about one fathom of water at low tide.

British American Bank Note Co. Montreal

VIEW OF MARBLE ISLAND, FROM DEADMAN'S ISLAND.

Deadman's Island consists of white and light grey quartzites and glossy mica-schist, striking N. 75° W. (mag.). The glacial striæ on this island are well marked and run S. 10° E. (mag.). In the course of the day which we spent at Marble Island, I rowed round its western end and thence eastward along its northern shore for some miles. I also explored the interior and took some photographs between this side of the island and the harbour. The whole of the western part of the island consists of white and light coloured quartzite, bearing a strong resemblance to white and veined marble, from which circumstance it has no doubt received its name. Viewed from sea, the shores have a very white appearance, the rocks being free from lichens, &c., and the hills in the interior, which are rounded, are also pure white, and contrast strongly with the dark brown of the peaty flats and hollows. Even the boulders and coarse shingle forming the raised beaches remain quite white, and these beaches appear as conspicuous horizontal lines against the dark vegetable matter. The beds of quartzite are usually very massive. Their surfaces are often ripple-marked, the ridges and hollows varying much in size, being sometimes as fine and regular as the fluting on a washboard, and at others two or three inches apart. On the south side of the island, near the west point, the quartzite is of a beautiful lilac tint, some of the beds being more deeply coloured than others. The strike is here N. 80° W. (mag.), the dip being to the northward, at an angle of 80°. The surface of the rock at this place is marked by large green stains of carbonate of copper, some of them being 3 or 4 feet in diameter. They appear to be due to the decomposition of small quantities of copper pyrites in the quartzite.

Quartzites of Marble Island.

Carbonate of copper.

At the north-west point of the island the dip is N. 75° W. (mag.), angle 45° and the striæ here run S. 20° E. (mag.). This is also the prevailing dip in the interior part of the island. On the north shore of the island, opposite to the harbour on the south side, the dip is N. 60° W. (mag.), angle 40°. Not only does the strike vary considerably on the large scale, but the lines of stratification were in places observed to undulate a good deal on a small scale, while the general course of the beds was pretty straight, the minor variations appearing as mere corrugations of the darker lines of stratification on smooth sections.

Although quartzite was the only rock found *in situ* on the main island, so far as I had time to explore it, the *débris* of the glossy mica-schist with cubes of iron pyrites, was so abundant along the north side that I have no doubt it exists "in place" close by. A fragment of the peculiar brown-weathering dolomite with white quartz strings of the Huronian series, was also found on this part of the island.

Mica schists with pyrites.

We left Marble Island in the evening of the same day that we arrived there (2nd September), and entered the harbour of Churchill on the 6th. The geology of this locality is described in the Geological Survey Report for 1878–79, pages 19 c to 21 c. After leaving Churchill we paid a visit of twenty-four hours to York Factory, from which we sailed for Digges, where we built station No. 5, as already stated, and after visiting all the other stations and building the one at Nachvak, which has been described in a previous part of this report, we continued our homeward voyage to St. John's, Newfoundland, which we reached on the 11th of October, and left the same evening for Halifax, where we arrived on the 14th and at Ottawa on the 16th of the same month.

GENERAL REMARKS ON GLACIATION.

It will be seen by an inspection of the chart, that Fox's Channel, in respect to width, general direction, &c., is a continuation of Hudson's Strait, and that the outlet of Hudson's Bay joins this great channel at right angles. It is much deeper than Hudson's Bay, the comparative shallowness and the uniformity of the bottom of which are remarkable features. If the sea in these latitudes were only about 100 fathoms lower than it is at the present time, James' and Hudson's Bays would become dry land, while the strait would remain as a long bay, but with a slightly diminished breadth. The bottom of the bay would have become a plain, more level in proportion to its extent than any other on the continent. The numerous rivers which now flow into it would traverse this plain, converging towards the north-east and falling into the strait near Cape Wolstenholme, after having, perhaps, formed one immense river, flowing northward down the centre of the bay, or probably nearer the East-main side.

During the "great ice age" the basin of Hudson's Bay may have formed a sort of glacial reservoir, receiving streams of ice from the east, north and north-west and giving forth the accumulated result as broad glaciers, mainly towards the south and south-west. It has been shown, in a preceeding part of this report, that the direction of the glaciation, on both sides of Hudson's Strait, was eastward. That an extensive glacier passed down the strait may be inferred from the smoothed and striated character of the rocks of the lower levels, the outline of the glaciated surfaces pointing to an eastward movement, the composition of the drift, and also from the fact that the long depression of Fox's Channel and the strait runs from the north-westward towards the south-east, and that this great channel or submerged valley deepens as it goes, terminating in the Atlantic Ocean. Glaciers are said to exist on the shores of Fox's Channel and they may send down the flat-topped icebergs which float eastward through the lower part of Hudson's Strait into the Atlantic. During the drift period, the glacier of the bed of Hudson's Strait was probably joined by a contribution from the ice which appears to have occupied the site of Hudson's Bay, and by another also from the southward, coming down the valley of the Koksok River, and its continuation in the bottom of Ungava Bay. The united glacier still moved eastward round Cape Chudleigh into the Atlantic.

Throughout the drift period, the top of the coast range of the Labrador, stood above the ice and was not glaciated, especially the high northern part. Further south on this coast, the range is lower and there may also have been more ice in this direction. Here the valleys and the hills, up to the height of 1,600 feet, at any rate, have been planed by glacial action, the course followed by the ice on the eastern slope having been down the valleys and fjords directly into the sea. In the southern part of the Labrador peninsula, the general course of the ancient glaciation appears to have been southward, varying to the eastward or westward with the courses of the rivers and valleys, and coming to the north shore of the Gulf of St. Lawrence, in a general way, at right angles to the coast line. On the Island of Newfoundland, the glaciation appears to have been from the centre towards the sea on all sides.

APPENDIX I.

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LIST

BY PROFESSOR MACOUN

OF

PLANTS COLLECTED ON THE COASTS OF LABRADOR, HUDSON'S STRAIT AND BAY.

BY

DR. ROBERT BELL IN 1884.

This collection is a very interesting one, and shows conclusively the arctic character of the climate of the straits and that part of Labrador north of Nachvak. North of Nain all the plants obtained are exclusively arctic, scarcely one of them extending south to the Gulf of St. Lawrence, and then only close to the sea or in cold peat bogs or on high mountains.

From the collection just examined, I consider the water of the straits to be constantly at a very low temperature and the atmosphere to be generally at the point of saturation. These two conditions give almost the same flora as would be found near the snow-line on a mountain. I believe the above conditions sufficient to produce the extremely arctic character of the flora of the straits.

In the accompanying List, the species collected at the various points are grouped as follows:—

Column I.—Shore of Hudson's Bay at York Factory and Fort Churchill.

II.—Mansfield, Digge's and Nottingham Islands, at the western end of the straits.

III.—Cape Prince of Wales and Ashe's Inlet, or North Bluff, in the middle of the straits.

IV.—Cape Chudleigh (Port Burwell) at the eastern end of straits.

V.—Nachvak, Ford's Harbour and Nain, coast of Labrador.

VI.—Plants collected at Hopedale and Nain, by the Revd. Dr. Samuel Weiz, Moravian Missionary.

VII.—Greenland Plants. List taken from Dr. Hooker's Catalogue of Arctic Plants.

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
	I. Ranunculaceæ.							
1	Anemone multifida, DC.	*						
2	" parviflora, Michx. (A. borealis, Richards)						*	
3	Thalictrum alpinum, Linn				*			*
4	Ranunculus aquatilis, L .var. trichophyllus, Wat				*			*
5	" nivalis, Linn		*		*		*	*
6	" affinis, R. Br. var. leiocarpus, Wat. (A. auricomus, Linn.)		*		*		*	
7	" Flammula, L. var. reptans, Gray						*	*
8	" Lapponicus, Linn						*	*
9	" pygmæus, Wahl				*		*	*
10	" hyperboreus, Linn				*			*
	II. Papaveraceæ.							
11	Papaver nudicaule, Linn		*	*	*		*	*
	III. Cruciferæ.							
12	Arabis alpina, Linn				*			*
13	Cardamine pratensis, Linn		*		*		*	*
14	" bellidifolia, Linn						*	
15	" hirsuta, Linn	*					*	*
16	Parrya arctica, R. Br		*	*	*		*	
17	Braya alpina, Sternb		*					*
18	Draba arabisans, Michx		*				*	
19	" stellata, Jacq. Var. nivalis, Regel (A. muricella, Wahl)		*	*	*		*	*
20	" stellata, Jacq			*	*			*
21	" alpina, Linn		*		*			*
22	" " var. glacialis, Dickie		*					
23	" " var. corymbosa, Durand		*					*
24	" rupestris, R. Br		*					
25	" androsacea, Wahl (C. crassifolia, Graham)		*	*			*	*
26	" incana var, confusa, Poir (C. contorta)	*					*	
27	" aurea, Vahl						*	*
28	Cochlearia officinalis, Linn		*	*	*		*	
	IV. Violaceæ.							
29	Viola canina, var. sylvatica, Regel					*	*	*
30	" blanda, Ait.?						*	
	V. Caryophyllaceæ.							
31	Silene acaulis, Linn		*		*	*	*	*
32	Lychnis alpina, Linn					*	*	*
33	" apetala, Linn	*	*	*	*		*	*
34	" affinis, Vahl	*					*	*
35	Arenaria Grœnlandica, Spreng					*	*	*
36	" verna, var. hirta, Watson	*			*	*		*
37	" stricta, Fenzl		*			*		*

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
38	Arenaria stricta peploides, Linn..........	*	*	*	*	*	*	*
39	" arctica, Linn						*	*
40	Stellaria humifusa, Rottb................		*			*	*	*
41	" longipes, var. minor, Hook	*		*	*	*	*	*
42	" " var. læta, Torr. & Gr...		*					
43	" " var. Edwardsii, Torr. & Gray		*				*	*
44	" borealis, Bigel	*					*	*
45	" crassifolia, Ehrh...............						*	
46	Cerastium trigynum, Vill...............				*		*	*
47	" alpinum, Linn...............							
48	" " var. Fischerianum,		*	*		*	*	*
	Torr. & Gray		*	*				*
49	" " var. glabratum, Hook.			*			*	
	VI. Leguminosæ.							
50	Astragalus alpinus. Linn...............				*	*	*	
51	Oxytropus podocarpa, Gray		*					
52	" arctica, R. Br.................		*		*		*	
53	" campestris, var cœrulea, Koch.			*	*	*	*	
54	Hedysarum boreale, Nutt						*	
55	" Mackenzei, Rich	*						
	VII. Rosaceæ.							
56	Rubus Chamœmorus, Linn..............	*	*	*		*	*	*
57	" arcticus, var. grandiflorus, Ledeb..					*	*	
58	" strigosus, Michx						*	
59	Dryas octopetala var. integrifolia, Cham. & Schl	*		*	*	*	*	*
60	Potentilla anserina, Linn...............	*				*	*	*
61	" tridentata, Solander............					*	*	*
62	" Pennsylvanica, Linn..........	*						
63	" pulchella, R. Br..............		*					*
64	" Norvegica var. Labradorica, Macoun					*	*	
65	" nivea, Linn....................		*	*			*	*
66	" maculata, Pourret.............			*		*	*	*
67	" emarginata, Pursh		*	*				*
68	Sibbaldia procumbens, Linn............			*		*		*
	VIII. Saxifragaceæ.							
69	Saxifraga oppositifolia, Linn............		*	*		*		*
70	" Hirculus, Linn	*	*					*
71	" tricuspidata, Retz.............	*	*	*		*	*	*
72	" aizoides, Linn...............			*		*	*	*
73	" cæspitosa, Linn...............		*	*				*
74	" " var. uniflora, Hook..		*	*				*
75	" nivalis, Linn. var. β. Hook....		*	*		*	*	*
76	" cernua, Linn..................		*	*		*	*	*
77	" rivularis, Linn...............		*	*	*		*	*
78	" stellaris, Linn						*	*
79	" Aizoon, Jacq						*	*
80	Ribes prostratum, L'Her						*	

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
	IX. CRASSULACEÆ.							
81	Sedum Rhodiola, DC.			*		*	*	*
	X. DROSERACEÆ.							
82	Drosera rotundifolia, Linn.						*	
	XI. HALORAGEÆ.							
83	Hippuris vulgaris, Linn	*			*		*	*
84	" maritima, Hellen		*				*	
	XII. ONAGRACEÆ.							
85	Epilobium angustifolium, Linn	*				*	*	*
86	" latifolium, Linn		*	*	*	*	*	*
87	" alpinum, Linn				*		*	*
88	" palustre, Linn						*	*
89	" organifolium, Linn.						*	*
	XIII. UMBELLIFERÆ.							
90	Archangelica atropurpurea, Hoffm.					*		
91	" Gmelini, DC					*		
	XIV. CORNACEÆ.							
92	Cornus Canadensis, Linn.					*	*	
93	" Suecica, Linn.					*		*
	XV. CAPRIFOLIACEÆ.							
94	Linnæa borealis, Linn	*				*		
95	Lonicera cærulea, Linn.						*	
96	Viburnum pauciflorum, Pylaie (V. acerifolium)	*					*	
	XVI. RUBIACEÆ.							
97	Galium trifidum, Linn (G. Claytoni, Mx.)	*					*	
	XVII. COMPOSITÆ.							
98	Aster Radula var. strictus, Gray (A. strictus, Mx)						*	
99	Solidago macrophylla, Pursh (S. thyrsoidea, Meyers)					*	*	
100	" multiradiata, Ait (S. Virga-aurea var. multiradiata)	*				*	*	
101	Erigeron uniflorus, Linn (E. humilis, Graham)		*	*	*	*	*	
102	" Eriocephalus, J. Vahl			*	*			
103	Antennaria alpina, Gærtn. (Gnaphalium alpinum)			*	*		*	*
104	" dioica, Gærtn	*		*	*			*

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
105	Achillæa Millefolium, Linn. Var nigrescens, E. Meyer					*	*	
106	Chrysanthemum arcticum, Linn.........	*						
107	" integrifolium, Richards.		*					
108	Matricaria inodora, L. var. nana, Torr. & Gray	*	*					
109	Artemisia borealis, Pall						*	*
110	Arnica alpina, Olin (A. plantaginea, Pursh.)	*		*	*		*	*
111	Senecio aureus, L. var. borealis, Torr. & Gray (S. pauciflorus)..........	*				*	*	
112	" Pseudo-Arnica, Less						*	
113	Taraxacum officinale, Web. var. lividum Koch (Leontodon Taraxacum)		*	*	*	*	*	*
114	Erigeron acris, Linn. var. Dœbachensis, Blytt (E. elongatus)..........						*	
115	Gnaphalium supinum, Vill. (G. pusillum, Hænke)..................						*	*
116	" Norvegicum, Gunner.......						*	*
117	Petasites palmata, Gray. (Tussilago palmata)						*	
	XVIII. Campanulaceæ.							
118	Campanula uniflora, Linn................			*	*		*	*
119	" Scheuchezeri, Vill. var. heterodoxa, Gray...............				*	*	*	*
	XIX. Ericaceæ.							
120	Vaccinium uliginosum, Linn		*	*	*	*	*	*
121	" vitis-Idæa, Linn			*	*	*	*	*
122	" Pennsylvanicum, Lam. (V. tenellum. Pursh.)						*	
123	" oxycoccus, Linn..............	*					*	*
124	Arctostaphylos alpina, Spreng............	*		*	*	*	*	*
125	Andromeda polifolia, Linn...............						*	*
126	Cassiope tetragona, Don..................		*	*				*
127	" hypnoides, Don (Andromeda hypnoides)				*		*	*
128	Bryanthus taxifolius, Gray (Andromeda cærulea)					*	*	
129	Kalmia glauca, Ait......................					*	*	
130	Rhododendron Lapponicum, Wahl.......						*	*
131	Ledum, palustre, Linn			*	*	*	*	*
132	" latifolium, Ait (L. Grœnlandicum)	*				*	*	*
133	Loiseleuria procumbens, Desv					*		*
134	Pyrola rotundifolia, L. var. pumila, Hook (P. grandiflora)		*	*	*	*	*	*
135	" minor, Linn		*				*	*
136	" secunda, Linn						*	*
137	Moneses uniflora, Gray. (Pyrola uniflora, Linn)	*					*	
	XX. Diapensaceæ.							
138	Diapensia Lapponica, Linn.............		*	*	*	*	*	*

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
	XXI. PLUMBAGINACEÆ.							
139	Armeria vulgaris, Willd. (Statice maritima)		*	*	*	*		*
	XXII. PRIMULACEÆ.							
140	Primula farinosa, Linn..................	*					*	
141	" Mistassinica, Michx						*	
142	Trientalis Americana, Pursh. (D. Europæus, Mx.).................						*	
	XXIII. GENTIANACEÆ.							
143	Gentiana amarella, L. var. acuta, Hook.....	*					*	
144	Pleurogyne rotata, Griseb...............	*					*	*
145	Menyanthes trifoliata, Linn..............	*					*	*
	XXIV. BORAGINACEÆ.							
146	Mertensia maritima, Don (Pulmonaria maritima)....			*		*	*	*
	XXV. SCROPHULARIACEÆ.							
147	Veronica alpina, Linn...................				*		*	*
148	Castilleia pallida, Kunth. var. septentrionalis, Gray..................	*				*	*	
149	Bartsia alpina, Linn						*	*
150	Pedicularis euphrasioides, Stephan (P. Labradorica, Houth)......					*	*	*
151	" Grœnlandica, Retz	*				*	*	
152	" Lapponica, Linn			*			*	*
153	" Langsdorffii, Fisch..........			*				*
154	" " var. lanata, Gray		*		*			
155	" hirsuta, Linn					*		*
156	" flammea, Linn..............		*		*	*	*	*
157	Euphrasia officinalis, Linn	*				*	*	*
158	Rhinanthus Crista-galli, Linn	*					*	*
	XXVI. LENTIBULARIACEÆ.							
159	Pinguicula vulgaris, Linn................	*				*	*	*
160	" villosa, Linn..................						*	
	XXVII. PLANTAGINACEÆ.							
161	Plantago maritima, Linn................	*	*			*		*
	XXVIII. POLYGONACEÆ.							
162	Oxyria digyna, Linn. (Rumex digynus)		*	*	*	*	*	*
163	Rumex occidentalis, Wat................	*						
164	Polygonum viviparum, Linn	*	*	*	*	*	*	*
165	" aviculare, Linn..............						*	*
166	Kœnigia Islandica, Linn		*	*			*	*

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
	XXIX. Empetraceæ.							
167	Empetrum nigrum, Linn	*	*			*	*	*
	XXX. Myricaceæ.							
168	Myrica Gale, Linn						*	
	XXXI. Betulaceæ.							
169	Betula glandulosa, Michx (B. nana, DC)					*	*	*
170	Alnus viridis, DC					*	*	*
	XXXII. Santalaceæ.							
171	Comandra livida, Richards						*	
	XXXIII. Salicaceæ.							
172	Salix reticulata, Linn	*	*		*	*	*	*
173	" Cutleri, Tuckerman				*	*	*	
174	" herbacea, Linn		*		*	*	*	*
175	" arctica, R. Br.		*		*	*	*	*
176	" vestita, Pursh					*	*	
177	" argyrocarpa, Anders (S. repens)		*	*		*	*	
178	" planifolia, Pursh					*	*	
179	" myrsinites, Linn						*	*
180	" Lapponum, Linn. (?)					*	*	
181	" ——— No. 1				*			
	XXXIV. Coniferæ.							
182	Picea nigra, Linn					*		
183	Larix Americana, Michx					*		
	XXXV. Lilaceæ.							
184	Tofielda palustris, Hudson					*	*	*
185	Maianthemum Canadense, Desf						*	
186	Streptopus amplexifolius, DC						*	
	XXXVI. Orchidaceæ.							
187	Habenaria dilatata, Lindl. (Orchis dilatata)						*	
188	Listera cordata, R. Br (Ophrys cordata)						*	*
	XXXVII. Alismaceæ.							
189	Triglochin maritimum, Linn	*					*	
	XXXVIII. Iridaceæ.							
190	Iris tridentata, Pursh (I. caurina)						*	
	XXXIX. Juncaceæ.							
191	Luzula spadicea, DC. var. parviflora, Wats.					*	*	*

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
192	Luzula arcuata, E. Meyer (L. campestris).		*	*		*	*	*
193	" spicata, Desv....................		*		*	*	*	*
194	Juncus triglumus, Linn..................						*	*
195	" castaneus, Smith						*	*
196	" trifidus, Linn....................						*	*
	XL. Cyperaceæ.							
197	Scirpus cæspitosus, Linn	*				*	*	*
198	Eriophorum vaginatum, Linn............		*		*	*	*	*
199	" polystachyon, L...........		*				*	*
200	" gracile, Koch.	*					*	
201	" russeolum, Fries............				*		*	
202	Carex nardina, Fries.....................		*					*
203	" glareosa, Wahl				*			*
204	" fuliginosa, Stern. & Hoppe.........		*		*			*
205	" rigida, Good........................				*	*	*	*
206	" saxatilis, Linn (C. cæspitosa)		*		*		*	
207	" atrata, Linn......................						*	*
208	" rariflora, Smith....................						*	*
209	" Magellanica, Lam..................						*	*
210	" festiva, Dew......................						*	
211	" heleonastes, ? Ehrh..............						*	*
212	" dioica, Linn......................						*	*
	XLI. Gramineæ.							
213	Hierochloa alpina, R. & A...............			*	*	*	*	*
214	Alopecurus alpinus, Smith...............		*	*				*
215	Deschampsia flexuosa, L. (Aira flexuosa)..					*	*	*
216	Deyeuxia Lapponica, Kunth.............		*	*	*	*		*
217	Trisetum subspicatum var. molle, Gray...	*	*		*	*		*
218	Phippsia algida, R. Br..................		*		*			*
219	Poa alpina, Linn......................	*			*		*	*
220	" laxa, Haenke......................		*		*		*	
221	" arctica, R. Br......................		*		*			*
222	Glyceria augustata, R. Br		*					
223	Dupontia Fischeri, R. Br		*					*
224	Colpodium latifolium, R. Br.			*				*
225	Dupontia psilezantha, Respet............		*					
226	Festuca brevifolia, R. Br.................		*	*		*		*
227	Elymus mollis, Trin		*	*		*	*	
	XLII.							
228	Equisitum sylvaticum, Linn..............					*	*	*
229	" arvense, L. var. scrotinum, E. Meyer......................	*			*		*	*
230	" scirpoides, Michx		*					
231	" limosum, Linn. (E. uliginosum)						*	*
	XLIII. Filices.							
232	Aspidium fragrans, Swartz			*	*		*	*
233	Cystopteris fragilis, Bernh...............			*		*	*	*
234	Woodsia hyperborea, R. Br..............		*					*

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
235	Phegopteris polypodioides, Fee..........						*	*
236	Botrychium Lunaria, Swartz	*					*	*
	XLIV. Lycopodiaceæ.							
237	Lycopodium selago, Linn................		*		*			*
238	" sabinæfolium, Willd........					*		*
	XLV. Musci.							
239	Sphagnum acutifolium, Ehrh			*				
240	Dicranum scoparium, Hedw..............					*		
241	" fuscescens, Turn...............		*					
242	" Schraderi, Web. & Mohr.......		*					
243	" Starkii, Web. & Mohr.........		*					
244	Distichium capillaceum, Linn.............		*					*
245	Grimmia apocarpa, Linn................		*					
246	" trichophylla, Grev		*					
247	Racomitrium sudeticum, Funk		*					
248	" fasciculare, Brid		*					
249	" lanuginosum, Brid.........		*	*				
250	Polytrichum juniperinum, Hedw		*			*	*	*
251	" strictum, Banks.............					*		
252	Pogonatum alpinum, L. var. brevifolium, Brid		*					
253	Mnium affine, Bland....................		*					
254	Bryum intermedium, Web. & Mohr......		*					
255	" inclinatum, Swartz		*					*
256	" arcticum, Bruch. & Schimp.......		*	*				
257	" ———, ? (No fruit)............		*					
258	" Brownii, Bruch. & Schimp.......		*	*				
259	Hypnum rivulare, Bruch................						*	
260	" ———, ?..........						*	
261	" nitens, Schreb.................		*					
262	" stramineum, Dicks		*					*
263	" aduncum, Hedw................		*					
264	" cordifolium, Hedw.............		*					
	XLVI. Hepaticæ.							
265	Scapania nemorosa, Linn........		*					
266	Ptilidium ciliare, Ehrh..................		*					*
267	Jungermannia minuta, Crantz............		*					*
268	" barbata, Schreb		*					*
	XLVII. Lichenes.							
269	Cetraria Islandica, Ach..................		*	*				*
270	" aculeata, Fries................		*					*
271	" nivalis, Ach....................		*			*		*
272	" arctica, Hook..................		*	*	*			*
273	Alectoria ochroleuca, var. rigida.........		*		*	*		*
274	" ochroleca, var. nigricans, Ach....			*				*
275	Theloschistes parietinus, Norm..........		*	*				
276	Umbilicaria anthracina, Schær...........		*					
277	" hyperborea, Hoffm..........				*			
278	Solorina crocea, Ach......................				*			

Nos.		I.	II.	III.	IV.	V.	VI.	VII.
279	Nephroma arcticum, Fries................					*		*
280	Petigera canina, Hoffm		*					*
281	Stereocaulon Despreaultü, Nyl............		*			*		*
282	" denudatum, Floerk...			*				*
283	Cladonia pyxidata, Fries		*					*
284	" gracilis, var. elongata, Fries		*					*
285	" rangiferina, Hoffm..............					*		*
286	" " var. sylvatica, Linn.					*		*
287	" decorticata, Flœrk...............				*			*
288	" Sphœporon globifera		*	*				
289	Thamnolia vermicularis, Schær..........		*					*
	XLVIII. Fungi.							
290	Lycoperdon			*				
291	Russula.................................		*					
292	Agaricus			*				
293	Lophodermium arundinaceum, Schr......			*				
294	Sphaerella Stellarinearum, Karst........		*					
295	Plæspora Drabæ, Schr....................				*			
296	" herbarum, Pers.................				*			
297	Rhytisma Salicinum, Pers................					*		
298	Excipula conglutinata, E & E............		*					
299	Urocystis Anemonæ, Pers................				*			

The last seven species were picked from the dead stems of a few specimens which retained some of the previous season's leaves and stems and were determined by Mr. J. B. Ellis, Newfield, New Jersey. They are very interesting. Nos. 294 and 295, not having been detected in America before. The former is found in Spitzbergen, the latter in Lapland, while No. 298 is found on Mount Paddo, in Washington Territory.

APPENDIX II.

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LIST AND NOTES

BY DR. R. BELL,

OF MAMMALS OF THE VICINITY OF HUDSON'S BAY AND LABRADOR.*

1. Star-nosed Mole, *Condylura cristata* (Desmarest). Common at Moose Factory at the southern extremity of Hudson's Bay.
2. Bat, a small species was seen at Moose Factory.
3. Hudson's Bay Squirrel, Chickaree or Common Red Squirrel, *Sciurus Hudsonicus* (Pennant).
4. Four-striped Ground-squirrel, Little Chipmunk, *Tamias quadrivittatus* (Say). Common along the Nelson and Churchill Rivers. The gray or black squirrel, *S. Carolinensis* (Gmelin), stated to range to Hudson's Bay, does not do so.
5. Great Northern Flying-squirrel. Common around Norway House. Occurs about Oxford House and at Nelson River House on the Churchill River.
6. Parry's Spermophile, *Spermophilus Parryi* (Richardson), Churchill, Nd. Specimens obtained from Eskimo from near Marble Island were kindly determined by Dr. Cowes.
7. Back's Lemming, *Myodes obensis* (Brants). Specimen from the neighborhood of Great Slave Lake, from Mr. MacF.

† 8. Wenusk or Woodchuck, *Arctomys empetra* (Sabine). The red or chestnut bellied variety of the woodchuck, *Arctomys monax*, (Linn.)

9. Common Meadow-mouse, northern variety, *Arvicola riparius*, var. *borealis* (Richardson). Specimens obtained at Nimamjok and Stupart's Bay.

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* Skins of the species marked thus (†) were obtained for the Museum.

†10. Chestnut-cheeked Meadow-mouse, *Arvicola xanthognathus* (Leach). One specimen obtained at Churchill.

11. White-footed Mouse, *Musculus leucopus* (Rafinesque). Moose Factory. Specimens determined by Dr. Coues.

12. Musk-rat, *Fiber zibethicus* (Linn.) Common in Labrador as far north as Nain. On the east side of Hudson's Bay about as far north as Cape Jones. A few found at York Factory.

13. Beaver, *Castor Canadensis* (Kuhl.) On the west side of Hudson's Bay, northern limit of the beaver is rather south of the mouth of the Churchill River. A party of natives, who had found a family of beavers some distance up the North River between the Churchill and the Seal rivers, related the circumstance as unusual for that latitude.

14. Common Porcupine, *Hystrix dorsata* (Linn.) In Labrador the porcupine is met with as far north as Nain where it is common. It is met with everywhere in the region between the Great Lakes and Hudson's Bay, but is always scarce. Mr. Isbister, of the Nelson River House on the Churchill, informs me that it was once abundant there. It is rare between Lake Winnipeg and Hudson's Bay, but an individual is occasionally found as far north as York Factory.

15. Common American Hare, *Lepus Americanus* (Erxleben). Around Hudson's Bay the northern range of this species appears to correspond with that of the forest. It is common in some years at Fort Churchill.

16. Polar Hare, *Lepus glacialis* (Leach). On both sides of Hudson's Strait and on the west side of Hudson's Bay as far south as Fort Churchill.

17. Canada Lynx, *Lynx Canadensis* (Desm. Sp.) This animal in its apparently erratic migrations does not reach the verge of the forests. A few skins are obtained at Fort George on the East-main coast and at York Factory. It has been occasionally rather numerous about Oxford House.

18. Common American Fox, *Vulpes fulvus* (Desm.) The Eskimo of Prince of Wales Sound, on the south side of Hudson's Strait, had in their possession, skins of the red variety and they informed us that the black or silver grey variety was also found on this side of the strait.

†19. Arctic Fox, *Vulpes lagopus* (Linn.) These animals, or indications of their existence, were found at every place touched at by the expedition, in the Labrador, Hudson's Strait and Bay. A specimen shot on Nottingham Island about the middle of September had short fur, bluish grey on the back and white beneath.

20. Wolf, *Canis occidentalis* (Richardson). Wolves appear to be rather numerous on the north-west side of Hudson's Bay. The winter skins, of which I have seen a good many at Churchill, are almost white. A darky variety is rare.

21. American Otter, *Lutra Canadensis* (Sabine.) I was informed by the Eskimo that on the Labrador coast the otter is found as far north as Okak. On the east side of Hudson's Bay it is rare as far north as Little Whale River and on the west as far Fort Churchill. Its northern range seems to be inside of that of the forest. I have frequently consulted the Indians of the regions to the south and west of Hudson's Bay, in regard to the *Lutra destructor* of Barnston. They are universally of the opinion that there is only one species.

22. Skunk, *Mephitis mephitica* (Shaw Sp.) On both sides of James Bay ; not very northern in its range.

†23. Common Weasel, *Putorius Noveboracensis* (DeKay). I have seen this weasel as far north as Fort Churchill. On the East-main coast it is said to extend to Little Whale River.

†24. Common Mink, *Putorius vison* (Brisson Sp.) The mink is of a more southern habit than the martin. Its range appears to fall considerably within the northern limits of timber.

25. Fisher, *Mustela Canadensis* (Schreber). The fisher does not appear to come to the shores of Hudson's Bay proper, although it ranges over the country around James' Bay.

26. Pine Martin, *Mustela Americana* (Turton). The northward range of the pine martin, both in the Labrador peninsula and on the west side of Hudson's Bay appears to correspond very closely with that of the limits of timber.

27. Wolverine, *Gulo luscus* (Linn. Sp.) Carcajou (Devil of the Indian). I ascertained from the Eskimo that this animal comes as far north as the southern shore of Hudson's Strait. The Eskimo bring their skins from the vicinity of Marble Island on the west side of Hudson's Bay.

28. Polar Bear, *Ursus maritimus* (Linn.) The polar bear is found at different seasons in all parts of Hudson's Bay, even to the southern extremity of James Bay, having been seen on two occasions at Moose Factory. The captain of one of the Hudson's Bay Company's ships informed me that he killed a large specimen, swimming in the open water, far from any ice, midway across the bay. During the expedition two were seen on Mansfield Island and several on Digges, of which three were killed (sup.—where their habit of eating grass is referred to). The Eskimo told us they were common in Hudson's Strait, and on

various occasions we saw their tracks on the floating ice. In the spring they come down the Labrador coast with the ice and are occasionally killed off the northern parts of Newfoundland.

29. Black Bear, *Ursus Americanus* (Pallas.) When at Nain on the Labrador coast the carcass of a black bear was brought for sale on board the "Neptune," and the Eskimo informed me that the animal is found on this coast as far north as Okak. On the East-main coast I have seen black bears as far north as Little Whale River. On the west coast of Hudson's Bay they are not known about Fort Churchill, but I killed one on the Churchill River about 100 miles from the mouth.

30. Barren-ground Bear, *Ursus arctos* (Richardson). This bear is found in the barren grounds south of Hudson's Strait. Capt. William Kennedy, who was formerly agent of the Hudson's Bay Company in the Ungava District, informed me that the skins they got there resembled those of the grizzly bear closely enough to pass as a variety of this fur in the trade. Some of the Hudson's Bay Company's officers regard the barren-ground as a variety of the cinnamon bear. In the barren grounds to the north-west of Hudson's Bay, I have been told that a large bear is found, which the Eskimo consider a variety of the polar bear, which has adopted a terrestrial life, and to which they have given the name of "blue" or "grey" bear.

31. Atlantic Walrus, *Odobœnus rosmarus* (Malmgren). The walrus is found at all seasons in Hudson's Strait, and in the northern parts of the bay. During the winter the Eskimo kill a few off the headlands along the northern portion of the Labrador coast. From frequent enquiries I found that these people hold the opinion that the walrus feeds almost exclusively on white clams (*Mya truncata* and *M. arenaria*) but they cannot account for his being able to open them without breaking the shells. This is probably done by pressing them with the tongue against the teeth and hard palate and perhaps also against the inside of the tusks which are always more or less worn near the roots, epecially on one side.

32. Bearded or Square-flipper Seal, *Erignathus barbatus* (Fabricius). This species appears to be common in Hudson's Strait. A few were seen by members of the expedition and their skins, some of them 11 or 12 feet long, were in the hands of all the parties of Eskimo we met with. In 1877 I noticed them occasionally on the East-main coast and in the end of September killed a female, in the mouth of the Moose River, which measured 8 feet 3 inches in length and was estimated to weigh upwards of 600

pounds. She had a fœtus about a foot long. A few cray-fish were found in the stomach.

33. Grey or Horse-head Seal, *Halichœrus grypus* (Fabricius). Skins of this seal were seen in the hands of the Eskimo in Hudson's Strait, and a large species known by the name is not uncommon along the East-main coast.

34. Hooded Seal, *Cystophora cristata* (Erxleben). This seal, of which a small number are killed every spring off the Labrador and Newfoundland coasts, is rather rare in Hudson's Strait, where we saw only a few skins among the Eskimo. Its skin is greatly prized for making the feet of moccasins, on both sides of Hudson's Bay, where the animal is called clapmatch and clapmutch by the Hudson's Bay people.

35. Harp Seal, *Phoca Grœnlandica* (Fabricius). This is the commonest seal at all seasons in Hudson's Strait and Bay as well as on the spring ice off the coasts of Labrador and Newfoundland. The young are called bedlimers and bedlamers by the Newfoundland sealers.

36. Harbor or Bay Seal, *Phoca vitulina* (Linn.). Rather common around Hudson's Bay and, apparently so, also in the strait, as we saw their skins in the hands of most of the natives we met. In Newfoundland it is called the dotard and doter. Around Hudson's Bay it is known by some as the spotted seal and fresh-water seal, and is said to follow up the rivers and lakes for long distances from the salt water.

37. Musk Ox, *Ovibos moschatus* (Zimm.) The musk ox is found only in the north-western part of the shores of Hudson's Bay, in the neighborhood of Chesterfield Inlet.

38. Reindeer, Barren-ground Caribou, *Cervus tarandus* (Kerr), var. *arctica* (Rich.) One of the commonest mammals of the barren grounds on both sides of Hudson's Bay and also on both shores of the strait.

In regard to the Cetacea, the white porpoise or white whale, *Delphinopterus catodon* (Linn.), is by far the most common being found in great numbers around both shores of Hudson's Bay and James' Bay and its southern extremity. They are not very often seen in the strait. The narwhal (39), *Monodon monoceros* (Linn.), is said to be occasionally killed in the northern parts of the bay. A dead specimen was cast ashore on the north side of the strait, near the Middle Savage Islands, last summer, and the "horn," a very large and old one, was brought by the natives to the observatory station at Ashes' Inlet.

I have obtained, from various sources, the common names of the

Cetacea frequenting the waters off the Labrador coast and also those found in Hudson's Bay, and have submitted the information to J. A. Allen, Esq., of the Museum of Comparative Zoology, Cambridge, U.S. In reply he has kindly written me as follows: "It is very difficult to identify the Cetacea by the vernacular names, except in a few cases. The 'Right Whale' and the 'Black Whale' are both doubtless (40), *Balæna cisarctica* (Cope). The 'Polar Whale' and 'Greenland Whale" must be (41), *Balæna mysticetus* (Linn.) The 'Sulphur-bottom' and 'Finner' are names too vaguely applied to be identified; they both relate to some species of (42) Fin-back Whale, of which there are a number of species, belonging to several genera. The 'Hump-back' is (43) *Megaptera longimana* (Rudolphi). The 'Killer' is (44) *Orca gladiator* (Bonn.) The 'Puffer' or 'Puffing-pig' is (45) *Phocæna communis* (Less.) It is impossible to say what the 'small black whale with a prominent fin on his back' seen by you near Cape Chudhigh may have been, there being five or six species that might answer to this description. Besides those already mentioned, the following must be more or less common: Common Fin-back (46), *Physalus antiquorum* (Gray); Rudolphi's Rorqual (47), *Sibboldius laticeps* (Gray); Bottle-nose Whale (48), *Hyperoodon rostratum* (Chem.); White Whale (49), *Delphinoplerus catodon* (Linn.); Grampus (50), *Grampus griseus* (Cuv.); Black-fish (51), *Globiocephalus melas* (Naill.); White-beaked Dolphin (52), *Lagenorhynchus albirostris* (Gray); Exhrichts Dolphin (53), *L. acutus* (Gray); Common Dolphin (54), *Delphinurus delphis* (Linn.) Of the large whales those most likely to occur in Hudson's Bay are the Hump-back, the Polar or Greenland Whale and the Fin-back."

APPENDIX III.

LIST AND NOTES

BY DR. R. BELL,

OF BIRDS OF THE VICINITY OF HUDSON'S BAY AND LABRADOR.

Fifty-one of the species of birds mentioned in the following list were obtained during the expedition :—

Skins of 35 of these marked thus (*) were presented by Dr. Matthews of York Factory. Seven skins were secured by Dr. Bell, and the remaining ten species in the list marked thus (†) are those observed, but of which no specimens were secured.

The skins have been examined and named by Mr. Whiteaves.

* 1. Ruby-crowned Kinglet, *Regulus calendula*, Linn. York Factory.

* 2. Yellow Warbler, *Dendrœca œstiva*, Gmelin. York Factory.

* 3. Pine-creeping Warbler? *Dendrœca pinus?* Wilson. York Factory.

* 4. Great Northern Shrike, *Lanius borealis*, Vieillot. York Factory.

* 5. White-crowned Sparrow, *Zonotrichia leucophrys*, Forster. York Factory.

* 6. Baltimore Oriole, *Icterus Baltimore*, Linn. York Factory.

7. American Raven, *Corvus corax*, Wilson. One specimen shot and several seen about Port Burwell, 28th September.

* 8. Common Kingfisher, *Ceryle alcyon*, Linn. One specimen from York Factory. This bird is rare so far north.

* 9. Hairy Woodpecker, *Picus villosus*, Linn. York Factory.

† 10. Peregrine Falcon, *Falco peregrinus*, Linn. An old bird and two young ones beginning to fly were shot on Marble Island on 1st September.

* 11. Winter Falcon, or Red-shouldered Buzzard, *Buteo lineatus*, Gmelin. York Factory.

12. Greenland Gerfalcon, *Falco candicans*, Gmelin. Two specimens killed at Port Burwell in August and September.

* 13. American Goshawk, *Astur atricapillus*, Wilson. York Factory.

* 14. Marsh Harrier, *Circus Hudsonius*, Linn. York Factory.

† 15. Willow Ptarmigan, *Lagopus albus*, Gmelin. Abundant in the wooded part of Labrador and on both sides of Hudson's Bay as far north as the limits of timber and brushwood.

† 17. Rock Ptarmigan, or Rocker, *Lagopus rupestris*, Gmelln. Abundant on both sides of Hudson's Strait. Vast numbers of them were congregated on the southern part of Resolution Island on the 27th September, as if preparing to fly south across the Strait to the Button Islands and Cape Chudleigh.

* 17. Canada Grouse, *Canace Canadensis*, Linn. York Factory. The ruffed grouse, *Bonasa umbellas* (Stephens) also comes nearly as far north as York Factory.

* 18. Black-bellied Plover, *Squatarola helvetica*, Linn. York Factory.

* 19. Golden Plover, *Charadius virginicus*, Borck. York Factory.

* 20. Ring-necked Plover, *Ægialites semipalmatus*, Bon. York Factory.

* 21. Turnstone, *Strepsilas interpres*, Linn. York Factory.

* 22. Spotted Sandpiper, *Tringoides macularius*, Linn York Factory.

23. Buff-breasted Sandpiper, *Tryngites rufescens*, Vieillot. Port Burwell, 28th September.

24. Larger Yellow-shanks, *Totanus melanoleucus*, Gmelin. York Factory and Fort Churchill.

25. Hudsonian Curlew, *Numenius Hudsonicus*, Latham Abundant at Churchill during August. Mostly gone by 1st of September.

26. Eskimo Curlew, *Numenius borealis*, Forster. Also abundant at Churchill in August, only a few remaining till the beginning of September.

* 27. Virginia Rail, *Rallus virginianus*, Linn. York Factory.

28. Trumpeter Swan, *Cygnus buccinator*, Richardson. Nottingham Island, Marble Island and Churchill. This bird also breeds on the islands off the East-main coast of Hudson's Bay.

29. Snow Goose, White Wavy, *Anser hyperboreus*, Pallas. Beginning to arrive at Churchill 5th September.

30. Brant Goose, *Bernicla brenta*, Steph. Digges Island and Stupart's Bay, Cape Prince of Wales.

* 31. Pin-tail Duck, *Dafila acuta*, Linn. York Factory.

32. Long-tail Duck, Ka-ka-wee of the Outchipwais and Ha-ha-wai-ya of the Northern Crees. *Harelda glacialis*, Linn. York Factory.

* 33. Lesser Scaup Duck, Little Blue-bill. Howden of the people of Labrador and Newfoundland, *Fulix affinis*, Baird. Breeds in large numbers on Nottingham Island; the young beginning to fly in the last week of August. Churchill, York Factory.

34. Green-winged Teal, *Querquedula carolinensis*, Steph. York Factory.

35. American Eider Duck, *Somateria Dresseri*, Sharpe. In various parts of Hudson's Strait, at Churchill and York Factory. Common on the East-main coast.

36. Surf Duck, *Œdemia perspicillata*, Linn., Sp. Stupart's Bay, Cape Prince of Wales.

* 37. Red-breasted Merganser, *Mergus serrator*, Linn. York Factory.

38. Common Gannet, *Sula bassana*, Brisson. Near North Bluff.

39. Arctic Tern, *Sterna macroura*, Naum. In Hudson's Strait and along the west coast of Hudson's Bay.

* 40. Bonaparte's Gull, *Chroicocephalus Philadelphia*, Ord. Sp. York Factory.

* 41. Black-headed Gull. *Chroicocephalus atricilla*, Linn. York Factory.

† 42. Common Kittiwake, *Rissa tridactyla*, Linn. Numerous along the Labrador coast, especially around Cape Chudleigh.

* 43. Long-tailed Skua, *Stercorarius Buffoni*, Boie. A specimen of this this bird shot near York Factory was presented by Dr. Matthews in 1880.

44. Fork-tailed Gull, *Xema Sabinii*, Sabine. Port Burwell, September.

45. Herring Gull, *Larus argentatus*, Brünnich. Hudson's Strait and Bay.

46. Slender-billed Fulmar, *Procellaria tenuirostris*, Audubon. Port Burwell, 28th September.

* 47. Common Loon, *Colymbus torquatus*, Brünnich. York Factory.

† 48. Arctic Loon, *Columbus articus*, Linn. Male, female and young (nearly full-grown) shot on Nottingham Island, 28th August.

† 49. Red-throated Loon, *Colymbus septentrionalis*, Linn. One specimen shot on Marble Island, 2nd September.

* 50. Pied-billed Grebe, *Podilymbus podicipes*, Linn., Sp. York Factory.

† 51. Black Guillemot, *Uria grylle*, Linn. Labrador coast, Hudson's Strait and Bay.

52. Least Auk, *Mergulus alle*, Linn. One specimen shot at Port Burwell, 28th September. Common in this neighbourhood.

(See also List of Birds by the writer in Report of the Geological Survey for 1878-79, p. 67C, and Notes on the Birds of Hudson's Bay in the Transactions of the Royal Society of Canada, Vol. I, Sect. IV, p. 49, 1882, in which many additional species are given.)

APPENDIX IV.

LIST

BY PROF. S. J. SMITH, YALE COLLEGE,

OF CRUSTACEA FROM PORT BURWELL,

COLLECTED BY DR. R. BELL IN 1884.

Eupagurus Kröyeri Stimpson.

Four specimens.

Ceraphilus boreas Kinehan ex Phipps.

One female 64^{mm} in length.

Hippolyte Fabricii Kröyer.

Two females.

Hippolyte Phippsii Kröyer.

One male and eleven females. The single male, 29^{mm} long, has only one supra-orbital spine each side.

Hippolyte polaris Ross ex Sabine.

Five males and eleven females. One female gives the following measurements: length from tip of rostrum to tip of telson, 68^{mm}; length of carapax including rostrum, 24^{mm}; length of rostrum, 10.4^{mm}; breadth of carapax, 11.2^{mm}.

Hippolyte Grœnlandica Miers ex J. C. Fabricius.

Eight males and seven females. The males from 43 to 68^{mm} long, and the females from 45 to 93^{mm}.

Pandalus Montagui Leach.

One large female over 100^{mm} long.

Mysis oculata Kröyer ex O. Fabricius.

Fragments of a single specimen.

Anonyx nugax Miers ex Phipps.

One specimen.

Pleustes panoplus Bate ex Kröyer.

One specimen.

Œdiceros lynceus M. Sars.

One specimen.

Gammarus locusta Fabricius. (G. *ornatus* M. Edwards.)

Many specimens.

Rhachotropis aculeata Smith. (*Tritropis aculeata* Boeck.)
Four females.

Æga psora Kröyer ex Linné.
Two specimens.

Phryxus abdominalis Lilljeborg ex Kröyer.
One specimen on *Hippolyte polaris.*

Arcturus Baffini Westwood.
Three specimens. The body of the largest specimen measures 46^{mm} in length and the antennæ 51^{mm}.

LIST

BY J. F. WHITEAVES,

OF MARINE INVERTEBRATES FROM HUDSON'S STRAIT,

COLLECTED BY DR. R. BELL IN 1884.

1. From Ashe's Inlet, Upper Savage Island, N. Side of Hudson's Strait.

Mollusca.

Pecten Islandicus, Müller.
Modiolaria nigra, Gray.
Modiolaria lævigata, Gray.
Nucula inflata, Hancock.
Leda pernula, Müller.
Leda minuta, Müller.
Yoldia myalis, Couthuoy.
Cardium ciliatum, O. Fabricius.
Aphrodite Grœnlandica, Chemnitz.
Astarte (*Triodonta*) *lactea*, Broderip and Sowerby.
Astarte (*Nicania*) *Banksii*, Leach.
Astarte compressa Linnè, non. Mont. (= *A. elliptica*, Brown.)
Cardita borealis, Conrad.
Macoma calcarea, Chemnitz.
Mya truncata, L.
Saxicava pholadis, L.
Acmæa rubella, O. Fabricius.
Margarita striata, Broderip and Sowerby.
Machæroplax varicosa, Mighels (Sp.)
Lunatia Grœnlandica, Beck.

Natica clausa, Broderip and Sowerby.
Trichotropis borealis, Broderip and Sowerby.
Turritella erosa, Couthuoy.
Turritella reticulata, Mighels.
Admete viridula, O. Fabricius.
Trophon craticulatus, O. Fabricius.
Buccinum tenue, Gray.
Buccinum Grœnlandicum, Chemnitz.

Annelida.

Pectinaria granulata.

Cirripedia.

Balanus crenatus, Auctorum.

2. From Port Burwell, Cape Chudleigh.

Echinodermata.

Ophioglypha Sarsii, Lutken.
Ophioglypha nodosa, Lutken.
Ophiopholis aculeata, O. F. Müller.
Asterias polaris, Müller and Troschel.
Asterias littoralis, Stimpson.
Strongylocentrotus Drobachiensis, Müller.

Brachiopgda.

Rhynchonella (*Hypothiris*) *psittacea*, Chemnitz.

Mollusca.

Modiolaria nigra, Gray.
Modiolaria lævigata, Gray.
Modiolaria nigra, Gray.
Nucula inflata, Hancock.
Leda pernula, Müller.
Leda minuta, O. Fabricius.
Yoldia myalis, Couthuoy.
Cardium ciliatum, O. Fabricius.
Aphrodite Grœnlandica, Chemnitz.
Astarte (*Triodonta*) *lactea*, Broderip and Sowerby.
Astarte (*Nicania*) *Banksii*, Leach.
Lyonsia arenosa, Möller.
Macoma calcarea, Chemnitz.

Mya truncata, L.
Margarita striata, Broderip and Sowerby.
Machœroplax obscura, Couthuoy. (Sp.)
Natica clausa, Broderip and Sowerby.
Amauropsis Islandica, Gmelin.
Trichotropis borealis, Broderip and Sowerby.
Turritella erosa, Couthuoy.
Turritella reticulata, Mighels.
Buccinum tenue, Gray.

The following additional species from Port Burwell have since been recognized by Prof. A. E. Verrill.

ECHINODERMATA.

Ophioglypha robusta, Ayres.
Pentacta frondosa, Jæger.

TUNICATA.

Cyrthia carnea, (Agassiz.)

MOLLUSCA.

Margarita helicina, O. Fabricius, (very large.)
Bela pleurotomaria, Couthuoy.
Bela bicarinata, Couthuoy, var. *violacea*.
Bela incisula, Verrill.

ANNELIDA.

Lepidonotus squamatus, L.
Harmothoe imbricata.
Ammochares, Sp.
Thelepus circinatus.
Spirorbis validus, Verrill.

APPENDIX V.

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LIST

BY H. H. LYMAN,

OF LEPIDOPTERA,

COLLECTED BY DR. ROBERT BELL IN HUDSON'S STRAIT IN 1884.

The collection consists of twelve specimens which, as far as can be determined, are as follows :—

Argynnis polaris, Boisd. Two specimens taken at Ashe's Inlet, north shore, August 13th. This species extends from Labrador to the extreme north, having been brought back by the naturalists attached to the "Alert," and "Discovery" Arctic Expedition.

Chionobas crambis, Freyer. Two specimens, Ashe's Inlet, August 13th; determined by Mr. W. H. Edwards. This has heretofore been regarded as a synonym of *C. Semidea.* Say, which flies on Mount Washington and in Labrador, but Mr. Edwards now regards it as distinct.

Laria Rossii, Curtis. One specimen, Ashe's Inlet, August 13th.

Agrotis dissona, Mœschler. One specimen, Ashe's Inlet, August 13th. This and the last species are very great rarities in collections.

Anarta Richardsoni, Curtis. Two specimens, Cape Chudleigh, Aug. 7th.

Tephrosia ? ———. Three specimens in too poor condition for accurate determination. Cape Chudleigh, August 7th.

——— One specimen undeterminable, Cape Prince of Wales, August 17th.

I am indebted to Mr. J. B. Smith of Brooklyn, an authority on the Noctuidæ, for the determination of the moths. There are no specimens of *Colias* in the collection, though one would naturally have expected to find them.

LIST

BY J. B. SMITH, BROOKLYN,

OF COLEOPTERA,

COLLECTED BY J. R. SPENCER AT FORT CHURCHILL.

(Per favor of Mr. James Fletcher, Ottawa.)

1. *Carabus baccivorus.*
2. *Pachyta liturata.*
3. *Acmæops proteus.*
4. *Criocephalus obsoletus.*
5. *Neoclytus conjunctus.*
6. *Amara similis.*
7. *Amara hyperborea.*
8. *Pterostichus Hudsonicus.*
9. *Cryptohypnus abbreviatus.*
10. *Colymbetes sculptilis.*
11. *Gaurodytes griseipennis* (?)
12. *Dytiscus confluens.*

13, 14. Two species unknown to Mr. Smith.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

REPORT

ON

EXPLORATIONS AND SURVEYS IN THE INTERIOR

OF THE

GASPÉ PENINSULA.

1883.

BY

R. W. ELLS, M. A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1884.

ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., &c.

Director of the Geological and Natural History Survey of Canada.

SIR:—Herewith I have the honor to submit my report on the Geology of the interior of the Gaspé Peninsula and a portion of Prince Edward Island, with illustrative maps. These are numbered 5 S.W., 5 N.W., 5 N.E., 3 N.E., 3 N.W., 6 N.W., 7 S.W., 15 S.E., 15 S.W., nine quarter-sheets in continuation of those already published. They include the results of the surveys of the last two seasons, as well as those by Sir Wm. Logan and the members of his staff, at various times from 1844 to 1868. In their construction we have availed ourselves of the latest information obtainable from the Crown Land Office at Quebec, to the members of which Department our thanks are due for assistance in making tracings of township plans. We are also indebted to Messrs. R. H. Montgomery and B. V. Willett of New Richmond, and to Messrs. J. and E. Collas and Joseph Eden, Esq., of Gaspé Basin, for sundry favors, as well as to Mr. P. S. Archibald, Chief Engineer of the Intercolonial Railway at Moncton for the use of the plans of the Prince Edward Island railroad.

I have the honor to be

Sir,

Your most obedient servant,

R. W. ELLS.

Ottawa, May 1884.

BIBLIOGRAPHY OF P. E. I. GEOLOGY.

1. Dr. Dawson announced the existence of Carboniferous plants in Prince Edward Island in an article on the geology of the Island, in the *Royal Gazette*, Charlottetown, in 1842.

2. Sir C. Lyell (*Travels*, Vol. II., p. 250,) mentioned this fact on Dr. Dawson's authority, but supposed that the whole island was Carboniferous.

3. In 1854, Dr. Dawson contributed a note to Dr. Leedy's description of *Bathygnathus borealis* (Proceedings Ac. Nat. Sci., Phila., 1854,) refrering to the Triassic beds.

4. In *Acadian Geology* (1st edition, 1855, and in subsequent editions, with additional facts,) the substance of the previous papers is stated.

5. Report by Drs. Dawson and Harrington, 1871.

6. Paper by Dr. Dawson on permo-Carboniferous of Nova Scotia and Prince Edward Island, *Journal of Geol. Society*, August, 1874.

7. Paper by Mr. Bain, *Canadian Naturalist*, 2nd series, Vol. IX., No. 9; communicated to Natural History Society, Montreal, by Dr. Dawson.

REPORT

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BY

R. W. ELLS, M.A.

To complete the map of the Gaspé Peninsula, of which the part bordering on the Bay of Chaleurs was published in 1882, it was found necessary to examine in greater detail, the country about the heads of the Cascapedia and Bonaventure Rivers on the south, and the Ste. Anne des Monts and the Magdalen on the north and east of the Shickshock Mountains, and to obtain if possible more precise information regarding the structure of that range, especially in its relation to the apparently underlying Levis formation on the north, and to determine the limits of the Silurian and Devonian systems which occupy the central and southern portions of the peninsula. The examination and survey of the St. Anne and upper Magdalen Rivers were entrusted to Mr. A. P. Low, B. Ap. Sc., who had been my assistant during two previous seasons; see report F. of the present volume.

The geological formations which exist between the Shickshock range and the Bay of Chaleurs were more particularly studied by myself. In this I was assisted by Messrs. N. J. Giroux, C.E., P.L.S., of L'Ecole Polytechnique of Montreal, and Alfred E. Barlow, B.A., of McGill College, the former of whom took charge of the topography, while the latter was principally engaged in the search for fossils at various localities. Assistants.

Micrometer surveys were made of the head waters of the Bonaventure River from the Upper Forks, which was reached by Mr. Murray in 1844, to the lake near the head of the main stream, by which a section of the rocks was afforded us almost to the Magdalen River. Subsequently the two main branches of the Cascapedia River were surveyed. The most easterly, called the Salmon Branch, takes its rise in Lake Cascapedia, in the heart of the Shickshock Mountains, and within a short distance of some of the branches of the Ste. Anne River. It joins the main stream fifty miles from its mouth, and has a total length of twenty-seven miles from the lake to the Forks. The western tributary, known as the Lake Branch, has a length of eighteen miles from the forks of the Salmon Branch to the junction of the Lake Inlet and Miner's Brook. These were both surveyed; the latter for a further distance of twenty-seven miles, making a total length of ninety-three miles from the mouth of the main stream, beyond which it is probably continuous through swamps for six or eight miles further to its source. The Lake Inlet, so-called, from the presence of a most beautiful sheet of water, half a mile from its junction with the Miner's Brook, was measured for about five miles, or to the great gorge through the western prolongation of the Berry Mountain range. Beyond this, it has a direction from the north-west, nearly parallel to the Miner's Brook, and probably takes its rise in the same swampy flats. The Causapscul, a large stream, flowing into the Matapedia River has its source in the same locality. This is in the vicinity of the Great Matane Lake, between which and the Causapscul, Indian portages are said to exist.

Rivers surveyed.

The operations of the past season were much hindered in June and July by heavy rains and consequent freshets which rendered it impossible, for days at a time, to ascend the streams, while in September the water had fallen so low that canoes could not be used at all. The necessity for ascending the streams in every case for fifty miles or more to reach the starting point of our surveys, also proved a source of great delay.

Previous exploration and surveys.

A large amount of work had previously been done in the areas under discussion. In 1844 a traverse was made by Sir William Logan, from the St. Lawrence to the Bay of Chaleurs. He ascended the Chat River to the Forks, twenty-seven miles, thence portaged through the woods by way of the Goashore Brook and Conical Mountain to the Lake Branch of the Cascapedia River, which he descended to its mouth, a distance of sixty-four miles. A large number of peaks in the Shickshock range were triangulated from the mountains in the vicinity of Chat Portage. In 1845 Mr. Murray surveyed the Ste. Anne des Monts to the Forks, thirty-two miles, and spent several weeks in triangulating the peaks in the eastern part of the range. He also ascended the Bonaventure as far as the Upper Forks, fifty-three miles from the mouth, and surveyed the St. John or Douglastown for fifty-four miles. In 1857, Mr. Richardson surveyed the Magdalen River for a distance of sixty miles to the Upper

Forks and made several traverses from that stream to the rivers flowing east into Gaspé Basin. The York and Dartmouth rivers were afterwards surveyed by Mr. Bell, the former for fifty miles to Magdalen Brook, and the latter for forty-three miles. During the past season (1883) Mr. Low made a traverse across the peninsula by way of the South Branch of the Ste. Anne des Monts and the West Branch of the Little Cascapedia rivers, a portage of three miles only being necessary.

From these various traverses and surveys, together with the additional work of the past season, we have been able to arrive at a very fair idea of the distribution of the several geological systems met with in this peninsula. The maps, however, show considerable areas in which the topographical details are wanting. Except the information furnished by the surveys named, as having been made by the Geological corps, and the details contained in the plans of the townships which skirt the coast on both sides of the peninsula, nothing is definitely known concerning the various streams, more especially those flowing into the Bay of Chaleurs and the Gulf of St. Lawrence. Rough sketches of some of the most important branches may be found in the plans made by surveyors who have traversed the area in search of timber limits, but these, from their disconnected character, are far from satisfactory. In such a country topographical surveys can only be economically conducted during the winter months; when, after the beginning of February a crust generally forms over the deep snow, making progress on snow-shoes comparatively easy. The blowdowns and dense undergrowth which often render the woods impassable in summer, are then, for the most part, concealed, and a small party could survey the many branches of the various rivers and connect their head waters at a comparatively small expense.

Imperfect maps.

Winter surveys

While, however, such surveys would give us much valuable topographical information, the geological results would be small, since, except in high cliffs, the rock exposures would, to a great extent, be hidden from view.

In pursuance of the plan for carrying on the past season's operations, we left Ottawa on the 6th June for Dalhousie, the most convenient centre for our work. While waiting for supplies, which had been delayed in transit from Montreal, an excursion was made to the forks of the Scaumenac River, on the opposite side of the Restigouche Harbour, to collect fossils, and thus determine definitely the horizon of the Silurian rocks which there underlie the Devonian basin. We were fortunate in getting a large variety and some perfect forms. These have, since our return, been submitted to Mr. Whiteaves for examination, the result of which will be given in the section on Silurian. From Dalhousie we proceeded to New Richmond and reached the mouth of

Plan of operations.

Fossils.

the Cascapedia River on the 15th of June. Here, while waiting for the freshet to subside, we employed the time in collecting fossils from various localities in the neighborbood. Having at length secured three canoes with their crews, we started up stream on the 19th. Continuous rains, however, compelled us to relinquish the attempt to reach the head waters of this river. We therefore proceeded to the mouth of the Bonaventure, and in six days, notwithstanding the high water and consequent heavy poling, reached the Forks. After clearing the way past the heavy timber jams, by which Mr. Murray was stopped, in 1844, we commenced the survey of the main stream on the 3rd July, and in six days reached the lake at the head, a further distance of twenty-seven miles, progress being slow from the obstructed character of the river channel, necessitating the cutting of numerous portage roads where the jams were too extensive to be cleared out. An inlet of considerable size enters the north end of the lake. This, at a distance of two miles, divides into three branches, the eastern and middle of which rise in close proximity to York River, while a ridge of moderate elevation separates their sources from the waters of the Magdalen on the north. The Lake by aneroid was calculated to be 1450 feet above sea level. The descent of the branch is much more rapid than that of the main stream, being about twenty-eight feet to the mile, while from the Forks to the sea the average fall per mile is not more than twelve feet.

Cascapedia and Bonaventure Rivers.

Character of the country.

The country bordering on the lower part of the Bonaventure River, has to some extent been already described by Mr. Murray, in the report of progress 1844. Above the Forks the general course of the valley is north. (Magnetic variation about twenty-five degrees west). The hills on both sides for fifteen miles are from 500 to 800 feet above the stream. Above this point the surface becomes much less rugged and there are quite extensive areas of low land along the banks. Timber of large size, spruce, fir and white birch, is plentiful, but the cedar, which is so abundant and of such excellent quality along the main stream, disappears almost entirely on its upper portion. As a source of supply for lumber the valley of the Bonaventure far surpasses any other stream examined by us in the Gaspé Peninsula. The spruce has so far apparently escaped the agency which has destroyed so much of the forests along the streams flowing east into Gaspé Basin, while large quantities of pine still remain on its branches. Extensive areas of good land, well suited for agriculture, border the river for twenty-five miles from the mouth, but on the upper part of the stream, the land, though in many places of good quality, has such an elevation that frosts will probably prove injurious. During the first half of July we had ice on nearly every clear night.

Timber.

Agricultural land.

The Bonaventure River is noted for the extreme clearness and coldness of its water. The temperature, taken at various times in July, gave an average of 45° Fahr. No fishes are found in it, except a few very small trout, till the advent of the salmon and sea-trout. Birds of all kinds, and especially water-fowl which are so plentiful on all the rivers of Gaspé and northern New Brunswick, are almost entirely wanting.

Temperature of the water.

Animals.

The survey of the several branches of which there are five of good size, was found to be impracticable in canoes on account of jams and the shallowness of the channel, while the coldness of the water rendered it impossible to wade them. Finding it therefore useless to attempt any further work in this direction, we descended the stream and returned to the Cascapedia, when a second attempt to reach the Salmon Branch, fifty miles from the mouth, was successful, and the survey of it was commenced on the 27th July.

The course of the Salmon Branch to Lake Cascapedia is twenty-seven miles, with a fall in that distance of 840 feet, making it very rough and rapid. Only twenty-two miles could be surveyed in canoes, and in this part there are three falls, the first at sixteen miles, of four feet; the second at eighteen miles, 25 feet, and the third at nineteen miles, 10 feet. Where our survey ended there are very heavy rapids. These are caused by the stream suddenly turning past the spur of an immense cliff, not less than 1000 feet high, on the west bank, while on the east a low flat lies between the river and the foot of a peak, called the South Mountain, which rises abruptly for nearly 1,400 feet.

Survey of the Salmon Branch

The upper part of the Salmon Branch for fifteen miles must have a descent of nearly fifty feet per mile, presenting the character of a mountain torrent. A short distance below its mouth a range of lofty hills, called the Big Berry Mountains crosses the Cascapedia. Northward from this range a tract of comparatively level country extends for eight or ten miles, forming a large inland plateau, which is well defined for many miles, both to the east and west, and probably stretches from the vicinity of Lake Matapedia to Gaspé Basin. It was traversed for a distance of forty-five miles on the Lake Branch of the Cascapedia, and appeared to extend much further as no highland was visible in that direction, while to the east, it crosses the head waters of the Little Cascapedia in the vicinity of Lake St. Anne. This plateau may be stated to contain from 1,200 to 1,500 square miles, with an elevation over a great part of the area of 500 to 700 feet. Should early frosts not be prevalent, its value, from an agricultural point of view, is very great, since the soil is generally of excellent quality, and the large areas of spruce and alder swamps, if cleared, would furnish extensive grass lands. The first white frost, which, however, was slight, was noted by us on the 16th of August.

Large inland plateau.

Good soil.

Valuable timber.

Railway route.

The valleys of the Shickshock range and of the several streams surveyed in this direction contain a large amount of valuable timber which as yet is unaffected by disease and will prove a source of revenue for many years. Should it ever be in contemplation to construct a line of railway from the Intercolonial to Gaspé Basin the route along this plateau would certainly be the shortest and easiest, since the country is comparatively level, while by crossing the heads of the several streams the expensive bridges that would be necessary on the shore line would be avoided. It would also open up a large tract, of at present, inaccessible country. The length from the Intercolonial to Gaspé by this route would not be much more than 150 miles. Between the Lake Branch of the Cascapedia and the Bay of Chaleurs the country is not well adapted for settlement. Near the rear of the townships of Maria and New Richmond, the surface becomes exceedingly broken and rugged and shows a succession of hills and ridges from 800 to 1,700 feet high. The stretch of table-land in the vicinity of the Nouvelle River, referred to in the Report for 1881, evidently does not reach this river, as the ranges are intersected by deep gorges, and from the reports of those who have traversed this area comparatively little level land exists. In the neighborhood of the Square Fork, which is a large tributary from the west, at thirty-eight miles from the mouth, the scenery becomes particularly wild, the Little and Big Berry Mountains having peaks 1,500 to 2,000 feet high. From the summit of these mountains a magnificent panoramic view of the Shickshocks is obtained, surpassing in grandeur the mountain scenery of any other portion of eastern Canada. In the foreground the immense mass of the Barn-shaped Mountain towers in a double-headed peak to a height of 3,400 feet. It marks the northern limit of the inland plateau and in its rear are the minor granitic peaks about the head of the Ste. Anne River and Lake. In the back-ground the long-serrated ridge of the Notre Dame Mountains, terminated eastward by the huge bulk of Mt. Albert, and containing among a hundred others the immense masses of Mounts Logan, Bayfield and Matawees, stretches westward beyond the limits of vision. Further eastward the transverse range of Table-top Mountain, with peaks but little short of 4,000 feet, cuts apparently right across the strike of all the others, while from the approximately level plain at our feet rise several cone-shaped masses which by their outlines indicate their probable igneous origin.

Rugged country

Berry Mountains.

Mount Albert.

Good land.

East of the Cascapedia the country is much less rugged. On the Little Cascapedia, Bonaventure, Port Daniel and Pabos Rivers large areas and extensive flats can be found, apparently suited for cultivation. Between the inland plateau, previously noted, and the foot of the Shickshock range, a second tract of apparently good land, formed from calcareous and slaty rock is seen. This also has a considerable extent, both east and west. It has an average elevation of 1,000 feet. Much of it is well-wooded, especially with spruce; the forests of which are continuous as far as the eye can reach.

The country along the Lake Branch of the Cascapedia and its two tributaries Lake Inlet and Miner's Brook, is, for the most part, comparatively low, and broken by a few ridges and scattered elevations. Of these, the most marked is the western prolongation of the Berry Mountains which extends for some thirty-five or forty miles, dividing, in their upper part, the waters of the Lake Inlet and the Miner's Brook. Of the country to the south of this range we cannot speak from personal observation, but from the reports of hunters, there seems to be another area of low land of considerable extent. The sluggish character of the Lake Inlet, and the fact that the Square Forks of the Cascapedia, and the Nouvelle River take their rise here in large lakes, tends to confirm this view.

Lake Branch of the Cascapedia

Prince Edward Island.

Work in Prince Edward Island.

Toward the end of the season some time was spent in the examination of the so called Triassic rocks of Prince Edward Island, to determine the extent and value of the recently discovered gold-fields in the vicinity of Cape Wolf, as well as to obtain, if possible, more definite information concerning the geological structure, and the prospect for finding coal seams by boring. The result of our investigations is given in the following pages.

The geological systems which came under our observation during the past season, were:—

Permo-Carboniferous. H. G.
Devonian. F.
Silurian. E.
Cambro-Silurian. D.
Pre-Cambrian. A. B. (metamorphic schists of the Shickshocks).
Serpentine, Dolerite, Trap, Granite, etc.

Permo-Carboniferous, H. G.

In the Report of Progress for 1880–81 attention was directed to a series of soft red beds, sandstones, shales, and calcareous conglomerates, resting upon the millstone grit unconformably, and occupying the coast of the Tormentine Peninsula from Cape Bald eastward into Bay Verte. Their resemblance to the strata composing Prince Edward Island was at that time stated, with the opinion that they belonged probably to an intermediate horizon between the Carboniferous and the Triassic, and were most closely related to the former. They were accordingly designated as Permo-Carboniferous. As strata, identical in

Age of the Prince Edward Island strata.

character, are found at Cape Brulé, the first headland east of Point du Chêne, as well as on the extremity of some of the points between Shediac River and Cocagne Head, a still greater development may be assigned to these beds in New Brunswick than was stated in that report.

Resemblance to the New Brunswick rocks.

During our visit to Prince Edward Island the greater part of the coast between Cape North and Orwell Bay, on the south and west, and various points on the north side were carefully examined. The great similarity of the strata there exposed to those just described as occurring across the Northumberland Strait in Westmoreland and Kent counties in New Brunswick was everywhere apparent.

These rocks differ in a marked manner from the red Triassic beds of the Minas Basin in Nova Scotia. At nearly every point on the coast and in the exposed ledges inland, they contain abundance of fossil plants, large tree stems, *Calamites*, *Cordaites*, and fine ferns, some of which have a decidedly Carboniferous aspect. The Triassic of Nova Scotia has not, however, though carefully examined for many years, disclosed any such fossils, except in one instance, recorded many years ago by Jackson and Alger.

Unlike the Triassic rocks of Nova Scotia.

In their composition and lithological aspect the rocks of the two localities also present marked differences. The red sandstones of Minas Basin, where this formation is principally exposed, are generally soft and homogeneous and contain interstratified beds of fibrous gypsum. Conglomerates are found only at rare intervals on the north side of the Basin. The red beds of the Island do not contain gypsum, and there are large areas of conglomerate, some of which in their character and contained pebbles closely resemble portions of the recognized Carboniferous of New Brunswick, while others, consisting largely of pebbles of red shale, cemented by a sandy and dolomitic paste and with much disseminated white calcite, do not appear at all in the Trias of the Bay of Fundy. Limestones are known to occur in the Trias of the latter place in only one locality, recognized by us in 1876, where they rest in a depression in the trap. These are grey in color, and contain geodes and nodules of jasper, agate, etc., but are entirely distinct in character from the so-called limestones of the island.

Carboniferous area of New Brunswick. Four anticlinals.

It has been stated in former reports on the Carboniferous of New Brunswick that the Gulf of St. Lawrence occupies the centre of a great irregular basin, the western prolongation of which extends nearly across that province in a south-westerly direction. In this area four distinct anticlinals were recognized, having a general course north-easterly. Of these the most northerly, or that between Bathurst and Miramichi, passes outside the northern end of the island. The second anticlinal, extending from Grand Lake to Richibucto Head, passes in its eastern extension through the northern part of the island in the vicinity of Miminegash. The third, crossing from the vicinity of Shediac, would reach the island in the neighborhood of Cape Egmont, while the fourth, leaving the mainland at Cape Tormentine, crosses the Strait of Northumberland, and reaches the island in the vicinity of Cape Traverse. This gives us at least three anticlinals along the western and southern portion, while a fourth, following the course of an anticlinal seen in the northern part of Cumberland county in Nova Scotia, extending from the head of Cumberland Basin to Pugwash Harbor, could account for the older aspect of the beds on Governor's Island in Hillsborough Bay.

The generally horizontal position of the strata prevents the exact location of these several anticlines, though the general structure is sufficiently apparent. The difficulty is still further increased by the presence of much false bedding in the various strata, so that a great seeming diversity of dip is disclosed at many points.

At North Cape, which is the extreme north end of the island, the beds exposed on the beach and in the low cliffs are soft red sandstone, with interstratified but irregular beds of brownish red conglomerate, containing pebbles of white quartz and other rock. The sandstones and shales are often highly micaceous and identical in character with the beds seen on the mainland from Cape Brulé to Cape Tormentine, and which are without doubt of the same horizon. Some of these are so cemented by manganese as to resemble at first sight solid beds of that mineral. It however becomes removed by washing in the water, though the percentage in some portions is considerable. The dip at North Cape is N. E. $< 2°$, though there is so much false bedding that dips in rocks so nearly horizontal are not always reliable. In places impressions of plants allied to Carboniferous forms are common in the shales and sandstones. Other interstratified beds consist of hard dark red sandstone with thin shales, while bands of a moderately hard reddish brown calcareous conglomerate, the pebbles being of red shale, and containing white calcite in considerable quantity form a feature which can be easily recognized at many points around the island as well as on the mainland.

North Cape.

Manganese.

Fossil plants.

The same character of rock extends all along the coast on both sides; on the east to Alberton, and on the west to Miminegash, the calcareous conglomerate being a marked feature. At the latter place the strata dip apparently S. E. $< 2°–3°$, and contain abundance of plant stems. Thin greenish grey irregular patches, sometimes an inch in thickness, occur in the red beds. These however are not distinct layers, but are due merely to the bleaching out of the generally red color by the action of the organic matter of the plants, and are hence only seen in the vicinity of the latter.

The opposing dips at North Cape and Miminegash afford us evidence of the low anticlinal axis, already noted as coming to the coast in New Brunswick near Richibucto Head. Boring operations were at one time undertaken near Miminegash to discover coal, but were not carried to a depth sufficient to give any practical results.

Cliffs at Campbellton.

At Campbellton, seven miles south of the locality just mentioned, low cliffs of twenty to thirty feet are seen, composed of soft red sandstones with thin bands of calcareous conglomerate, like that already noted. Here also irregular patches of grey occur in the brownish red beds, due to the presence of plant stems, but no grey strata were seen. The rocks are identical with those seen at Kildare and Miminegash, and dip S. E. $< 2°$.

At Cape Wolf, seven miles and a half farther south, and at McWilliams Cove, two miles beyond, the rocks dip S. 70° E $< 2°$. They present the same characters as seen at the places just described, with perhaps a greater thickness of calcareous conglomerate. Plant stems are abundant, causing grey patches in the strata. Particular interest attaches to this locality from the reported discovery of gold in the conglomerate and the sands of the beach. Further reference will be made to its mode of occurrence and probable value under the head of Economic Minerals.

Gold.

Cape Wolf to Cape Egmont.

Between Capes Wolf and Egmont the soft micaceous sandstone and calcareous conglomerate are easily recognized in every cliff. The strata are so nearly horizontal that dips are of little value, but it is probable that a low anticlinal extends across the strait from a point between Shediac and Cocagne, and reaches the island in the vicinity of the last named cape, in which case the waters of Egmont Bay would occupy a shallow synclinal basin.

Cape Egmont to Summerside.

Between Cape Egmont and Summerside the coast, where examined, but more particularly at Fifteen Point, showed strata of the same character. The calcareous conglomerate which is here called a limestone, and stated by some of the residents to be suitable for burning, forms a marked feature. Plant stems, *cordaites*, *calamites*, etc., are abundant.

Of the rock at Summerside and about the shores of Bedeque Bay the same remarks may be made, but the strata are so nearly horizontal that no definite dip can be ascertained.

Cape Traverse.

At Cape Traverse, which is the portion of the island most nearly connected with the mainland of New Brunswick, being separated by only nine miles, the rocks are identical with those there seen to extend from Cape Brulé to Tormentine, already described in the Report for 1880-81, under the heading of Permo-Carboniferous. Soft red sandstones with scales of whitish mica are interstratified with hard dark red calcareous conglomerate, similar to that already noted. In addition to *calamites*, *cordaites*, etc., large trunks of trees are visible in the strata at this place. It is to be regretted that the rock is so incoherent, as in several cases, where fine ferns were seen, the attempt to remove them failed from its crumbling in pieces. Fossil plants.

Thence to Crapaud, where our observations along this part of the coast ended, the prevailing rocks are soft and micaceous with occasional bands of conglomerate. The banks are generally low, with rocky cliffs at the extremities of the points, and occasional ledges show in excavations along the roadside.

It is highly probable that the beds of Cape Traverse represent the lower portion of the formation brought into view by the extension of the Cape Tormentine anticlinal, the course of which, as shewn in New Brunswick, would cause it to reach the island in this vicinity. In this case, the waters of Bedeque Bay would, like those of Egmont, occupy a shallow synclinal.

On the road between Crapaud and Rustico, the country is much broken, elevations of 250 to 400 feet occurring. The cuttings on the summit of these hills often reveal ledges of soft red sandstone and shale, in which the remains of plant stems are visible, but all the strata seem to be affected by false bedding. The rocks are generally horizontal, and doubtless are the upper members of the formation, as represented at Cape Traverse and elsewhere. Crapaud to Rustico.

At Rustico, on the north shore, the strata consist of soft, red micaceous sandstone, like those already described, but without any special point of interest.

To ascertain the character of the fourth anticlinal, which was regarded as reaching the island in the vicinity of Pownal Bay, the beds at Gallas Point and Orwell were examined. Above the mouth of Hillsborough River, and along the road from Charlottetown to Cherry Valley the rocks are red sandstone of the usual type, and dip northerly at a low angle. At the extremity of Gallas Point, beds of a slightly different aspect are seen, which have a close resemblance to those observed at Cape Traverse, and along the west coast. These dip S. E.$>$5°—7°. Plant stems similar to those seen at other points were observed; among others a beautiful fern, nearly two feet long, which, however, owing to the incoherence of the bed could not be extracted. Tree trunks of large size are also seen in the vicinity, the bark of which has been converted into coal. This fact has led many persons to suppose that workable seams of this mineral exist at this place. Nodules of reddish oxide of iron are also common in some of the beds, but the quantity is not apparently sufficient to render the locality valuable. The tree stems and other organic matter have removed the red colouring matter from the rock, sometimes in patches of considerable size. Gallas Point beds.

The axis of the anticlinal is not visible at this place, but from the slightly reversed dips seen on Governor's Island and the Pownal shore it probably extends up Pownal Bay, a little to the west of Gallas Point Thence around the shore eastward to China Point and Point Prim the rocks are the usual soft, red micaceous sandstone, dipping uniformly south-easterly at a low angle.

The Pownal Bay anticlinal is, as already remarked, probably the extension of that seen in the northern part of Cumberland county in Nova Scotia. In this event, the synclinal in which the Spring Hill Mines are situated, embraces the eastern end of the island in the vicinity of Wood Islands and Murray Harbor.

Report by Drs. Dawson & Harrington. 1871.

It will be seen by reference to the report on this Province by Drs. Dawson and Harrington, (1871), that though the larger part of the island was at that time considered by the authors as of Triassic age, certain portions, among which are the coast from West Cape to Nail Pond and the vicinity of Gallas Point, were considered as pertaining to the upper Carboniferous. It is, however, manifest, from a close study of the various strata from Cape North to Point Prim, that both from their lithological character and the stratigraphical evidence, no such separation can be carried out. The great similarity, also, of all the plant remains from so many points, tends to confirm the impression that the whole of the strata exposed along the south and west coast must be assigned to the same horizon. The occurrence, also, of similar beds in the province of New Brunswick, about whose age but little doubt can exist, as well as on the coast of Pictou and Colchester, which have already been assigned to the upper portion of the Carboniferous, strengthens this view. We have, therefore, from the careful consideration of all these facts, been led to remove the great bulk of the island rocks, from the position which they have so long held as Trias, and to classify them under the head of Permo-Carboniferous.

Such full sections of the strata at the various points around the coast have been given in the report mentioned, that it is not deemed necessary to repeat them here. The marked similarity in character will be manifest at a glance.

Although the extreme eastern end of the island was not visited by us, it is evident from the description given by Dr. Dawson, that the rocks there are identical with those already described as occurring on the south and west coast.

Probability of workable coal seams.

Since we have no less than four synclinal basins of Carboniferous rocks underlying the island, it becomes a question of considerable importance whether seams of coal of workable size do not exist at such a depth as to be easily worked. The conclusions arrived at on the main land, especially in New Brunswick, should aid us materially in the solution of this problem.

In that province, the basin corresponding to that which is seen at the extreme north end of the island has several outcrops of coal. The most important are those seen on the Miramichi and Dungarvon Rivers, where the thickness of the seam is from four to twelve inches. The second synclinal, extending from Miminegash to Cape Egmont, contains on the mainland the largest seams known in the province. These have been worked for many years both at Grand Lake and on the Richibucto River, not far from the eastern coast. The thickness of coal ranges from fifteen to twenty-two inches, but at one place in the Grand Lake area, two seams occur, separated by a thin parting of shale, which give an aggregate of nearly three feet of workable coal. The horizontality of the measures is such that the outcrops at the two places are probably on the same seam, and in both the coal is very near the surface. As the distance between the mines on the Grand Lake and the Richibucto is about the same as between the latter place and the west side of the island, and as the measures which border on Northumberland Strait have the same horizontal position as at Grand Lake, we may fairly conclude that the same seam should be found underlying the island at no great depth. There is also the possibility that in its eastern extension this seam may acquire greater thickness, as changes in its character are frequently visible on the mainland.

Coal seams of the Miramichi and Dungarvon rivers.

Grand Lake coal seam.

The third synclinal, or that of Bedeque Bay, has in New Brunswick several outcrops of coal, but in all observed cases of no greater thickness than four inches. It may be also remarked that this basin does not constitute a portion of the main Carboniferous basin, but is separated from it by the great ridge of lower Carboniferous rocks, seen to the north of Moncton. The prospects of finding workable coals in this area do not therefore appear so favorable as in that just described. The same may be said of the fourth synclinal which extends under Hillsborough Bay.

East of Pownal Bay the extension of the Spring Hill synclinal, which contains at that place seams from one to fourteen feet thick, should, if continuous, be found. As the Spring Hill seams do not appear to maintain their thickness over any great part of the basin, either from thinning out or the presence of faults, it would be extremely hazardous to say that such seams as there exist would be found in the eastern portion of the island.

It does however seem practicable to prove the measures in the western portion of the island at a comparatively small expense. Two or three bore-holes could be put down to a depth of 500 feet, at a cost of from one to two dollars per foot, while the finding of a seam of coal of workable size would be of very great importance to this locality.

Borings desirable in western portion of the island.

From the facts just presented, the productive coal measures in which occur the immense beds of Cape Breton, Pictou and Spring Hill are probably wanting, in so far as the greater portion of the island is concerned. This fact has been clearly proved by boring, and in other ways in the province of New Brunswick, the formation being there confined to the lower portion of the Middle Carboniferous. Since therefore these beds extend eastward in a nearly horizontal position, there is evidently a great geological break, by which the rocks under discussion, now called Permo-Carboniferous, rest directly upon the millstone grit. The existence of thick seams, similar to those of Pictou, can therefore scarcely be expected.

General geological considerations.

From the general consideration of the geological problem affecting this area, it is probable that the western and central portion of the Carboniferous basin of the Gulf of St. Lawrence was elevated above the sea level after the deposition of the Millstone grit, and that this position was maintained undisturbed by the fluctuations of level that so seriously affected the measures in Nova Scotia, till near the close of the Carboniferous time. A gradual subsidence then took place, during which the rocks now seen on the island, and [at several points on the adjacent shore, were deposited. This probably marked the close of the palæozoic age. There is no evidence of subsequent disturbance in this area by the protrusion of dykes or extensive faulting, except at one point in New Richmond Bay, where a small dyke of trap has penetrated the sandstones of Hog Island, and altered the surrounding rocks to a slight extent.

Auriferous conglomerate.

The auriferous character of the red calcareous conglomerate which occurs at so many points along the south and west coast, adds an additional interest to the geology of the island. Assays were made from samples taken at random from the beach at Cape Wolf and McWilliam Cove, but there is apparently no reason why similar rocks from any part of the coast should not be equally gold bearing. Although the result of the assay was not such as to warrant the expenditure of money in mining, a company has already begun operations at Cape Wolf, and the practical result should be speedily visible.*

Views of Dr. Dawson and those in this report compared.

From a comparison of the views expressed with those contained in the report of Dr. Dawson referred to, there would seem to be a slight difference of opinion as to the age of the rocks under discussion. In a note from the author of that report in reference to this formation as developed at Cape Tormentine, he expresses himself decidedly to the effect that he regards the rocks of that locality as undoubtedly of Permo-Carboniferous age. Since, therefore, the rocks of a large portion of the island are manifestly of the same character and horizon, the apparent

* The yield of gold per ton from the red rocks of this portion of the Island will be seen by reference to the report of Mr. Hoffmann, p. —.

difference of opinion disappears. The strata along the northern coast will, therefore, constitute the upper part of this formation, but from the finding of the remains of Bathygnathus at New London, on the north side of the island, which has been regarded as a true Triassic fossil, it is possible that limited outliers of this age do occur, the separation of which, however, from the great mass of the Permo-Carboniferous cannot be done with accuracy.

Further remarks on the age of the formation under discussion will be found in the supplement to the Acadian Geology, page 33, and in "Fossil Plants of the Erian and Silurian," 1882, by Dr. J. W. Dawson, page 127, where the Carboniferous aspect of many of the plants found in the island is referred to.

Superficial deposits.

From the limited time at our disposal, special attention was not directed to the superficial deposits of the province. This subject has, however, been so exhaustively treated in the report referred to, that very little remains to be said. Of the economic value of the peat it may be generally stated that, though of excellent quality, the results of the manufacture of compressed peat for fuel in the Province of Quebec have been such that it is not probable these deposits can be at present utilized, except locally, when we take into consideration the nearness and cheapness of the Pictou coal; since that can be laid down at any point on the island at a much cheaper rate, proportionately to the value of the two as a fuel, than the peat could possibly be prepared for market.

Peat.

Gaspé Peninsula.

Devonian.—F.

Gaspé Peninsula

The area about to be described as belonging to this system is for the most part situated in the interior of the Gaspé Peninsula and forms a basin of large extent. It is continuous from a point west of the Matapedia River to Gaspé Basin, and has a breadth about the head of the Nouvelle and Cascapedia Rivers of about twenty-five miles. This, however, decreases to ten or twelve about the head waters of the Ste. Anne des Monts. Further east, on the Bonaventure and Gaspé Rivers, it again assumes large dimensions, having a total breadth of not much less than forty miles. The rocks of the system here are sandstones and shales, both red and grey, sometimes hard and gritty, and in their lower part associated with considerable beds of limestone. The hard and gritty portion, having better resisted the agencies of denudation, now form extensive ridges at some points 2,000 feet above the sea.

From the difficulty of penetrating the country, except along the large streams, the entire outline has not been traced. It has been fixed, however, at so many points, that its general position can be defined with tolerable accuracy. Its western limit can be seen on the Matapedia River, where the character of the rock and the contained fossils readily distinguish it from the underlying Silurian. It has here a breadth of a little over four miles, the southern border being found at a distance of seven miles in a direct line south of the mouth of the Causapscul River. As no surveys have yet been made on this stream,* the extent of the system, as there developed, is largely conjectural, but the area is presumably large, as it approaches very closely to the Matane Lake. Large lakes are said to occur on the upper part of the Causapscul, and the country in their vicinity is generally low and swampy. This area was penetrated by us for several miles in our survey of the Miner's Brook of the Cascapedia River, along which stream ledges and debris of Devonian rocks alone were found. This brook approaches to within about two miles of the great bend of the Chat River, where fossils of the age of the Gaspé limestone series occur. We may therefore safely conclude that the head waters of the Chat lie in the northern portion of the great Devonian basin under consideration, and we can assume the forks of the Chat and the great bend of the Matane to be not far removed from its boundary in this direction.

Limit of the Devonian basin

Fossil plants.

The rocks seen in the upper part of the Miner's Brook consist of grey sandstones and shales, holding abundance of *Psilophyton* stems and other fossils peculiar to the horizon of the Oriskany and Hamilton formations, a list of which will be given further on.

Unconformable contact with Silurian.

As we approach the forks of the Lake Inlet, the beds gradually become reddish, and resemble in character the lower Carboniferous of the Bay of Chaleurs. These extend down the Lake stream to a short distance below the forks of the Salmon Branch. On this stream they extend northward for six miles in a direct line, where they again gradually pass into the typical grey sandstones and shales of the Gaspé sandstone series, and further north, rest unconformably upon Silurian strata. The red beds lie in a nearly horizontal position or dip southerly at angles of 5°–7°.

Trap Hills.

On the Cascapedia the contact of the Devonian and Silurian systems is seen at Woodman's Brook, twelve miles below the Salmon Branch. Near the junction, large masses of trappean rock, generally fine grained, are exposed in the stream, and form lofty hills of considerable extent. These have apparently been thrust up through the Devonian and Silurian strata, as these are considerably altered in their vicinity.

The width of the Devonian basin on this stream and on the Salmon

* Surveys since made on the Causapscul River have confirmed the western extension of the Devonian in this direction; and disclosed a basin of large extent.

Branch is twenty-one miles, of which the upper ten constitute the great inland valley described in our introductory remarks. The country along the lower eleven miles is exceedingly rugged, including the ranges of the Big and Little Berry Mountains, which form a chain of lofty hills extending for many miles in either direction.

Eastward, on the Little Cascapedia River, this system was crossed by Mr. Low in his traverse from Lake Ste. Anne to the Bay of Chaleurs. The superficial breadth in this direction is not more than twelve miles, and the strata rest upon the Silurian on either margin. About Lake Ste. Anne, the sandstones are much broken up by important masses of intrusive granite, generally fine grained and felspathic, which rise into irregular hills of considerable elevation. Their direct contact with the Devonian could not be seen, owing to the generally low and swampy character of the country, but further west, between the two Cascapedias and on the larger stream, doleritic and granitoid dykes of large size were frequently seen to penetrate both Devonian and Silurian strata. The Barn-shaped mountain, which is composed of granite closely resembling that seen about the Lake Ste. Anne and probably identical with it, is apparently thrust up along the line of contact of the two systems, and it is therefore presumable that all these granites, as well as the doleritic masses, are intrusive and of Devonian age. The northern outcrop of this system was observed on the Ste. Anne River, about two miles north of the lake of that name. Eastward of this, a low and generally level tract of country appeared to extend for a considerable distance, which doubtless marks its continuation in that direction.

Intrusive rocks, granite, &c.

On the Bonaventure River the Devonian has a much more extended development. The entire breadth on this stream, so far as known, is about thirty-seven miles, in which, however, are included three anticlinals, by which the Silurian portion of the Gaspé limestone series is brought to view. These are the western prolongation of those described in former reports as occurring in the eastern portion of the peninsula, and terminating at Percé and the shores of Gaspé Bay. The Devonian rocks, for the most part, lie in synclinal basins separated by the anticlines just mentioned. The most northerly of these includes the lake at the head of the main stream of the Bonaventure. Its northern limit was not, however, fixed, owing to the impossibility of penetrating that part of the country at the time of our visit, but is doubtless determined by the general outline of the underlying Gaspé limestones which bound the system in this direction.

Devonian on the Bonaventure River.

The existence of the Gaspé sandstone and limestone series on this river was noted by Mr. Murray in 1844. The intimate relations of the various members of these two series render it very difficult to draw any line precisely separating the two systems, but from a careful consideration of the various exposures we have been led to fix the southern limit of the Devonian basin at a point five miles below the Third East Fork. It must, however, be stated that at several points between this and the coast, outcrops or patches of strata, closely resembling those we have assigned to the upper division, occur. An instance of this may be seen towards the summit of the Three Brothers Mountain, but in such cases they are so intimately associated with calcareous and other rocks which represent the Silurian portion, that we have not been able, from the evidence at present obtainable, to draw a fixed line of distinction.

Difficulty in defining the line separating Devonian and Siluran.

The separation of the two series on this stream has in some cases been made largely on lithological and stratigraphical grounds, and by comparison with rocks of established age on the Cascapedia and elsewhere; but in the vicinity of the Third East Fork, true Devonian strata are seen which hold abundant remains of ferns and psilophyton stems. These dip S. $< 60°$.

Double synclinal.

The northern limit of this basin is four miles above the Third East Fork. In this space a local fold occurs which makes a double synclinal in the area, separated from the next by the western extension of the Percé anticlinal which, curving gradually towards the south, crosses the main stream at the point indicated. This anticlinal is also easily recognized on the Cascapedia and Little Cascapedia at distances of nineteen miles and ten miles and a-half respectively, from their mouths.

The second area has a breadth of about five miles, and is bounded on the north by the Point St. Peter anticline. This, like that of Percé, can also be easily recognized farther west on the rivers just mentioned. A third basin with a breadth of only two miles and a-half succeeds further up stream, lying between the Point St. Peter anticlinal and that which terminates at Tar Point on the coast, while the western prolongation of the Haldimand anticlinal has not yet been noticed, but probably lies in the unexplored country between the head waters of the Bonaventure and Magdalen Rivers.

In all these areas the character of the rocks is similar to that of the Gaspé sandstone series, and though no fossil shells were seen, many of the beds contain impressions of plants. The anticlinal ridges are largely calcareous and distinct in character from the overlying beds.

The development of the Devonian rocks further east on the Gaspé rivers has already been described in preceding reports (1863, 1880-81-2) and their further discussion is therefore not considered necessary in this place.

The fossils named in the following list are from the Miner's Brook, branch of the Cascapedia River, near the northern limit of the inland Devonian basin. They were determined by Mr. H. M. Ami, B.A., under the supervision of Mr. Whiteaves:— Fossils.

Zaphrentis incondita ? Billings.

Orthis, a species closely allied to *O. Vaneuxemi.*

Orthis Aurelia.

Strophomena rhomboidalis, Wilckins.

Strophomena, Sp.

Spirifera Gaspensis, Billings.

Rensselæria ovoides, Eaton.

Atrypa reticularis, Linnæus.

Goniophora, Sp.

Mytilarca, Sp.

Grammysia, most likely *G. sulcata*, Conrad.

Pterinea textilis, var. *arenaria*, Hall.

Cytherodon, Sp.

Tentaculites, Sp.

Dalmanites, Sp.

Correlation of the Gaspe series.

It will be seen from the above that several of the forms are strongly typical of the Hamilton formation. The Gaspé Sandstone series, of the coast, is probably of the same age, though the absence of typical shells in a large portion of it makes their separation more difficult. The Oriskany would then be confined to the upper portion of the limestone series and a portion of the sandstone series, as developed in the vicinity of Gaspé Basin, the actual thickness of which it would be difficult to determine. The Hamilton would embrace the middle and upper portions of the sandstone series, while the upper conglomerates, described in the Report for 1881-82 as unconformably underlying the Lower Carboniferous at Percé and Point St. Peter, would be of the horizon of the Portage and Chemung. These latter, in the interior, would be represented by the soft, red sandstones and shales of the Lake Branch, which so closely resemble the Bonaventure formation in physical haracters.

To determine, if possible, more clearly the line of separation between the Silurian and Devonian in the Gaspé Limestone series, Messrs. Barlow and Giroux were instructed to make collections of fossils at several points between Cape Rosier Bay and Gaspé Basin. Of these, the species found at the base of the series will be given under the head Silurian.

From Grand Grève, which marks the upper part of the series (No. 8), Vol. II., Pal. Fossils, the following forms were obtained:—

Favosites Gothlandicus, Goldfuss.
Zaphrentis, Sp., allied to *Z. prolificus*.
Zaphrentis, Sp.
Zaphrentis incondita, Billings.
Cystiphyllum, Sp.
Orthis Livia, Billings.
Orthis Aurelia, Billings.
Strophomena punctulifera? Conrad.
Strophomena magniventra, Hall.
Strophomena rhomboidalis, Wilckens.
Strophomena Galatea, Billings.
Spirifera superba, Billings.
Spirifera cycloptera, Hall.
Spirifera arenosa? Conrad.
Rensselæria ovoides, Eaton.
Eatonia peculiaris, Conrad.
Athyris arcuata, Hall (as of Billings).
Atrypa reticularis, Linnæus.
Pterinea textilis? Hall.
Cypricardinia distincta, Billings.
Murchisonia Hebe, Billings.
Murchisonia, Sp.
Platystoma ventricosum? Hall.
Proetus Phocion, Billings.
Dalmanites, Sp.

From the hills in rear of Gaspé village the following were collected by Mr. A. E. Barlow:—

Psilophyton.—Numerous fragments.
Strophomena Blainvillei, Billings.
Chonetes melonica, Billings.
Chonetes Canadensis, Billings.
Leptocœlia flabellites, Conrad.
Rensselæria ovoides, Eaton.
Spirifera Gaspensis, Billings.
Grammysia Canadensis, Billings.
Tentaculites, Sp.
Orthoceras, Sp.

All of the above belong to the Oriskany. Concerning the beds between Cape Rosier Bay and Grand Grève, it can only be said that a certain portion, representing an aggregate thickness of about 1,000 feet, contain fauna of both Silurian and Devonian horizons, with probably, from the specimens obtained, a preponderance in favor of the former.

Mixture of Silurian and Devonian fossils.

We have heretofore drawn the dividing line between the two systems to reach the coast at Cape Gaspé, by which the passage beds will be placed as the upper portion of the Lower Helderberg, while Nos. 7 and 8 of the scale, Vol. II. Pal. Fos., will be assigned to the lower part of Lower Devonian.

Comparison of maps accompanying this report with the general Geological Map of 1866.

It will be seen, by comparing the maps accompanying this report with the general geological map of Canada, that important changes have been made in the geology of the Gaspé peninsula; more particularly about the headwaters of the principal rivers. The limits of the Devonian have been greatly extended, its northern boundary now reaching almost to the Lévis formation, while it is made continuous from the Matapedia River to Gaspé Basin. The great granite area of Table-top mountain, as there laid down, is greatly reduced, especially in its southern extension, and the areas of the Quebec group (Lévis) south of the Magdalen have been restricted to the immediate vicinity of that river. The headwaters of the York have not yet been examined, but it would seem, from the distribution and strike of the Devonian and Silurian strata to the west and north, that the whole of this area is probably occupied by the rocks of these two systems, as is indicated by the great area of low land mentioned as forming the Devonian basin on the Upper Cascapedia, and which evidently stretches away to the east from Lake St. Anne past the head of the Bonaventure to the Gaspé rivers.

Eruptive rocks.

The Devonian strata are in many places penetrated by eruptive rocks, granitic as well as trappean. The former are mostly fine-grained, but the latter present a great variety of character. Many are dense and fine-grained, others coarse, with large disseminated crystals of felspar and pyroxene; others, again, are amygdaloidal, and contain agates and chalcedony. These dykes have not only altered the Devonian, but the Silurian as well, wherever they have broken through, but the alteration has never been of any great extent and entirely local in character. The localities and descriptions of these trappean and other rocks are given page 32 E.

Silurian.—E.

As the description of the rocks of this system has been given in former reports, it will be only necessary to refer to their distribution in the area under consideration. On the Matapedia River they have a

Limits of Silurian areas.

breadth from the confluence with the Restigouche northward, of no less than fifty-four miles to their overlap on the Quebec group near the northwest angle of Lake Matapedia. Thence they extend eastward in an unbroken belt to the extremity of the peninsula. On the Great and Little Cascapedias, the Bonaventure, the Pabos and the streams flowing into the River St. Lawrence, their limits have been determined with accuracy. Much of this work was done by different members of the staff in the earlier years of the survey, but, as in the case of the other formations, their distribution in the interior was not then worked out in detail.

On the Cascapedia, after passing the area of the Devonian which occupies the lower portion of this stream for six miles from the mouth, grey limestones and calcareous shales are seen, having a southerly dip. These have a surface breadth of twenty-one miles, in which distance three distinct anticlinals are observed, whch are the western extension of those previously described as occurring in the vicinity of Gaspé Bay. The river makes a section across the rocks almost at right angles to the strike, and at Woodman's Brook, twenty-seven miles from the mouth in a direct line, the rocks of this system are overlaid unconformably by the strata of the Devonian just described. Fossils were not observed in this portion of the stream, but the beds are undoubtedly the equivalents of those seen to the west on the Scaumenac and Matapedia rivers. These have yielded a plentiful supply of organic remains, the horizon of which has been carefully determined.

Fossils.

From a collection made at the forks of the former stream during the past season, the following forms were recognised:—

Stromatopora concentrica ? Goldfuss.
Favosites Niagarensis ? Hall.
Syringopora, Sp.
Strophomena rhomboidalis, Wilckens.
Strophomena, Sp.
Leptaena transversalis ? Dalman.
Atrypa reticularis, Linnæus.
Pentamerus oblongus, Sowerby.
Pterinea textilis, var. *arenaria*, Hall.
Pleurotomaria ? Sp.
Murchisonia, Sp.
Platystoma Niagarensis, Hall.
Proetus, Sp.
Calymene Niagarensis, Hall.
Encrinurus punctatus, Wahlenberg.

These are almost certainly Silurian and most probably Niagara species. Niagara fossils

From another locality, midway between the mouth of the Little Cascapedia River and Black Cape the following were obtained:—

Zaphrentis, Sp.
Heliolites, Sp.
Halysites catenulatus, Linnæus.
Stricklandinia Gaspensis, Billings.
Atrypa reticularis, Linnæus.
Strophomena, Sp.
Pentamerus galeatus, Dalman.

These also will be seen to be characteristic Silurian species, and possibly from as low a horizon as the Niagara formation.

The sandstones and shales which occupy the country for some miles on either side of the confluence of the Salmon Branch are seen on the latter stream, nine miles and a half in a direct line from its mouth, to rest unconformably upon hard limestones which have a dip of S. 20° E. $<$ 10°; the overlying strata dipping S. 15° W. $<$ 10°. This unconformity apparently marks the contact of the two systems in this direction. Between this point and the foot of the Shickshock range, the stream shows a succession of exposures of calcareous slates and limestones, often dolomitic and weathering a dirty yellowish-brown. These have a general southerly dip at angles of 15° to 40°, occasionally rising to 80°, where evidences of disturbance are visible. In places these beds contain fossils of Silurian age, corals, crinoids and brachiopods, among which *Strophomena rhomboidalis* and *Atrypa reticularis* are common. Contact of Silurian and Devonian systems.

The breadth of this Silurian area, which is bounded on the north by the serpentines and other rocks of the Shickshocks is about six miles and a half. The main falls of the branch occur midway and are caused by the intrusion of an immense dyke of greenish dolerite which is seen to cut the slates and to send off spurs from the main mass into the adjacent strata. This dyke has a generally east and west course. It extends about midway between the Barn-shaped Mountain and Mount Albert, but its eastern termination is not known. Dolerite dyke.

Among the lowest beds which flank the mountain range are coarse calcareous conglomerates, the pebbles of limestone, cemented by a sandy and calcareous paste. These are interstratified with bands of hard sandstone and impure dolomitic limestone, and contain corals, etc., of Silurian age, but so poorly preserved as to be of little value for determination. The rock as a whole is very similar to that seen on the coast east of the Little Cascapedia, both as regards the conglomerates and associated beds. This would make the horizon of this portion of the Silurian possibly as low as the Niagara. On this branch a small exposure of metamorphic rocks about fifty yards wide lies between the beds last described and the foot of the South Mountain. They are hard silicous and dolomitic, very ochreous on weathered surfaces, and are associated with a band of serpentine which has an exposed breadth of 100 feet. This latter appears to be a spur from the great mass of the mountain. These metamorphic rocks were at first thought to be an altered portion of the Silurian strata, but on a careful reconsideration they more probably belong to the old crystalline schists of the main range. The immediate contact with the Silurian is not visible.

Metamorphic rocks.

Further east the strata under discussion rest upon the flanks of the crystalline schists and continue in that direction till cut off by the intrusive mass of Table-top Mountain.

Dolerite dykes.

On the Little Cascapedia the rocks of the system extend from near the coast to within six miles of Lake Ste. Anne. There they are overlaid by the Devonian beds already mentioned. At several places on this stream they are cut by dykes of dolerite often of considerable size, and the several anticlinals which extend longitudinally through the peninsula are well defined. The strata are of the usual character, sandstones, slates and limestones, andthe dips range in inclination from 30° to 75° with a general strike east and west.

Distribution on the Bonaventure River.

On the Bonaventure River their distibution as far as the Third East Fork has been given generally by Mr. Murray (Report of Progress 1844), but some further details have since been obtained regarding the structure which we will briefly state.

On the lower part of the river the first rocks seen consist of hard, bluish-grey, fine-grained sandstone with small patches of white quartz. These are fossiliferous, but the remains are so nearly obliterated by metamorphism as to be too indistinct for determination. In places, cleavage transverse to the bedding is well defined. These beds probably indicate the lower portion of the Gaspé limestone series. At the mouth of the Duval River, and for several miles below, they dip S. 10° W. $<$ 15°, but one mile above the dip becomes reversed to N. $<$ 40°. This anticlinal is probably identical with that which brings the Quebec group into view at Cape Maquereau.

Ascending the stream, we have a repetition of the strata just noted, constituting the northern side of the axis. They are often calcareous and flaggy, in beds of four to six inches. Some are hard and felspathic with a reddish tinge, others coarse and gritty with grains of white quartz. The dip rapidly declines from 40° to 5°, and a short distance below the elevations known as Three Brothers Mountain is again reversed to S. $<$ 5° — 7°, showing a broad synclinal structure. This dip is maintained to the elevations just mentioned, the direction changing slightly to the west so that they are probably situated near the centre of the basin. In these hills, which rise to a height of 500 feet above the sea, the lower portion consists of reddish-grey felspathic and quartzose grits with fine conglomerates made up of small pebbles of red shale, felspar and white quartz. Ascending the cliff, the beds become greyer in color and resemble those of the sandstone series. Interstratified beds of shale contain carbonized impressions of plants of Devonian aspect, which may mark a limited outlier of this age. Between this locality and the West Fork the rocks dip S. 40° to 60° W $<$ 7° — 10° and consist of hard flaggy sandstones like those at the base of the Three Brothers, with calcareous shales which contain imperfect remains of corals, etc. Between the West and East Fork, which comes in near the beginning of the great bend to the west, calcareous slates and limestones, of similar aspect to those seen on the Matapedia River dip S. 10° W. $<$ 30°. These are very ochreous in places. A little above the East Fork the dip again becomes reversed to N. E. $<$ 45°. This second anticlinal brings into view a repetition of the beds seen below. The northerly dip continues for several miles, but about two miles and a half below the Second East Fork it is again reversed to S. $<$ 40°, which dip is maintained, though the strata are considerably disturbed for over a mile beyond the Second West Fork. Two miles above this the beds again dip N. 20° W. $<$ 50°, the rocks being purple and bluish-grey slates and limestones, in layers of one to three inches thick. This is not far from the southern margin of the Devonian basin, which extends hence to the Third East Fork already described.

Devonian outlier.

The anticlinals just described are entirely distinct from those which are seen in the eastern part of the peninsula. These come to the shore between Port Daniel and Percé, though owing to the overlapping Lower Carboniferous beds their termini are not always visible.

The distribution of the rocks of this system in the eastern part of Gaspé has already been given in Report of Progress for 1881-82.

From the report of Mr. Murray, 1845, the Gaspé limestones are first seen on the Matane River, near the mouth of the Tawagadee Brook where the river makes its sharp bend to the north after skirting the south side of the Shickshock range. The fossils from this locality are very similar to those seen in the vicinity of Cape Gaspé. The older or Niagara portion is therefore probably concealed from view or may be entirely wanting in this direction.

Further west, the Silurian is found on the east side of Lake Matapedia at two miles from its lower end, while the west shore of the lake is entirely occupied by strata of this age. These rest upon the rocks of the Quebec group, about two miles and a half north of Sayabec station on the Intercolonial railway.

Lake Matapedia.

East of the Ste. Anne River, the northern boundary on the West Branch of the Magdalen was fixed by Mr. Low during the past season. The result of his examination is given in the following report F.

A further collection of fossils was made from the Ruisseau de la Grande Carriere on the road from Gaspé Basin to Griffin Cove, from which place fossils were obtained the previous year. The result of their examination discloses the presence of forms which are apparently more closely related to the Silurian than to the Devonian, as was then suggested. This locality is not far from the base of the Gaspé limestone series, and from the new evidence the Upper (Lower Helderberg) horizon of these beds is confirmed. Among the fossils obtained, of which many were in a fine state of preservation, the following Lower Helderberg forms were noted :—

Helderberg fossils.

Favosites. Sp. Undt.
Atrypa reticularis, Linnæus, abundant.
Rhynchonella, Sp. Undt.
Strophomena rhomboidalis, Wilckens.
Strophomena punctulifera, Conrad.
Strophomena Blainvillei ? Billings.
Orthis, Sp.
Meristella, Sp., allied to *lœvis*, Hall.
Pteronitella, Sp.
Anodontopsis, Sp.
Dalmanites pleuropteryx ? Green.

From the basal beds of the limestone series, at their contact with the rocks of the Quebec group at Cape Rosier Bay, a small collection was made by Messrs Giroux and Barlow, which contained forms characteristic of the upper portion of the Silurian. Among them were recognized,

Favosites Gothlandica, Goldfuss.
Leptocoelia flabellites, Conrad.
Spirophyton Cauda Galli, Vanuxem.
Strophomena punctulifera, Conrad.
Pterinea textilis, Hall.

Cambro-Silurian. D.

The rocks of this system, examined by us during the past season, were confined entirely to the vicinity of the Grand Pabos River. On this stream, they have a considerable area inland, reaching to a point about twelve miles from the mouth. In character they resemble many of those seen on the south side of the St. Lawrence, and consist largely of gritty sandstones resembling somewhat the grits of the Sillery formation. With these are associated red, green and black calcareous slates. The series is identical with that seen on the coast between Cape Maquereau and the Grand Pabos Post office. No fossils could be found in any of the beds, which are generally much altered and often greatly broken up. These rocks, as developed on the coast, have been described in the for Report 1880-81, and there assigned to the Cambro-Silurian system. No further evidence has been obtained which can throw light upon their age, and we therefore see no present reason for assigning them to a different horizon.

Pre–Cambrian. A. B.

The only areas it is proposed to include under this head are confined to the range of the Shickshock mountains. In former reports, these have been referred to the horizon of the Sillery sandstones on the supposition that they were altered strata of that age. The rocks, however, are so like the Pre-Cambrian, as seen in New Brunswick and other parts of Canada, that it has been considered more in accordance with the true structure to remove them from their position as an integral portion of the Quebec group and to assign them to an older horizon.

In so far as yet ascertained they are all highly crystalline. Large areas of epidosite, garnetiferous gneiss, hornblende, chlorite and mica-schists, with masses of serpentine often well stratified are found. On the Salmon Branch also hard metamorphic beds apparently composed of silica with dolomite and serpentine, very ochreous on weathered surfaces, occur. These form the mass known as the South mountain and rest upon the south flank of the hornblende schists. Crystalline and Metamorphic rocks.

The dip of all these beds is southerly at angles of 75° to 80°, and as the breadth of the mountain chain is from six to eight miles, this would give an enormous thickness, provided there were no repetition of the strata,. We are, however, led to suppose that the true structure is of the nature of a great overturned anticlinal, and on this hypothesis their apparent super-position upon the Lévis, which occupies the country north to the River St. Lawrence, can be easily explained.

The apparent position of the various formations along this part of the coast may be stated to be in ascending order, Hudson River or Utica, Lévis, Crystalline schists, etc., Silurian and Devonian. Since then the Lévis undoubtedly belongs to an older horizon than the Utica, if we reverse the order of the three first, we have them probably in their true position. This would place the crystalline portion at the base; the Silurian and Devonian being simply unconformably overlying areas of much later age. Apparent structure misleading.

The relations of the various formations as shown on a line of section from the mouth of the St. Annes de Monts River to the Bay of Chaleurs, will be seen by reference to the accompanying sketch section. This is drawn to a uniform scale, horizontal and vertical, of one mile to the inch.

Serpentine, Diorite, Granite, &c.

Mt. Albert and South Mountain.

Among the prominent features of the Shickshock range are the two bare hills of serpentine, the one on the eastern extremity, overlooking the forks of the Ste. Anne River and known as Mount Albert; the other, twelve miles west on the Salmon Branch and called by Sir Wm. Logan the South Mountain. Of these the former was carefully studied and is described by Mr. Low, while the latter was the only one accessible to us. The latter presents a bold bluff on the south and west, rising to a height of over 1,200 feet above the Salmon Branch, and extends for about two miles and a half east. The surface, like that of Mount Albert, is either bare rock or is slightly clothed with a scattering growth of stunted spruces from five to twelve feet high, and small ponds with marshy edges occupy the depressions.

The width of this mass of serpentine and associated rocks is about three-eighths of a mile. It rests upon the south flank of the hornblende schists and terminates abruptly on the east bank of the branch, though a spur from its southern flank, of forty yards in width, crosses the stream in close contact with the crystalline, dolomitic rocks referred to in the preceding chapter. The serpentine of this mountain apparently lacks the stratification seen in that of Mount Albert, and no traces of asbestos or chromic iron were discovered. On weathered surfaces it is exceedingly rough and ochreous.

Although the serpentines of this area have generally been regarded as an integral portion of the metamorphic series and contemporaneous in age, there are indications, at several places, which point to an eruptive origin. The position of the eastern or Mount Albert mass in particular, breaking, as it does, apparently across strata of Pre-Cambrian and Silurian age, gives it the aspect of an immense dyke, while the exposure noted as crossing the Salmon Branch, much of which is of peculiar character, is also like an intrusive rock. Specimens from it are now in the hands of Mr. Adams for examination, the results of which will be given in his report.

Barn-shaped Mountain.

The Barn-shaped Mountain, which rises to a height of about 3,400 feet, is a huge dome like mass of fine trachytic granite, similar in character to that of Table-top Mountain further east. It is at the contact of the Silurian and Devonian, like the great masses of doleritic rock seen on the upper part of the Bay of Chaleurs. It is not unlike some of these in character, being very highly felspathic and is probably of the same age.

Dolerites of various kinds are found at many places on the upper part of the Cascapedia and Bonaventure Rivers. The most southerly noted on the former stream was about one mile south of Woodman's Brook, where a large dyke of purplish-grey color, holding iron pyrites, and moderately coarse, has broken through the Silurian strata, throwing them into confusion, and changing the adjacent rock to a highly crystalline condition. Intrusive dolerite.

Just above this Brook another large mass of trap has broken through the lower beds of the Devonian, portions of which have been caught up and included in the eruptive rock. This outcrop has an exposure of several hundred yards and rises into hills on the eastern side of the river to a height of 500 to 800 feet above the stream.

On the Salmon Branch, intrusions of greenish-grey dolerite cut the Devonian sandstones and shales, about seven miles above the mouth. They are mostly fine-grained and dark colored, though purple shades are seen, and rise into low knolls of fifty to one hundred feet, and at one place a bed of brecciated trap ash is interstratified with the sandstones dipping S. 20° E. $<$ 20°. Another dyke in the vicinity has thrust the Devonian strata into a low anticlinal arch. In this case a belt of trap conglomerate similar to that on the Restigouche River occurs.

Half a mile below the Grand Falls on this branch, a dyke of moderately coarse dolerite seven feet thick, cuts the Silurian limestones, but at the falls a great mass of the same rock composed of grey felspar and blackish-green hornblende with occasionally black mica occupies the stream for some distance, and extends eastward for several miles. It has, on the Branch, a breadth of about fifteen chains, and from its strike appears to be a prolongation of the doleritic masses seen on the Miner's Brook to the west.

The Miner's brook discloses numerous dykes of dolerite, sometimes of large size, but varying greatly in character. Of these, the largest mass that of the Conical Mountain, noticed on the traverse of Sir Wm. Logan, and supposed by him, at that time, to be connected with the Barn-shaped Mountain. Its position is just east of the forks of the Miner's Brook and Lake Stream. Three miles and a-half from the Forks, large exposures of these rocks, having a breadth altogether of about one mile and a-half, are seen cutting Devonian strata. These, judging from their strike, may be connected with that exposed on the Salmon Branch. Conical Mountain dolerite.

On this stream, for a further distance of ten miles, dykes and bosses of trappean rock, often of large size are found. Sometimes these are dense and fine-grained, at others coarse and with large crystals of hornblende and pyroxene. In all observed cases, these penetrate the Devonian strata.

It is evident, therefore, from the facts before us, that a period of considerable igneous activity existed during the Devonian time, the evidences of which are seen at many points from the Restigouche to the extremity of the Gaspé peninsula. To this belonged not only the great masses of dolerite about the upper part of the Bay of Chaleurs, but also the large areas of granite known as the Barn-shaped and Table-Top Mountains, as well as the scattered masses in the vicinity of Lake St. Anne.

The numerous dykes of dolerite and other igneous rocks seen in the several rivers of the peninsula as well as on the coast of Gaspé Bay, and alluded to in the report for 1881-2, are also, without doubt, of the same age.

Economic Minerals.

Throughout the portion of the Gaspé peninsula examined by us during the past season, no minerals of economic importance were noted. Various rumours have long been current that valuable deposits of gold and silver exist at some point in the Shickshock range, about the head waters of the Cascapedia River. The precise location of these have, however, never been discovered. As the story must, in the first place, have originated with the Indian hunters, by whom so many rumours of like character are started, its reliability may safely be questioned. Several expeditions have been fitted out for the purpose of discovering the locality, but without success.

The only thing seen by us which could have led to such a conclusion, was an abundance of scales of yellow mica in some of the small brooks. These have been taken for gold by many persons, and at the present day, in many houses along the coast of the peninsula, large chests filled with mica scales are safely stowed away, under the belief that they contain minerals of great value.

During our visit to Prince Edward Island, our attention was particularly directed to two points, viz., the possibility of finding coal which has already been pretty fully discussed in previous pages, and the value of the so-called gold-producing areas on the west coast. Specimens of the rock, said to be gold-bearing, have been assayed both in the laboratory of the Survey and at McGill College. These in both cases shew but a trace of the precious metal.

In view of these results, it is difficult to reconcile the assays of rock purporting to be from this locality, in the hands of the company, and which shew in many cases a large percentage of gold. On the strength of these, however, operations have been commenced with a crusher and amalgamator at Cape Wolf, the results of which have not yet been made public.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., Director.

REPORT

ON

EXPLORATIONS AND SURVEYS IN THE INTERIOR

OF THE

GASPÉ PENINSULA.

1883.

BY

A. P. LOW, B.A.Sc.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1884.

To Alfred R. C. Selwyn, Esq., LL.D., F.R.S., etc.,

Director of the Geological and Natural History Survey of Canada.

Sir :—I have the honor to submit herewith a report on the geology of that portion of the interior of the Gaspé Peninsula which I examined during the summer of 1883.

I am, Sir,

Your obedient servant,

A. P. LOW.

Ottawa, May, 1884.

Note.—Where not otherwise stated, the bearings given throughout this report are with reference to the true meridian.

REPORT

ON

EXPLORATIONS AND SURVEYS IN THE INTERIOR

OF THE

GASPÉ PENINSULA.

BY

A. P. LOW, B. A.Sc.

Topographical Features.

According to my instructions to continue the exploration of the interior of the Gaspé Peninsula, I left Ottawa on May 23rd for Ste. Anne des Monts, accompanied by Messrs. J. A. Porter, B.A., and H. E. Hamilton, 4th-year student in Applied Science, McGill College, as assistants. We arrived there on June 6th, having been detained several days at Quebec, making tracings of Crown Lands plans for the use of the Survey, and also at Matane, where some time was spent collecting fossils from the Levis shales, about two miles to the east of that place. *Arrangements for work.*

On arriving at Ste. Anne des Monts it was found impossible to ascend the river on account of the freshet caused by the melting snow on the mountains, and it was not until the 20th that the river was at all navigable with canoes. *Bare Line.*

While waiting, a carefully measured base line, nearly two miles long, was run on a bluff distant about one-quarter of a mile from the shore. This was connected with the mouth of the river, by a chained survey and its position fixed. From this base line three prominent peaks in the Shickshock range, distant about eleven miles, were accurately determined.

Having engaged four men with two canoes, we left Ste. Anne des Monts on the 20th, and reached the forks of the river, distant about thirty-two miles, three days later. Here the geological work of the *Ste. Anne des Monts River.*

season commenced, as the river had been explored and a micrometer survey made to this point by Mr. Murray, in 1846. His description is as follows :—"The total measured distance up the Ste. Anne River was rather less than thirty-two miles. The first general course from its mouth was S. 5° W. [Mag.], for a distance of 13 miles 66 chains (10 miles 30 chains straight), when it reached the base of the Notre Dame, or Shick shock Mountains; then S. 70° E. 10 miles 8 chains (8 miles 40 chains straight), falling very rapidly along the northern base of the range. At the end of this distance it is joined by a branch from the north called Marten River, and then turning S. 43° [Mag.] E. it bears that course for 7 miles and 58 chains (6 miles straight) to the end of the measured distance, where it splits into two streams of about equal size."

Description by Mr. Murray.

Three days were spent collecting specimens of rocks and plants in the neighborhood, while the men were employed bringing up provisions to a store camp established at the Forks.

South Branch.

Leaving the Forks on June 27th, a micrometer survey of the South or Main Branch was made as far as Lake Ste. Anne. This distance was accomplished in three days, including a portage of upwards of one mile, past the falls, which occur about half a mile above the Forks, and are about 60 feet high. The river here breaks through the east flank of Mount Albert, and below the falls passes through a deep and beautiful cañon one-quarter of a mile long, with perpendicular walls rising to more than 200 feet above the river. In places it is not more than six feet wide, but very deep, and above the falls so rapid that it cannot be ascended except at high water, and then only with great difficulty.

Seven miles above the Forks, in the distance of half a mile, there are five small falls from two to seven feet high, caused by ledges of granite which here cross the river. These had to be passed by five portages, causing much delay.

From here to the lake, about three miles distant, the river passes through a flat country, and has very little fall, but is obstructed by timber-jams, and is very crooked. The total distance from the Forks to the lake is 10 miles 67 chains (9 miles 52 chains straight), the general bearing S. 15° E.

Fall of River.

As the Forks are 709 feet above sea level, and Lake Ste. Anne is 1,313, there is a difference of 604 feet, which gives the river an average fall of nearly sixty feet per mile between the two places.

The river for the first four miles of its upward course passes through a deep valley formed in the Shickshock Mountains, which rise from its bed on either side into peaks varying from twelve to fifteen hundred feet in height. Having passed through the range, the country becomes comparatively flat, with small hills bordering the river. These rise

Flat Table-land

two or three hundred feet, and among them are a few isolated granite peaks, which rise to a height of more than 1,400 feet. This region is a continuation of the Devonian table-land which extends from near Lake Matapedia, along the south side of the Shickshock range to Lake St. Anne, and thence to the Magdalen and York rivers, forming an almost level tract of country from the Intercolonial Railway, near Lake Matapedia, to Gaspé Basin, more suitable for a branch line of railway to Gaspé than the route by way of the coast from Matapedia station.

On account of its elevation this table-land is of little or no importance for agricultural purposes, summer frosts being frequent. The timber growing on it is of small size and apparently stunted, and consists principally of white and black spruce, balsam fir, and white birch, cedar not being found above the falls of the Ste. Anne.

Lake Ste. Anne, three miles long and rarely more than a quarter wide, general course S.E., is divided into two portions by a shallow strait about one hundred yards long by fifty wide. The lake is very deep, a forty yard line failing to touch bottom in the middle of the larger portion. On the east and west sides of the lake granite peaks rise to heights of from 1,200 to 1,500 feet above its level; while to the N.E. and S.W. low ranges of hills not more than 500 feet high are seen. These hills are composed of Devonian sandstone, as are also the lower flanks of the granite peaks. The granite has burst up through the sandstones and is part of the mass of Table-top mountain to the north. Lake Ste. Anne

Having completed the survey of the lake and explored a portage to the head water of the west branch of the Little Cascapedia River, which passes about three miles south of the lake, we returned to the Forks on July 4th. The next day we ascended Mount Albert. Its summit is about 3,000 feet above the bed of the river and one mile and a-half distant.

Here a camp was formed, and two weeks were spent on the flat top of the mountain, running a base line three and a quarter miles long. From this line we were enabled to triangulate 158 peaks in the surrounding ranges. Geological investigations were carried on at the same time, and sections made along three brooks which rise on the mountain and flow into the Ste. Anne. Camp on Mt. Albert.

The top of Mount Albert is nearly flat, and is rent by a deep gorge on the east side, which, near its head, splits into several smaller ones. The sides of these gorges are quite destitute of vegetation and the bare serpentine rocks are weathered to a light buff color. On the top of the mountain blocks of serpentine are scattered around, and are partially covered by a thick growth of mosses and lichens. Sheltered places Character of Summit.

are occupied by a stunted growth of black spruce (*Abies nigra*), which rarely attains a height of ten feet. The branches interlace near the ground and form an impenetrable thicket. The whole surface has a dead appearance, and reminds one of the pictures of the moon. The top of the mountain has a gentle slope from the S.W. and N.E. towards the centre, and the base line was run from the flag-staff point on the N.E. to an elevated point on the southern side, the course being S. 28° W. From the north-east end of the base line, where the accompanying sketch was made, a fine view of the surrounding country was obtained.

View from Summit of Mt. Albert.

Commencing from the west, all the important peaks of the Shickshock range are seen stretching to beyond the Matane River. North of this the lower hills of the Cambrian rocks run in a series of ridges parallel to the coast, and are cut by the valleys of the Cape Chat and Ste. Anne rivers. Beyond is the Gulf dotted with passing ships, and on the horizon the mountains of the north shore are seen, the whole forming a grand and beautiful picture.

As we turn east the mountains of the coast become higher often rising into peaks having an altitude almost equal to those of the Shickshocks, and shut out the view of the Gulf. Further to the N.E. we see the northern part of the great granite mountain called Table-top Mountain by Mr. Richardson.

This mountain, with its several peaks (a few of which are higher than Mount Albert), fills up the whole eastern horizon. It rises abruptly more than 2,000 feet above the surrounding country, which undulates from the valley of the Ste. Anne to its base. The higher parts and sides of the mountain are bare, trees being unable to grow in such exposed places.

To the south-east is seen the valley of the Ste. Anne, with the Lake Ste. Anne in the distance, looking like a streak of silver; surrounding it are bare granite peaks. To the South, the great table-land, already mentioned, stretches along the base of the Shickshocks, broken only by a few granite peaks, while in the distance, the Devonian mountains are seen in a number of parallel ranges, cut by deep transverse valleys, through which flow the branches of the Cascapedia River.

Having finished the work on the mountain, and made a collection of Alpine plants, we descended to the Forks on July 20th.

Messrs. Porter and Hamilton remained there to make paced surveys along several small brooks on the north side of the river, and two men were sent to cut a road to the summit of Table-top Mountain, about eight miles distant, while I descended the river to Ste. Anne des Monts, to procure a fresh supply of provisions and compare my barometer with that of Mr. Vibert, who kindly kept readings three times a day during the entire summer, thus enabling me to fix the heights of all the peaks ascended during the season.

Table-top Mountains.

On account of a freshet, I was unable to return to the Forks until the 27th. The men had then completed the road, and we started for Table-top Mountain but did not reach the top till next day, being unable to travel fast from the poor condition of the path, and the heavy packs carried. Table-top Mountain is about fifteen miles from North to South, with an an average breadth of three miles. The surface is uneven, and numerous peaks, often rising five hundred feet above the general level, are found around its edges, while the centre is an undulating plain dotted with many lakes (as many as twenty-six were counted from one point) varying from one to one hundred acres in extent. The central area is about 3,000 feet above the sea-level, but several of the peaks are higher than Mount Albert. Richardson's Peak (3,700 feet), is the highest. This mountain presents a marked contrast to Mount Albert. The peaks on its margin form a basin of the central part, in which, protected from the severity of the weather, black spruce grows to a height of thirty feet, many trees being over a foot in diameter; these are clustered together with open glades between, covered with a rich growth of Alpine timothy and ferns. The mingled colors of the dark spruce, the light grasses, the blue lakes, and the pink, bare, granite peaks, form a pleasing picture. Brook trout abound in all the lakes and in the brooks flowing out of them, while the woods are alive with spruce partridges.

Lakes on Summit.

The lakes are arranged in groups, each group being drained by one large brook. East magnetic from the forks of the Ste. Anne, on the west side of the mountain, there are two groups; one of five to the south, and the other of three to the north. The brooks from these, in leaving the mountain, fall directly more than 600 feet, and unite a short distance from its base, joining the north branch of the Ste. Anne River about two miles from the Forks.

Sources of Streams.

Immediately south of these lakes is another group of three, forming the head of the Middle Branch of the Magdalen; and the North Branch rises from a group to the east of the last.

To the north, several lakes empty into a brook which joins the North Branch of the Ste. Anne about six miles from the Forks, while further north is a large lake, and several small ones, which form the head waters of the branch itself.

After having spent several days examining the top of the mountain, being greatly delayed by rain, I started, accompanied by Mr. Porter and two men, down the Middle Branch of the Magdalen River. A micrometer survey was made from the lakes at its head to the Forks, to connect with the survey made by Mr. Richardson in 1857.

While we were thus engaged, Mr. Hamilton remained on the mountain, triangulating peaks to the east and south.

Middle Branch of the Magdalen.

From the lakes, the Middle Branch flows down a gorge in the mountain for a distance of seven miles, the general course being S. 20° E. This gorge is very deep and divides the mountain into two portions. Below the gorge the stream turns east for a distance of two miles, and passes through limestone hills not more than 800 feet above its level. It then turns N. 20° E, and flows through the same description of country for seven miles, where it joins the South Branch and half a mile beyond is the junction of the North Branch where Mr. Richardson's survey ended.

Timber.

Along the first course the timber is small and stunted, consisting principally of black spruce, white spruce, white birch and balsam fir. That found along the second course and the upper part of the third is even poorer, consisting of a thick growth of black spruce, few trees of which exceed six inches in diameter. The lower half of the third course is well wooded with valuable timber, mainly white spruce and white birch, many fine trees remaining although considerable lumbering has been done in the vicinity.

Explorations on Ste. Anne River.

This survey was rendered very difficult by the rain which fell steadily for the last three days. It caused a freshet in the river, making it impossible to wade, while the woods along the banks were almost impenetrable on account of fallen timber. We reached the Forks about 10 a.m. Aug. 4th, and being without provisions, immediately started for the camp on Table-top Mountain, fifteen miles distant, which we reached at 9 p.m. After resting the next day we descended to the Forks of the Ste. Anne on the 6th. Here high water detained us three days, when we proceeded down about four miles to a large brook which comes in from the north. From here Mr. Porter descended directly to Ste. Anne des Monts, so that he might dry and arrange the specimens of plants collected during the summer. Having spent two days surveying this brook, we descended to another which enters the Ste. Anne River from the south about twenty miles from its mouth. From the head of this brook we endeavored to reach Lake Cascapedia, about three miles distant, but were unable to do so on account of the great "blow-down" of timber which covers the sides of the mountain as far as could be seen. In passing through it I strained my knee so severely that I had great difficulty in again reaching the Ste. Anne. The next day, Aug. 19th, we descended eleven miles to a large brook called Rivière Coté, flowing from the south. My knee being very painful, I left Mr. Hamilton to survey the river, and descended to Ste. Anne des Monts. Mr. Hamilton having finished his survey joined us there on the 18th and left with Mr. Porter for Ottawa on the 22nd. They took with them all the specimens collected during the summer and part of the outfit not in use.

On the 23rd of August I started up the Cape Chat River with two men and a canoe. Great difficulty was experienced owing to the low state of the water, and we were only able to reach a point about twenty-five miles from the mouth. This river has been described by Sir William Logan in his report for 1844. Cape Chat River.

Descending the river, we returned to Ste. Anne des Monts, and left there on the 29th to make a traverse across the Gaspé peninsula by way of the Ste. Anne and Little Cascapedia rivers. We arrived at the Forks on Sept. 1st, and a day was spent cutting cedar and putting a bottom on the canoe, as the river above the Forks was so low that we had to drag the canoe the greater part of the way to the lake, which latter we reached on the 6th. From thence we made a portage to the West Branch of the Little Cascapedia River, three miles distant. Two days were necessary to clear a trail, and carry the canoe and baggage across. Traverse across Gaspe Peninsula.

Where we reached this stream it is only fifteen feet wide, and greatly obstructed with logs and fallen trees, so much so, that four days were occupied cutting it out, and hauling the canoe seven miles. The river for this distance is very crooked, with little current. Beyond this, having been joined by several large brooks, it becomes more navigable, attaining a width of about fifty feet with a swift current. The fallen trees which are swept down it, form huge jams at intervals of three or four miles. These had to be passed by cutting portages, and carrying everything over them, entailing great loss of time. Little Cascapedia.

Seven miles from the portage the river is joined by a large brook from the west, and just below this passes over a fall thirty-five feet high, at the foot of which it meets a large brook from the east. Fall.

Below the falls the hills are higher, having an elevation of 800 to 1,000 feet above the river. The soil along the flats of the valley seems to be much better than near Lake Ste. Anne. Good spruce and birch timber is found close to the river, with a quantity of pine on the hills. Timber.

Nine miles below the first fall a second one of ten feet occurs, and below this the current, which so far has been rapid, slackens, and the river winds from side to side in a valley about one mile wide, containing excellent bottom land covered with a rich growth of white spruce, white and yellow birch, cedar and poplar, with a few trees of ash and maple. On the hills there are found large spruce, and a few pines all fit for lumber. This fine valley extends for a distance of twelve miles, with a south course. A mile above the Forks, distant eighteen miles from the mouth, the river again becomes rapid, and the valley narrows to less than a quarter of a mile.

The Little Cascapedia, from the Forks to the mouth, has been described by Mr. Ells. (Report of Progress 1880–2, pp. 9 D, 12 D.)

Close of season's work.

Being much delayed by the causes mentioned above we did not reach the mouth of the river until the night of the 10th, and having counted on making the traverse in ten days we only carried provisions enough for twelve days, and so were without food for two days. Next day we proceeded up the Bay of Chaleurs to Dalhousie, where we were met by Mr. A. E. Barlow, who had been left there by Mr. Ells, to assist in making micrometer surveys in the neighbourhood of Rimouski. After spending three days at Dalhousie, collecting fossils and specimens of prehnite from the cliffs of Cape Bon Ami, we proceeded to Lake Matapedia, where three days were spent examining the rocks on the east shore of the lake. From here we went to Rimouski to make several surveys of roads in that vicinity, but as the weather was cold and unsettled, and the roads very bad, it was found impossible to do this work; we, therefore, left Rimouski on September 28th, and returned to Ottawa October 1st.

The work of the season was greatly retarded by the frequent rains during the months of June and July, and the first week of August.

Geological Structure.

Silurian.—E.

Silurian limestones.

This system is represented by a series of limestone beds, many of which are highly fossiliferous, while others contain no visible traces of organic remains.

This limestone series rests in places upon a pinkish or grey sandstone of no great thickness, which is seen on the Ste. Anne and Matane rivers and on the west side of Lake Matapedia. This sandstone is supposed to be the lowest part of the system.

Silurian rocks were seen on the Ste. Anne and Magdalen rivers. On the former their northern boundary is found crossing the South Branch at a point about four miles above the Forks; from here they occupy the bed of the river to a point two miles below Lake Ste. Anne, a distance of nearly three miles.

On the latter, the northern boundary crosses the Middle Branch at ten miles, and re-crosses at one half mile above the Forks.

These rocks are supposed to be continuous with the fossiliferous limestones which have been observed by Sir William Logan and others, on the Cape Chat and Matane rivers to the west, and with those south of the Magdalen on the east. They form a band, the breadth of which varies from ten to four miles, stretching from Lake Matapedia and beyond, to the end of the Gaspé peninsula.

Stratigraphical relations.

Along their northern limits the sandstones and limestones are found resting unconformably upon hornblendic and chloritic schists, which are supposed to have formed the shore line of the Silurian sea in which these sandstones and limestones were deposited. On the north the limestones dip under the great Devonian sandstone basin described by Mr. Ells, and come up again to the south of it.

The Silurian rocks being much softer than the hard semi-crystalline rocks of the Shickshock range, have suffered greater denudation, and so form the low rounded foothills on the south side of the range, seldom rising more than 500 feet above the adjacent level country, which is itself more than 1,000 feet above the sea level.

Character of Silurian tract.

The soil on these rocks is apparently rich in calcareous matter, and supports a thick growth of good timber, although of no great size, few trees exceeding twelve inches in diameter. The timber consists principally of white and black spruce, white birch and balsam fir. The country is useless for agricultural purposes on account of the frequent summer frosts and the shortness of the season.

Along the Ste. Anne the lowest bed is a red sandstone, which is very hard, and is considerably altered by a penetrating dyke of dark green amygdaloid. This sandstone rests unconformably on dark hornblende, schists, which form part of the Pre-Cambrian rocks of the Shickshock Mountains.

Exposures on Ste. Anne River.

The sandstone is overlaid by beds of dark blue limestone containing *Strophomena, Rhynchonella, Orthis, Zaphrentis* and fragments of crinoid stems.

Half a mile farther up the river, a ledge of light-grey, highly crystalline limestone is seen, having a dip of E. 20° S. <40° and altered by a dyke of dark green trap passing across the measures.

The rocks are again covered up for nearly half a mile, when, at a sharp bend of the river, beds of dark grey shaly limestone crop out, dip S.W. <40° These split easily into large flags, from one-half to three inches in thickness, affording capital material for building purposes.

Beds of dark-grey limestone are seen above this, at intervals, for a distance of 600 yards, having a general dip of S. 30 ° W. Above these for 200 yards the measures are covered, when limestone, cut by dykes of dark trap, is again found. The trap dykes are numerous and vary from one to six feet in thickness, altering the limestone where they come in contact with it. The limestone here dips S. W. <30°.

The above dips show that the limestones have had their general easterly strike thrown to the south by the great mass of granite in this vicinity.

The next exposure occurs about 700 yards farther up the river, and consists of beds of light-greenish crystalline limestone, dip N. 30° W., altered by dykes of porphyry. On the west, close to the river, a granite mountain rises 1,200 feet above its level.

Four hundred yards beyond the crystalline limestone, a bed of compact, light-grey limestone is found, (strike E. 20° N.) The measures are then covered for 200 yards, when a mass of pink granite is seen, which occupies the bed of the river for 700 yards, and evidently connects the mountain to the west with the great mass of Table-top Mountain. Beyond the granite, a band of light-grey, highly crystalline limestone is found, which extends about 200 yards; dip S. 10 ° E. <40 °. This is followed by a light-grey porphyrite, and after 300 yards by another band of limestone, for about 250 yards, dip S. 10 ° W. <40°; then comes another band of similar porphyrite, of no great thickness, which in turn is succeeded by more limestone, dip S. 10 ° W. <50°. These beds continue for upwards of 1,000 yards, where they pass under the grey and green sandstones of the Devonian.

Exposures on Magdalen River

On the Middle Branch of the Magdalen descending the river in the Silurian limestone is first met at a point about ten miles above the Forks. Here it is found overlying unconformably a light-green chloritic rock of Pre-Cambrian age, which dips S. <40°. Below this the fossiliferous limestone and shales continue to crop out at intervals along the river. On account of many minor contortions, great difficulty is found in determining the general strike of the rocks, but from the information obtained, they are supposed to sweep round the south base of Table-top Mountain from the Ste. Anne River, having, where they first cross the Magdalen, a N. E. strike, which again turns E. and then S. E., their northern boundary crossing the Magdalen one half mile above the Forks, where they are found, (according to Mr. Richardson's Report of Progress 1857,) resting unconformably upon the dark Levis limestone of the Quebec Group.

Cambrian.—C.

Relations of Cambrian beds.

This system is represented along the Ste. Anne River, and along the east and west flanks of Table-top Mountain, by grey and black shales, limestones, and limestone-conglomerates, of the Levis formation.

These form but a small part of the great area of these rocks, which stretches from Cape Rosier along the south side of the Gulf of St. Lawrence to Quebec and thence through the Eastern Townships into the United States. In the vicinity of the Ste. Anne River, they extend south as far as the base of the Shickshock Mountains, where they apparently dip under the slates and crystalline schists of the mountain, and have been described as so doing by Murray (Report of Progress, 1846) along his 2nd and 3rd courses of the river.

A similar case is seen on the Island of Orleans, where the Hudson River slates apparently dip under the older Levis rocks. Other cases have been mentioned by Dr. Selwyn as occurring in the Eastern Townships, and also by Mr. Ells at several points on the coast between Cape Rosier and Metis.

This also accounts for the seeming interstratification of bands of limestone-conglomerate among beds of grey and green chloritic slates, near the junction of the two systems, which is seen along the upper courses of the Ste. Anne River, particularly at a small fall about ten miles below the Forks; also along a brook on the north side of the river, four miles below the Forks.

At the former place, a bed of conglomerate about twenty feet thick is found folded up between grey and green chloritic slates. On the brook several thin beds of limestone conglomerate were found among the grey chloritic slate.

Cambrian of Table-top Mountain

Along the east and west flanks of Table-top Mountain, beds of a dark-grey limestone are seen, which upon careful examination showed no trace of fossils, but which, on account of their resemblance to the Levis limestones of the coast, described in former reports, and their position in relation to these rocks, are thought to be of the same age.

They appear to have been lifted up by the great granite mass which forms the main portion of Table-top Mountain, and for some distance from their contact with this mass, they show signs of alteration, being more or less changed to a dark-grey marble. The country occupied by these rocks is very mountainous. The ridges run east and west, seemingly along the general strike of the rocks, and are cut by numerous brooks on both sides of the water-shed, distant about six miles from the coast, and between it and the Ste. Anne River.

The mountains have rounded outlines, and are well wooded, although in the vicinity of Table-top, they rise to a height of three thousand feet above the sea level, the general height being about fifteen hundred feet.

Much of this area has been burned over, but quantities of good timber still remain, consisting principally of white spruce, white and yellow birch, cedar, poplar, balsam-fir, and a few ash and maple trees.

The soil is very good for agriculture, and is cultivated for about six miles up the Cape Chat River, where good crops of hay, barley, buckwheat and wheat were seen on September 1st; most of the hay being cut and much of the barley quite fit for reaping, and the other crops well advanced. The land is also cultivated for a distance of four miles from the mouth of the Ste. Anne River. The shortness of the season is, however, a very serious drawback to agriculture here as well as along the whole coast.

Pre-Cambrian.—A.B.

Metamorphic rocks of Shickshock Mountains.

This system is represented by the metamorphic schists and slates of the Shickshock Mountains, which were examined along the Ste. Anne River and several of its tributaries; also along the Cape Chat and Magdalen Rivers and on the shores of Lake Matapedia. These rocks extend from the east side of the lake, being covered by the Silurian sandstones and limestones on the west side, as far as the head waters of the Ste. Anne River, where they are interrupted by the great mass of granite forming Table-top Mountain.

To the east of the granite a small Pre-Cambrian outlier crosses the middle branch of the Magdalen about ten miles above the Forks. This mass occupies a small area overlaid by Silurian limestone.

Destribution of Pre-Cambrian.

The breadth of the area occupied by the great mass of rocks of Pre-Cambrian age varies from four miles on Lake Matapedia to about nine miles near the Ste. Anne and Cape Chat Rivers. It extends almost parallel to the shore, and is sixteen miles distant from the mouth of the Matane and eleven from that of the Ste. Anne.

These rocks are the oldest found in the Gaspé peninsula, and probably formed the shore line against which the Silurian and Devonian rocks to the south were deposited.

As already stated, they are intimately associated with the Cambrian and Cambro-Silurian rocks on the north side, and seem to conformably overlie them. The Pre-Cambrian rocks form an important physical feature of he Gaspé peninsula, constituting the Shickshock Mountains. These mountains are considerably elevated above the surrounding country, and their altitude increases as they proceed eastward, so that in the neighborhood of the Ste. Anne and Cape Chat rivers many of the main peaks have an elevation of more than three thousand five hundred feet above the sea level, while on the Matane River few points exceed one thousand feet in height.

Shickshock Mountains.

The sides of the mountains are very abrupt and well wooded. The tops are generally flat, and many of the higher peaks being above the tree limit, are covered only with moss and grass.

Section on Devil's Brook.

Several good sections of these rocks were examined along the Ste. Anne River and its tributary brooks. One of the best is that found on the Devil's Brook, which rises on top of Mount Albert and passes down a deep gorge on the east side, entering the South Branch of the Ste. Anne about two and a half miles above the Forks. This section gives the lower beds of the system and their contact with the serpentine.

The following are the rocks observed along the brook from its mouth, the section being in a descending order:—

	PACES.
Impure limestone, containing green chlorite, associated with beds of grey chloritic slate, splitting into thin laminæ....	50
Measures covered by drift..	600
Pea-green massive chloritic rock, which breaks into long splinters, and is penetrated by veins of quartz, associated with dark green epidote..	450
Hornblendic and chloritic schists, causing a fall of 150 feet in the brook	300
Hornblendic and green chloritic schists, greatly contorted both on strike and dip..	50
Grey gneiss, consisting principally of black hornblende and quartz, with some pink felspar; dip S. 50° W. <80°.....	120
Impure limestone, containing scattered grains of chlorite; dip S. W. <80°	62
Dark hornblende-schist, associated with thin bands of light-green chloritic slates; dip S. W. <70°	95
Hornblende-schist and massive chloritic rock of dark-green colour; dip S. 30° W. <60°............................	40
Dark hornblende schist..	120
Hornblende-schist, associated with thin beds of light-green chloritic slate; strike E. 80° S. <80°	10
Dark hornblende-schist..	125
Dark limestone, containing dark-green chlorite..................	90
Serpentinous limestone, interstratified with bands of serpentine; dip S. 30° W. <70°	270
Dark-green serpentine, weathering buff; dip S. 50° W. <80°	

This section shows the lower beds of the system only.

Section on N. Slope of Mount Albert.

The upper beds, composed chiefly of grey chloritic slates, together with a few green beds, were seen in a section examined along a small brook which takes its rise on the northern slope of Mount Albert, and flows into the Ste. Anne River at the Forks.

The following is the section exposed along this brook from its mouth upwards :—

	PACES.
Beds of light-grey chloritic slate, much crumpled along the strike, but having an average dip of S. 20° W. <60°.............	1680
Beds of green chloritic slate..	700
Beds of light grey-slate..	140
Massive green chloritic rocks, penetrated by veins of quartz, intermingled with dark green epidote..........................	270
Beds of light-grey chloritic slate, same as above................	170
Light-green massive chloritic rock	310

The section here ends, but farther up the side of the mountain and forming its peaks, are found the hornblende schists which occur at the Devil's Brook.

The hornblende schist on the top of Mount Albert contains quantities of small red garnets, few of them being larger than a pea.

Apparently overlying these rocks, and between them and the great mass of dark-green serpentine, beds of a beautiful banded serpentine occur. This rock shows, on weathered surfaces, bands of red and opaque yellowish-white color, while on newly fractured faces these bands are dark-brown and blood-red, and vary from one-eighth inch to one inch in width. Very thin layers of asbestos are sometimes found separating the red beds.

Section on W. side of Mount Albert.

The next measured section of this system occurs along a brook which takes its rise in a small lake on the west side of Mount Albert, and flows into the Ste. Anne River, about four miles below the Forks.

This section is given as found in descending the brook, or from the lowest beds upwards, and is as follows :—

	PACES.
Dark hornblendic schist, dip S. 30° W. <80°	80
Dark hornblende-schist, dark-grey mica-schist, and light-green chloritic slate in thin beds	135
Fine-grained grey gneiss, made up chiefly of white orthoclase, dark hornblende and small quantities of quartz	30
Light and dark-green massive chloritic rock, containing numerous veins of quartz associated with dark-green epidote	490
Altered limestone-conglomerate, the matrix being formed of a greyish-green schistose sandstone, and the pebbles highly crystalline. Dip S. 30° W. <60°	48
Light-green chloritic slates	210
Massive dark-green chloritic rocks	1013
Light-green chloritic slates	106
Light-grey and green slates, full of veins of quartz and epidote	1000
Beyond this, to the mouth of the brook, about one mile distant, the rocks are chiefly light-grey chloritic slates, associated with beds of light-green chloritic slates, which in the upper beds show less alteration.	

Many of the beds in the above section may be identical, and probably are, as the rocks are greatly twisted up, showing in many places sharp synclinals and anticlinals with reversed dips.

Other sections, similar to these, were observed on several brooks to the westward, and they all gave a similar series of rocks, consisting of grey and light-green chloritic slates, with massive dark-green chloritic rock; the hornblende-schists were not seen, probably because they lie to the south of the sections made.

General Structure.

Along the South Branch of the Ste. Anne River, on the south side of the great mass of serpentine and olivine which crosses the river, dark hornblendes-chists and green chloritic slates were seen, corresponding to those on the north side, and probably identical with them, thus showing that the great mass of serpentine which composes Mount Albert has thrust up the beds of this system, forming a great anticlinal with reversed dip. The top of this anticlinal having been denuded off, leaves beds of the same rocks on either side of the serpentine; those on the north side apparently dipping under the mass, while those on the south appear to lie upon it.

These hornblende-schists were also seen by Mr. Ells on the Salmon branch of the Great Cascapedia, where they also underlie the serpentine.

Rocks in Lake Matapedia.

On the east shore of Lake Matapedia (as described in the "*Report of Progress*" for 1863), a series of pink and green schistose sandstones were seen associated with a dark-green chloritic rock which has an igneous appearance, and contains concretionary nodules, many more than one foot in diameter, which consist of an intermixture of quartz and epidote, generally green, but in places dark red.

The junction between these rocks and the sandstones on the shore of the lake is always covered with debris, but in a large boulder found on the shore the green chloritic rocks are seen lying unconformably on the bedded sandstones, having the appearance of a bed of trap overflowing the uneven surfaces of the sandstone, and filling up the interstices.

Serpentine and Olivine.

Relations of Serpentine and Olivine.

These rocks are largely developed at the eastern extremity of the Shickshock range, and form the prominent peak of Mount Albert. They extend in a south-westerly course from the west side of Table-top Mountain across the south branch of the Ste. Anne River to Mount Albert, which is about the centre of the mass, and thence to the head waters of the East Fork of the Salmon Branch of the Cascapedia River, making a total length of twelve miles.

The greatest breadth is four miles, on Mount Albert, but the average is not more than two and a-half miles.

The rocks are chiefly olivine, more or less changed into a dark green serpentine, associated with patches of mottled brownish-red, the whole overlaid by the banded beds before described.

The green serpentine has sometimes a coarse fibrous structure (picrolite), but the quantity is small and the quality not fine enough to make it commercially valuable as asbestos.

All the rock seen on Mount Albert was altered into the above serpentine, but on the eastern slopes, along the Ste. Anne River, olivine was found only slightly decomposed upon weathered surfaces.

Lithological Character.

Mr. Adams examined a section of this rock, under the microscope, and gives the following description of it:—"This rock, which is very fresh, is in section seen to be composed of olivine, arranged in very irregular bands of larger and smaller grains, together with a small quantity of an opaque black iron ore, which, judging from its association with the olivine, is probably chromic iron ore. A few grains of a very light brownish-green fibrous mineral, some of which show parallel extinction, are also present. These are probably enstatite, but none of them are cut so as to enable this to be determined with certainty. An interesting point in connection with this rock is, that each grain of iron ore is surrounded by a greenish ring composed of an aggregate of wavy fibres, which in a few cases, where they were sufficiently large for examination, were found to have a parallel extinction, and which resemble serpentine. It is an olivine rock." See also description of similar rock from nearly the same locality by Dr. B. J. Harrington. (Report of Progress 1877-78, p. 40 G.)

These rocks all change to a light buff color where they are exposed to the action of the atmosphere; and as the soil above them is very poor, supporting little or no vegetation, a dead appearance is given to the scenery.

Banded structure is distinctly seen amongst the serpentines on the mountain, but the direction of the strike of the beds is not continuous, nor parallel to that of the surrounding stratified schists, and is supposed to be due to flow structure, as the olivine is undoubtedly of igneous origin.

Chromic Iron Ore.

Chromic iron is found associated with the green serpentine, and seems to be confined to certain beds of the rock, as it is found scattered along the strike in loose blocks, some of which are ten inches in diameter.

This mineral was observed on the surface near the banded beds of serpentine, at the north-east side of the mountain, and also along a bed about two miles south of the first place.

The ore was found to occur in small, widely-separated pockets, scattered through the serpentine, and where seen is not in sufficient quantity for profitable mining.

Where the olivine crosses the Ste. Anne River, veins of steatite of a light-green color were observed, but the cost of transportation renders them of no economic value.

Granite and Trap.

Great masses of granite were found forming Table-top Mountain, and several isolated peaks to the south of it and Mount Albert.

Granite Masses.

The granites of this region are evidently of later date than the Silurian and Devonian rocks. Fragments of the country rock are enclosed in them, and the adjacent stratified rocks all show more or less alteration, as they do in parts of New Brunswick, Nova Scotia and in south-eastern Quebec.

The granite differs in appearance over this wide area. On the northern and central parts of Table-top, where the mass appears to have cooled slowly, it is typical granite, composed of pink orthoclase, white quartz and black hornblende, with little mica; while to the south and in the isolated peaks, where the mass evidently cooled rapidly, the felspar predominates. To the naked eye the rock appear to be almost wholly composed of the latter mineral.

Lithological character.

Examined under the microscope by Mr. Adams, this rock is found to be composed of orthoclase, plagioclase, quartz, chlorite and a little magnetite. "The chlorite is a decomposition-product, being derived for the most part from magnesia mica. Part of it, however, may be a decomposition product of hornblende. The porphyritic character of the rock is due to the presence of larger individuals of the felspars, mica (chlorite) and quartz, which have good crystalline forms (those of the quartz being the least perfect), and lie imbedded in a ground mass consisting of the same minerals in smaller grains, which, however, are still easily recognizable. It is a porphyritic variety of granite, known as granite porphyry. It occurs near the junction of the granite with the surrounding stratified rocks."

Felspathic dykes.

On the South Branch of the Ste. Anne River, five miles above the Forks, beds or dykes of a light-grey, felspathic rock are seen crossing the river, and penetrating the Silurian limestones. Mr. Adams examined a section of one of them under the microscope, and thus describes it:—

"The rock consists of a microcrystalline groundmass, through which felspar crystals are porphyritically distributed. Most of these show the polysynthetic twins of plagioclase, a smaller number are single crystals and are probably orthoclase. In addition to these felspar crystals, there are scattered through the groundmass crystalline outlines, now entirely filled with decomposition products, but which from the forms can be referred to hornblende, and magnesia mica. The rock is therefore a Porphyrite."

Doleritic dykes

Farther to the south, along the Ste. Anne and Little Cascapedia Rivers and the Middle Branch of the Magdalen, dykes of a dark-green, doleritic trap, varying from a few feet to many yards in width, were found.

Much of the trap is amygdaloidal, and contains quartz or jasper; being very similar to that found at Seal Cove on Gaspé Bay, and described in *Geology of Canada*, 1863, page 396.

One dyke on the Middle Branch of the Magdalen, about four miles above the Forks, is highly charged with magnetic pyrites, which, however, gives no traces of nickel.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

REPORT

OF

EXPLORATIONS AND SURVEYS

IN PORTIONS OF

YORK AND CARLETON COUNTIES,

NEW BRUNSWICK.

1884.

By L. W. BAILEY, M.A., Ph.D., F.R.S.C.,

PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF NEW BRUNSWICK.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1884.

To Alfred R. C. Selwyn, Esq., LL.D., F.R.S.,

Director of the Geological Survey of Canada.

Sir ;—I beg to submit herewith a report of geological investigations in central New Brunswick, made by myself and others up to the close of the past season.

Accompanying the report is a map embodying the results of these investigations and constituting quarter sheet No. 1 N. W. of the geological map of New Brunswick now in process of construction. Large portions of the area represented, more particularly in Queen's and Sunbury counties, have been fully described in previous reports. The present report relates to those portions of York and Carleton counties to which the investigations of the years 1881–83 have been confined.

In addition to the aid afforded by my successive assistants, Mr. Wallace Broad in 1879 and Mr. Wm. McInnes in 1883, by whom the greater part of the topographical work and map-making has been effected, I would here express my obligations to members of the staff in the Crown Lands Department in Fredericton for the use of their office in draughting as well as for copies of plans and surveys, and to the Manager of the New Brunswick Railway Company for free passes over the lines of that company granted to myself and assistants.

In addition to the work on the rock formations, the investigations in New Brunswick during the past season included a study of its superficial geology by Mr. R. Chalmers. The results of these investigations form the subject of a separate report.

I have the honour to be,

Sir,

Your obedient servant,

L. W. BAILEY.

Fredericton, N. B., March 25th, 1884.

REPORT

OF

EXPLORATIONS AND SURVEYS

IN

PORTIONS OF YORK AND CARLETON COUNTIES,

NEW BRUNSWICK.

The region to which this report more particularly relates may be described as embracing the northern half of York and the southern portion of Carleton county; being divided obliquely into two nearly equal sections by the valley of the St. John River, from which one section extends in a westerly direction to the United States boundary and the other eastwardly to the valley of the Nashwaak River. The more remarkable physical features of the region are described in the report on the surface geology by Mr. Chalmers, and are further noticed in the present report. Its geology has been the subject of more or less extensive examination by various observers, including Dr. Chas. T. Jackson (1837), Dr. A. Gesner (1842), Prof. James Robb (1849), Prof. C. H. Hitchcock (1862), Prof. H. Y. Hind (1865), and in connection with the Dominion Geological Survey by Mr. Chas. Robb and Mr. R. W. Ells. The reports of the last two gentlemen are contained in the Reports of Progress 1866–69 and 1874–75. In 1879 a survey was made by myself and Mr. Wallace Broad of that portion of the country lying to the westward of the St. John River, and simultaneously a partial examination of the district along the eastern side of the same river, in the county of Carleton, was made by Mr. G. F. Matthew. In 1880, 1881 and 1882 the survey and work of exploration was continued on both sides of the river by Mr. Broad. No report, however, on any of these latter investigations had been made when, in 1883, I was requested to resume the direction of the work and to obtain the necessary data for the completion of the map. The observations which follow are the results of the past season's work, as both comprehending and supplementary to those which have preceded it. In the prepara-

Region described.

Earlier investigation.

tion of the map the larger part of the topographical data was obtained and the subsequent reductions effected by Mr. Broad and his successive assistants, to one of whom, Mr. W. McInnes, my own assistant during the past summer, the final completion of the work is due. For the geological boundaries and determinations, as well as for the views of structure or origin hereinafter expressed, I am alone responsible.

G. Carboniferous.

A considerable portion of the area included in the map to which this report relates is occupied by rocks of Carboniferous age, but as these have been for the most part described in previous reports, it will not be necessary to dwell at length upon them here. As in other parts of the province they present two marked subdivisions. These are strongly contrasted, alike in color, composition and agricultural capacity. There are also many evidences of their unconformability.

Upper Division. The upper division embraces the Coal Measures and Millstone-grit. It covers extensive areas in York and Sunbury counties, and is readily recognizable by its generally grey color and coarse texture. The latter feature increases towards the base of the formation, where the beds are usually a very coarse conglomerate, largely consisting of white quartz pebbles. Beds of massive sandstone, of grey and purple colours, are often found higher in the series. These are admirably adapted for architectural purposes. Thin seams of coal are not uncommon, but no beds of workable thickness are known to occur. The country occupied by these rocks is flat and undulating. To the southward, in the direction of the centre of the Carboniferous basin, it becomes low, but in the opposite direction is more hilly, and along its northern edge often presents long and high mural escarpments. In general its agricultural capabilities, owing to the sandy character of the soil, or where clayey, to imperfect drainage, are of low grade, but where the grey are replaced by red or purplish red beds, there is usually a considerable improvement in this respect, while the occurrence of numerous streams and rivers gives rise to extensive intervales, on some of which are the most productive soils in the province.

Lower Division. In contrast with the coal measures, wherever the Lower Carboniferous rocks occur, there are soils of great fertility. This is evidently the result of the highly calcareons nature of the beds and the consequent facility with which the latter crumble and disintegrate. Their color is very generally red, varying from a deep brick red on the one hand to a brownish red or chocolate brown on the other; and in texture they range from coarse conglomerates to fine marls and shales. At several points, (more particularly referred to in the sequel), they include small beds of limestone.

At the summit of the Lower Carboniferous and directly beneath the Millstone grit there are found at several points beds of volcanic or semi-volcanic origin, such as basalt or anamesite, amygdaloid, felsite, claystone porphyry, &c., the details of which are given in earlier reports. Their position is thus the same as that of similar beds on the other or southern side of the great central Carboniferous basin. It is to their association with beds of this character that the bright red color of the accompanying sandstone and shales is due. Igneous rocks.

In general the attitude of the coal measures and millstone grit is not far from horizontal. A remarkable exception, however, occurs in a limited patch of such rocks to be found on the eastern side of the St. John River, in the parish of Bright, where they have a dip of nearly 90°. The Lower Carboniferous beds are also often inclined at low angles, but with more numerous exceptions, these being apparently connected with the greater inequality of the surface on which they rest. Attitude.

The supposed unconformability between the Lower Carboniferous and coal measures is evidenced not only by local differences of attitude and by the occurrence of volcanic outbursts between the two, but by the marks of extensive erosion along their surfaces of contact. The occurrence of numerous small detached areas of both these formations, together with their altitude with regard to the surrounding region, show clearly that they both at one time spread widely if not continuously over it, but the irregularity of their distribution, together with the frequent absence of the lower beds altogether, would seem to indicate that these had been already extensively removed prior to the deposition of the later strata. It is noticeable that in Carleton county the Lower Carboniferous belt follows approximately the line of contact of the Silurian and Cambro-Silurian systems. Unconformity.

E. Silurian.

The reference of Pre-Carboniferous rocks in the northern portion of Carleton County, in common with those occupying the larger part of the northern portion of the Province, to the so-called Upper Silurian formation, was first made by Dr. Gesner in 1842, on the evidence of their contained fossils, and has been generally accepted by later investigators. Much uncertainty has, however, existed as to the exact position of the boundary between the Silurian and the supposed Cambro-Silurian rocks which border them on the south, as well as with regard to the grounds of their separation; and it has accordingly been one of the main objects of recent exploration to settle these points more definitely. In the summer of 1879, Mr. G. F. Matthew, in his study of eastern Carleton, found evidence of the looked for physical break in the occurrence, along the course of the tributaries of the Beccaguimic River, of conglomerates near the base of the Silurian system containing embedded fragments which were clearly traceable to the Cambro-Silurian rocks below; while in the same season the author of the present report was led to recognize a similar line of separation in the region west of the St. John River. The observations of Mr. Matthew derived additional importance from the fact that the rocks along the supposed line of junction were at several points found to hold organic remains which, it was hoped, would be the means of fixing definitely the age of the beds in which they are contained.

Between the two regions, however, there existed a considerable interval, and it was hence thought desirable in commencing the work of the past season that the formations thus independently studied should be traced into connection, and that by the collection of additional fossils from the Beccaguimic, such aid should be obtained towards the elucidation of the age and structure of the district as these might be able to afford. This was accordingly done, and a careful re-examination made of the whole area. Unfortunately, however, the fossils obtained, though they embrace a considerable variety of forms, such as brachiopods, crinoids, trilobites, orthocerata and graptolites, and in some instances are pretty well preserved, are mostly fragmentary and have proved too imperfect for even generic determination. For this reason and from the fact that the district in which they occur will be the subject of renewed and more extended examination in another season, it has been thought best not to consider them further here, but to confine the present report to the region embraced in the map which accompanies it. For a like reason the following observations on the Silurian district are for the most part restricted to what is seen along its southern margin.

Fossils.

Succession on St. John river.

The highest Silurian beds to which reference will here be made occur along the west bank of the St. John River, at and below Hartland Ferry. They are soft clay slates which are conspicuously banded with thin alternating layers of calcareous and argillo-calcareous material, and with which thin beds of quartzite also occur. The calcareous layers are from one to four inches in thickness, and attempts have been made to burn the rock for lime, but without success. Their dip is mostly to the northwest but irregular, and with several reversals. In descending on the measures they are found to include several heavy beds of grit and conglomerate. These are largely composed of pebbles of grey quartzite and black petrosilex closely resembling in character portions of the rocks to be presently described as Cambro-Silurian, and indicate an approach at this point to the base of the Silurian system. The superposition, however, at Victoria Corners, of a belt of Lower

Carboniferous rocks prevents the actual junction of the two systems from being observed.

Contact of formations.

From Victoria Corners to the iron-works near Woodstock, the same Lower Carboniferous belt hides from view the subjacent rocks, but beyond this point they again appear and their line of junction can be readily traced to the western frontier of the province. Crossing the Meduxnakeag River and the Houlton road, about a mile and a half west of Woodstock, it follows a nearly uniform southwesterly course. It intersects the New Brunswick railway (Woodstock Branch) between the 84th and 85th mile-posts, or about two miles east of Debec Junction, and again at O'Donnell's crossing, south of the latter. Thence it extend along the Pokomoonshine Brook to Kirkland post office, in South Richmond, and finally crosses Bull's Creek, a tributary of Eel River, and the northern boundary of York county, in Monument settlement. Through this district the conglomerates which mark the base of the Silurian system are exposed but at few points. They may, however, be seen near O'Donnell's crossing, where they repose unconformably upon a pale quartz-porphyry, from which their included pebbles have been in part derived ; and again on Bull Creek where they are similarly filled with fragments derived from the underlying rocks. It is further noticeable that in approaching the frontier to the southwest, these basal beds of the Silurian successively overlap different members of the Cambro-Silurian system and hide them from view. Thus the unconformity of the two systems is strongly marked, as these are also in strong contrast in their lithological characters and in the conditions of their origin.

Woodstock.

Richmond.

Unconformity and overlap.

Limestone.

The banded grey and dark grey calcareous slates which succeed the basal conglomerates last noticed, are readily traceable through southwestern Carleton, having a nearly uniform southwesterly trend and a general dip to the northwest, though with many local irregularities. They contain also, as on the St. John River and in the Beccaguimic region, occasional beds of limestone. One of these, at Joy's Corner, near Lake Asphaltes, was formerly worked for lime, but owing to its unfavorable position has been abandoned. It abounds with crinoid stems and small brachiopods, showing chiefly on weathered surfaces, but which are too imperfect for identification. Buff weathering sandstones resembling certain beds which on the Beccaguimic are highly fossiliferous, also occur, but were not found to contain any organic remains. Farther north, and forming a portion of the same system, are the red hematite slates of Jacksontown. These are mostly, however, beyond the limits of the map, and as they have been fully described in earlier reports, will not be further noticed here.

Fossils.

Hematite.

D. Cambro-Silurian.

The rocks now to be described as Cambro-Silurian are a part of those which in earlier reports have been variously described as Cambrian (Gesner and J. Robb), Mica-schist formation (Hitchcock), Quebec group (Logan and Hind), Lower Silurian (Bailey and Ells), or simply as non-calcareous slates, gneisses, etc., (Chas. Robb). They lie on either side of, or as outliers on, the great central granite axis of York county, and with the latter extend to the northeast, where they are believed to be continuous with the similar beds described and mapped by Mr. Ells in the counties of Northumberland and Gloucester. It is but right, however, to state that in referring them to the horizon first above named, this is done in the absence of any positive proof of their true position. Within the region examined they have as yet yielded no fossils, and the only evidence of age is that furnished by the unconformable overlap of the Silurian rocks, as described in previous pages, and the fact that they have supplied material for the formation of the conglomerates at its base. They are thus at least as old as the Cambro-Silurian, to which they are here provisionally referred. Amid strata, however, of such diverse character, which include at many points rocks of igneous or semi-igneous origin, which are not only in contact with, but are penetrated by great masses of intrusive granite, and which are themselves, over large areas, of a highly crystalline character, the writer would hesitate to assert that there may not also occur rocks of Cambrian or even of Pre-Cambrian age. On the contrary, among the descriptions which follow, references will in several instances be made to cases in which irregular masses of fine grained rock, which are more or less crystalline and of obscure stratification, are associated with the usually schistose strata of the region in such a way as to indicate that they may possibly be protruding Pre-Cambrian bosses. As these, however, invariably partake more or less of an igneous character, it is always a question and one usually not easily answered, whether they are not rather to be regarded simply as eruptive masses, contemporaneous with or even later in origin than the beds which they accompany. The facts that in several instances they exhibit, through long distances, a close parallelism with the general trend of the latter, that in some cases the sedimentary and volcanic sediments are interbedded, and that the former are of such a character as are usually found accompanying rocks of igneous derivation, have led the writer to regard them, at least provisionally, as members of one system. It may be added that in all these features they not only resemble the formations described by Mr. Ells towards the Baie Chaleur, but those also which border the northern edge of the granite in Charlotte county, and which have been similarly mapped as Cambro-Silurian.

Earlier investigations.

Supposed age.

Pre-Cambrian rocks.

Igneous rocks.

It will be evident that in the discussion of this system of highly crystalline rocks and their relations to the granite, one is necessarily brought face to face with all the vexed and difficult questions of local and regional metamorphism, including the origin of the granite itself and its possible influence. Without entering at length into the discussion of these questions, it is proposed to give here simply a summary of the facts observed, with such conclusions as they may seem to fairly warrant.

Questions of metamorphism.

The district occupied by the northern belt of Cambro-Silurian strata is of variable breadth and irregular outlines, due on the one hand to the overlapping of Carboniferous strata along its line of junction with the Silurian, and on the other to the sinuous, ill-defined and often vein-like character of the granitic axis which bounds it on the south. Of these lines of contact the first has been already described, and details of the second are given in the sequel. It will be enough to state here that the width of the belt as exhibited along the St. John river, between the mouth of the Sheogomoc and Woodstock, is about fifteen miles; this is slightly increased along the lines of railway on either side of the first named stream, but near the western frontier, owing to a northward bend of the granite in connection with the trend of the Silurian, is reduced to about one quarter of that amount. On the west side of the main river it includes about one half of the parishes of Canterbury and North Lake in York county, and the southern half of the parish of Woodstock, while eastward of the river it occupies the larger part of the parish of Southampton in the first, and much of that of Brighton in the second of the counties named. In this direction it is continuous with a belt of similar rocks extending across the valley of the Nashwaak, the limit of our exploration, but is known to re-appear upon the Miramichi and its tributaries, as well as upon the north-east coast, where it has been examined and described by Mr. Ells.

Northern belt.

Its limits.

The second or southern belt is less extensive and at the same time more variable in contour than the northern, for while one of its borders, corresponding to that of the granite, is tolerably uniform, the other is rendered irregular by the encroachment of the Carboniferous strata which bound it upon the south and mark the northern edge of the great central coal-field of the province. On the west of the St. John this belt occupies the greater portion of the parishes of Prince William and Kingsclear and on the eastern side portions of the parishes of Queensbury and Bright. The average breadth is about twenty miles, but along the Keswick valley and the line of the New Brunswick railway this is reduced, by the overlapping of Carboniferous sediments, until it hardly exceeds four or five. In the upper part of the same valley the area occupied by these rocks becomes, through

Southern belt.

Limits. the partial disappearance of the granite, continuous with that of the third or central belt of schistose strata, extending through the Caverhill and Haynesville settlements, and with the latter is prolonged in an easterly direction to the Nashwaak River, upon which it includes the entire interval between Stanley Bridge and the mouth of the Napadaugon.

Topography. The several districts above referred to are very generally of a hilly and broken character, exceeding in this respect even the granite areas with which they are associated. This is especially true of the northern belt, which along much of its extent is marked by the occurrence of prominent ridges, such as Pokowogamis Ridge, Oak Mountain, Carrol Ridge, Sheogomoc Ridge and Dorrington Hill on the western, and Maple Ridge, Howland Ridge, &c., on the eastern side of the St. John River, their average elevation being about 600 feet; while in the case of the southern belt a similar feature is seen in such prominences as Magaguadavic, Blaney and Magundy Ridges and the Keswick Ridge. In each district, however, there are large areas which, while far from being low, are comparatively flat, as along either of the lines of railway leading north to Woodstock, and near the western frontier in Monument settlement. Soils. As usual the character of the soils and the general agricultural features of the region are primarily dependent upon the nature and durability of the underlying rocks, which by their hardness determine a more stony, and by the comparative absence of lime a much less productive soil than such as characterizes the Silurian region; but their effects are greatly modified, whether favorably or unfavorably, by the distribution of the drift.

General geological features. As already intimated, and as further suggested by its topography, the rocks in the Cambro-Silurian area are highly disturbed as well as greatly altered. The strata are everywhere tilted at high angles, with innumerable folds and contortions, and with repeated indications of faulting. In addition to the main axis of granite, they are invaded by several smaller masses of the same rock, as well as by syenite, felsite, diorite, &c., which help still further to obscure their geological relations. Plications. Indeed no finer illustrations of arched and crumpled strata are to be found in the province, and probably not in Acadia, than are afforded by the almost continuous section of these rocks exposed along the St. John River valley, between Woodstock and Fredericton, while along the lines of contact with the granite on the same section equally fine opportunities are afforded for the study of the supposed connection Granite intrusions. of the latter with the metamorphism of the associated strata. Innumerable veins of granite are seen to penetrate the adjacent schists, while detached blocks of the latter, of every shape and size, may also be seen actually imbedded in the granitic mass. In view of these facts, in connection with the further circumstance that the country occupied by the Cambro-Silurian rocks is still only partially cleared and largely covered with drift, it is very difficult, if not impossible, to reach satisfactory conclusions either as to their succession or thickness, but the following ascending arrangement is that which seems best to accord with the facts observed:—

PROBABLE SUCCESSION OF CAMBRO-SILURIAN STRATA.

Coarse to fine grey gneiss and dark-grey mica schist; chloritic, hornblendic and felspathic schists, with heavy masses of diorite and felsite.

Grey, dark-grey and purplish-grey (or lilac) micaceous sandstones and slates, with thin beds of limestone and belts of grit and conglomerate; grey felspathic slates and quartzites; intrusive and interbedded diorites.

Supposed succession.

Dark-grey to black pyritous and graphitic slates.

Highly felspathic schistose rocks, often gritty with particles of white quartz and angular pieces of felsite, in part a coarse conglomerate.

Grey, green and purple amygdaloid, vesicular sandstone and slate, in heavy beds.

Grey and pale-grey, pink and reddish felsite.

Grey felspathic sandstones or quartzites and slates, often chloritic.

The highly crystalline gneissic and micaceous strata which, from their position, are believed to be the oldest representatives of the Cambro-Silurian system, are most clearly exhibited on the northern side of the granite, in the parish of Canterbury, where they occupy a broadly crescentic area, having its greatest width, of about six miles, along the main line of the New Brunswick railway, and from this narrowing westwardly to the frontier at North Lake, and eastwardly to the St. John River about Sullivan's Creek. Through the length of this area all the more prominent members may be continuously traced.

Gneiss and mica schist in Canterbury.

Near the granite the rock is usually a fine-grained, imperfect gneiss, of a grey color, commonly very much corrugated and mingled with granitic or quartzose veins in the most complicated manner. At some points, however, as at the head of North Lake, the rock is coarser, and is in part a true granitoid gneiss, of the ordinary composition, weathering with a rough uneven surface, while other portions are composed of a granular admixture of felspar, mica, hornblende and chlorite, with but little quartz. With the gneisses occur well developed mica-schists, which are highly cleavable and lustrous. They also contain numerous veins of quartz, and occasionally hold minute garnets or imperfectly developed crystals of staurolite. The rock most commonly met with, however, throughout the district, and sometimes in close proximity to

North Lake.

Micaceous sandstones.

the granite, is a fine, tender, highly micaceous or gneissic sandstone, sometimes grey but commonly possessing a purplish grey or lilac tint, distributed in clouds or bands, and not unfrequently characterizing the whole mass of the rock. With these sandstones are found at some points considerable bands of hornblendic and felspathic rocks, the former including a very coarse dark-green diorite, together with beds of hornblendic and actinolite schist, while the latter are usually grey, white-weathering and quartzose, with small crystals of felspar. Rocks of this character are well-exposed along the road leading from Sullivan's Creek, on the St. John River, to Canterbury station, and especially at and about the eminence known as Dorrington Hill. Here also are the best exposures of the calcareous beds, which seem to form a well-marked member of the group, and which are traceable at intervals throughout its entire length. Where exposed on the railway south of Canterbury station they are of inconsiderable thickness and quite impure from admixture of sandy and micaceous material, but at a point about one and a half miles south of Dorrington Hill, they are much purer, and of sufficient extent to induce their removal for calcination. They may here be clearly seen to form a part of the micaceous series, alternating with dark-grey micaceous sandstones, which are sometimes chloritic and contain sheafs of hornblende, or with beds of true hornblende schist; all the strata being much disturbed and the dip irregular, though usually to the northwest 70—80°.

Hornblendic and felspathic rocks.

Limestones of Canterbury.

Conglomerates.

Another set of beds seen in the vicinity of Dorrington Hill, and forming an exception to the usually fine-grained texture of the Cambro-Silurian rocks, is that of a series of somewhat coarse conglomerates and grits, exposed in and along the valley of Four-mile Creek, a small stream skirting the above-named eminence on its northern side and thence flowing to its junction with Eel River. These conglomerates are intimately connected with the micaceous sandstones, containing beds and layers indistinguishable from the latter, and are themselves highly micaceous, but at the same time contain numerous well rounded pebbles of grey felspathic quartzite, from one to twelve inches in length, together with others which would seem to have been derived from beds of gneiss, diorite and mica-schist. They thus at first sight suggest the idea of their being a series newer than, and derived from the Cambro-Silurian, but of this we could obtain no confirmation from the study of their stratigraphical relations, while their alternation with, and apparent graduation into, the sandstones, seem rather to indicate that both are of contemporaneous origin, the highly micaceous character of both, with the nature of the pebbles referred to, either resulting from a common derivation from some unknown Pre-Cambrian source, or else being the effect of a common alteration, in connection with the granitic intrusion, of beds of coarse and fine material. Similar conglomerates and grits, with similar associations, may also be seen just west of Deadwater Brook, along the more northerly of the roads leading westerly from Canterbury to Skiff Lake; where pebbles in the conglomerates, owing to their superior hardness, project in rough knobs over the weathered surface of the rock often as much as an inch or more. These beds are interstratified with grey and lilac micaceous sandstones, but both are irregular in dip, with sharp local curves and corrugations. They may also be seen, though less conspicuously, on the west side of the First Eel River Lake, south of Monument settlement, and on the St. John River north of Sullivan's Creek. Deadwater Brook.

Another well-developed belt of rocks traversing tbe parish of Canterbury bears some resemblance to that last described in the fact that it is likewise composed of somewhat coarse material and has a distinctly crystalline aspect, but differs in being much more felspathic and gneissoid, with evidences of at least a partially igneous origin. At its eastern extremity this belt approaches and appears to become continuous with the rocks of Four-mile Brook, forming somewhat prominent hills overlooking the Canterbury and Eel River road near Grant's mill, and apparently forms an anticlinal, flanked on either side by dark colored argillites, which are more less chloritic; but further west the two belts diverge until along the line of the railway they are separated by a considerable interval, occupied chiefly by argillites. At each of these localities the bulk of the rock is a highly felspathic and schistose or gneissic grit, containing in addition to glassy particles of quartz, others of white or green felspar and often chlorite; but at Grant's mills the beds are further peculiar in holding light-grey felspathic seams, from one to two inches in breadth, which branch and bifurcate irregularly after the manner of injected veins. In the hills near the railway, (at the 70th mile post,) they are equally remarkable as exhibiting upon their weathered surfaces, in addition to fine wavy lines which are apparently of fluxion origin rather than the result of sedimentation, innumerable closely-aggregated nodules, or what appear to be such, which often possess a distinctly concentric structure, and are probably concretionary. Still further west, beds which conform both in character and position to these form the eminence known as Pokowogamis Ridge, and were finally seen crossing the road along the west side of Eel River Lake. Igneous rocks.

In addition to the features noted, the partially igneous origin of these rocks is, at each point of their occurrence, indicated by their association with well-marked amygdaloidal beds, of grey, green and purple colors, which are usually found flanking the felspathic and gneissoid beds. The re-appearance of rocks of this latter character, with similar associations, still further north, in two or more belts traversing the southwestern portion of Carleton county and separated by belts of argillite, would seem to indicate that they represent the crests of so many folds over which these argillites were at one time spread, but which are now exposed by denudation. Another of these belts may be seen crossing the railway track at mile post 72, in the form of a light-grey, white-weathering quartz-porphyry, and again about half way between mile posts 72 and 73. Here they consist chiefly of light greenish-grey felspathic grits, which are somewhat coarse in texture and contain imperfectly developed hornblende crystals and are often porphyritic or amygdaloidal, but they include also some beds of fine felspathic slate which are nearly vertical (N. 10 W. $>$ 80°–90°). By far the most considerable, however, as well as the most remarkable belt of such rocks is one appearing along the line of railway two or three miles north of Benton, and forming the prominence of Oak Mountain, from which in a westerly direction it extends along the northern side of Eel River to Monument settlement in South Richmond, and in an easterly one to and beyond the St. John River at Woodstock. As seen on the eastern slope of Oak Mountain and along the railway track, where the belt of these rocks has a total breadth of about a mile-and-a-quarter, the bulk of the latter, as at the localities already described, is evidently sedimentary, showing distinct lines of deposition and having the aspect of an altered or gneissoid grit, as well as including some layers of slate, but here these appearances are in general much less marked and the evidences of alteration more extreme. Many of the beds are massive, without evident stratification, conspicuously porphyritic, and contain distinctly formed crystals of hornblende and sometimes of augite, together with chlorite and epidote. It seems, moreover, impossible to doubt that these peculiarities are intimately connected, either as accompaniments or as a consequence of their association with the great mass of presumably intrusive syenite with which on their southern side they are in contact, into which they seem to graduate and which accompanies them throughout their length. This graduation is the more remarkable as it is in singular contrast with what is seen along the lines of contact with the granite, where the transition is usually quite abrupt.

Benton and Oak Mountain.

Felspathic and augitic rocks.

The bulk of the strata composing Oak Mountain are similar to those exposed in the railway sections at its base, including, besides felspathic grits and slates, beds of compact and amygdaloidal diorite and imperfect syenite. In addition, however, to these beds, there are also some, not elsewhere seen in connection with this formation, in the form of deep red and highly ferruginous slates, containing beds of red slaty hematite. These rocks, which occur on the northwest slope of the

Oak Mountain.

Hematites.

mountain, overlooking the valley of Pokomoonshine Brook, are not unlike many of the iron-bearing beds of the Silurian, and they may possibly be an outlier of that formation, but it seems more probable that they are Cambro-Silurian and the equivalents of the similar beds described by Mr. Ells and others in Gloucester county. The point where they occur being in a dense forest and the exposures therefore few, nothing definite either as to their thickness or relations could be determined. Their dip, where observed, was N. 20 W. $>$ 80°. Beyond these beds, but at a much lower level, there are, in the valley of the brook last referred to, ledges of very hard greenish-grey vesicular rock, containing dark-brown prismatic crystals of augite, as well as beds of white weathering felspathic quartzite; these being in turn overlapped by the ribbanded calcareous slates which here represent the base of the Silurian system. Contact of systems.

West of Oak Mountain this belt of rock becomes less conspicuous, both it and the associated syenite sinking out of view beneath the low and artificially flooded area along the upper course of Eel River. Boulders, however, which are evidently derived from it, and consist chiefly of extremely coarse and highly crystalline amygdaloid, of bright-green, red and purple colors, and contain much chlorite and epidote, are thickly scattered over the country to the south, more particularly along the Dinnen road, where the latter traverses Pokowogamis settlement. Near Kirkland post-office in South Richmond similar beds are seen *in situ*, consisting in part of amygdaloidal diorites, but chiefly of a coarse agglomerate, in which both pebbles and paste are alike composed of chlorite, epidote and vesicular diorite. Here also their relations to the Silurian are well exhibited, they being directly overlaid by the ribbanded calcareous slates, while only a short distance to the westward are the coarse calcareous conglomerates of Bull Creek, through which fragments derived from these amygdaloids are abundantly distributed. Pokowagamis Sett. So. Richmond. Contact of systems.

Eastward of Oak Mountain the relations of the two systems of rocks are equally clear. Their unconformable contact at O'Donnell's crossing near Debec, has already been described. Here the supposed Cambro-Silurian rocks consist of flinty felsites and of very hard white-weathering felspathic quartzites, together with beds of amygdaloid, both of which are similar to those of Pokomoonshine Brook, and are covered by a Silurian conglomerate containing fragments derived from these rocks; and further east similar felsites outcrop on the branch railway leading into Woodstock; but in approaching the last named town these are less clearly seen, while beds more like those of Oak Mountain again come prominently into view. Along the west bank of the St. John River they are exposed at intervals all the way from Bull's Creek, Woodstock.

south of Woodstock, where they meet and pass into red and grey syenite, to within four miles of Victoria corner, north of the same place. Along portions of this shore, as at the mouth of the Meduxnakeag, are slates of a greenish or reddish color, which may be a continuation of the hematite beds of Oak Mountain, and there are also grey slates and sandstones, but the prevailing rock is a quartzose felspathic grit, generally containing hornblende or augite mingled with particles of green felspar. It is very obscurely stratified and at times markedly columnar, and often difficult to distinguish from a true syenite. These varying features are well exhibited in the railway cuttings south of the town, and again about and between the bridges which span the St. John River a short distance above it.

Meduxnakeag.

The rocks which have been described above as gneissoid, felspathic and syenitic grits, with the associated felsites and the similar rocks to be presently noticed on the eastern side of the St. John River, are those about which a doubt has been expressed whether they may not really be of Pre-Cambrian rather than Cambro-Silurian age. Their lithological characters, recalling those of certain parts of the Huronian system in St. John county, certainly give some countenance to this view, and it is one which derives some further confirmation from the observations of Mr. Ells on what is probably the eastward extension of these beds on the Miramichi and Nepisiquit, while their stratigraphical relations leave the matter in doubt; but considering their limited and irregular distribution, the impossibility of mapping them separately with accuracy, and especially the want of any positive evidence of their greater antiquity, it is deemed best, as has been stated, for the present at least, to include them as a part of the Cambro-Silurian system.

Argillites.

It only remains, in concluding the description of this system as seen on the west side of the St. John River, to add a few words relative to the less altered slates and sandstones which occupy the intervals between these crystalline belts, and which are believed to be the most recent Cambro-Silurian rocks. In their inferior portion, where they rest upon and alternate with the micaceous sandstones, they are themselves micaceous, as well as black, pyritous and sometimes graphitic, (including on the St. John River, above Sullivan's Creek, some highly calcareous beds, remarkable for the extent to which they are seamed with spar); but commonly they are of simple grey or dark-grey colors, often with a pale greenish tint from the presence of disseminated chlorite, and consisting of alternating beds of ordinary slate and hard fine sandstone or quartzite. The latter vary from one to four or five feet in thickness, and are usually more or less felspathic. With the exception mentioned they are rarely calcareous in any sensible degree but usually contain more or less pyrite and are often rusty weathering

Many of the beds exhibit surfaces covered with ripple marks and other indications of their aqueous and shallow water origin, but the most diligent search has as yet failed to discover the existence of any organic remains. In attitude they are greatly disturbed, exhibiting numerous folds and slickensides, indicative of faulting, while veins of quartz and chlorite abound, and, less commonly, dykes or irregular masses of diorite and syenite. All these features may be well studied along the line of the St. John River between the mouth of Eel River and Woodstock, as well as on the main line of the New Brunswick railway and the Woodstock branch.

The extension of the northern belt of Cambro-Silurian rocks east of the St. John River will admit of more brief description, as the features which these present are similar for the most part to those already described, while they are at the same time less thoroughly exposed. Along the river front the succession, as far as seen, corresponds to that of the opposite side. The slates and quartzites form the greater portion of the shore in Middle and Upper Southampton and the lower part of Northampton, but are broken by irregular masses of syenite, while opposite Woodstock the hills are chiefly composed of felspathic, granitoid and gneissoid grits. These are followed, towards Newburgh, by green and red chloritic schists, which run parallel to the river with a high northwesterly dip, and are well exposed in the deep gorge at the mouth of Acker's creek. The more northerly beds of the system exposed in this section are seen in the cuttings along the railway track at and about the mouth of Deep Creek. They consist of heavy beds of greenish-grey dioritic sandstone, mingled with more schistose beds of green and purple colors, all of which contain much disseminated chlorite and are stained with iron and manganese. The dip varies from S. 20 W. at Deep Creek to N. 20 W. about a-quarter of a mile above. In this direction these beds are, at the mouth of the Little Pokiok, followed by the grey calcareous conglomerates of the Silurian.

Southampton and Northampton.

Acker's Creek.

Contact of systems.

Eastward of the river the country is to a large extent uncleared. Members of the lower crystalline division (gneiss, &c.) may, however, be seen at many points along the northern side of the granite, through the settlements of Middle Southampton, Maple Ridge and Norton-dale; the beds most frequently met with being dark colored slates, which are sometimes plumbaginous, and greenish schists containing chlorite. In the settlement west of Nigger Brook they include a workable bed of limestone, in character not unlike that of Dorrington Hill and Canterbury. It is noticeable that there are here but few beds of the purple or lilac micaceous sandstones so conspicuous in the last named parish; the rocks which approach the granite most nearly at Millville being the black plumbaginous slates, while just east, on Howland Ridge, still

Limestone.

Millville. higher beds, consisting of dark-grey to black fissile and rusty argillites, seem to run against and to be cut off by a northward sweep of the granitic mass. Along the railway and roads north of Millville the rocks are also chiefly argillites, which are often quite chloritic, but with these are heavy beds of grey and dark-grey felspathic sandstones or grits, which are somewnat amygdaloidal. Beds of diorite and pale pink to red porphyritic felsite also occur. These rocks are evidently the same as those of Oak Mountain, Benton and Woodstock, and like the latter may be of Pre-Cambrian origin, though no distinct evidence of a difference of age could be detected. Other considerable areas of rocks to which similar remarks apply occur to the east of the railway, Nacawicac. about the headwaters of the main Nacawicac and the Beccaguimic. Near the source of the first named stream, in Mapleton, three very prominent hills, known as the Spruce Peaks, but which actually form Spruce Peaks. parts of a single ridge, constitute a marked feature in the landscape. They consist of grey felspathic rock, in part fine-grained and approaching felsite and in part granular, with white silicious blotches and veins of epidote. Six miles further east another prominent ridge, separating Felsite. the North-east Branch of Nacawicac from the heads of the Keswick and Beccaguimic, consists of a hard crystalline felsite, varying from dark-grey to red in colour and which is porphyritic with small crystals of felspar. Similar rocks occur upon both branches of the Beccaguimic, and may possibly be intrusive. With these exceptions the rocks of this district are chiefly slates and sandstones, sometimes chloritic and sometimes felspathic, the bare white ledges of which are exposed for over a mile along the railway track south of Nacawicac station.

We come now to consider the second band of Cambro-Silurian rocks, included in or resting upon the great granitic axis of York county.

West of the St. John River the rocks of this system included in the granitic area are few and unimportant—the only points known being a small area at the Meductic, others at the head of Grand (Schoodic) Lake, and, as reported, on the Palfrey stream, a few miles below Skiff Lake—but on the eastern side they are more considerable, forming a Queensbury. belt traversing portions of the parishes of Queensbury and Bright, and gradually widening from the St. John River at the Coac to the valley of the Keswick. They are here chiefly interesting from their relations to the granite and the comparatively clear view which they exhibit of the Cambro-Silurian succession. The former are well seen at the Coac, Contact with granite. where purplish-grey or lilac micaceous sandstones, similar in every respect to those of Canterbury, not only show their contact with the granite, but are filled with a network of quartzose and granitic veins. Caverhill. Eastward of this, in Upper and Lower Caverhill, similar sandstones, which are often gneissic, are associated with black pyritous and rusty-weathering mica slates and micaceous quartzites, traversed with numerous white quartz veins, and have a general southerly dip (S. 40 E. < 60°); while in Springfield similar beds, again rest upon granite and dip northerly (N. 70 E. < 80°). The synclinal structure thus indicated is, however, better seen along the roads leading south from Haynesville to Blowdown and Zealand. In Haynesville proper the micaceous and gneissic strata, which are often mottled or filled with dull black specks, probably representing incipient staurolite crystals, dip, as in Caverhill, southerly from the granite of the Nacawicac; but on the other side of the belt, on approaching the granites of Zealand, similar strata are again met with, with a somewhat irregular but generally northward dip, the intervening area being occupied by bluish grey slates and sandstones, exhibiting a similar arrangement. These latter rocks, which tend to break up into angular blocks, are in this respect as also in colour and texture indistinguishable from those of the Woodstock branch railway, as well as from those of the southern Cambro-Silurian belt to be next described in Prince William and Bright. Both their position and their graduation into the micaceous strata below indicate that they are portions of a single formation, of which the lower members have been altered in connection with their proximity to the granite upon which they rest. It is noticeable that among these strata there are no representatives of the felspathic gneisses, schists, felsites or amygdaloids which are so conspicuous in the northern belt, a fact which gives some further support to the view that these latter are Pre-Cambrian rocks protruding through the Cambro-Silurian slates.

Springfield.

Synclinal.

The southern Cambro-Silurian belt, referred to above, is a very extensive one, embracing, as it does, most if not all of the Pre-Carboniferous rocks between the granite and the Coal basin. Owing to the irregular course of the granite on the one hand and the still more irregular distribution of the overlapping Carboniferous strata upon the other, the belt is of somewhat variable breadth and outline, but may be described as extending continuously from the Maine frontier, south of Vanceboro, through the parish of Prince William to the St. John River; and eastward of the latter, through portions of Queensbury and Bright, to the valley of the Keswick; beyond which it is again seen in the valleys of the Nashwaak and Miramichi, though outside of the limits to which this report relates. Owing to the hardness of the rocks underlying this district and their deficiency in lime, the soils covering them are usually neither deep nor rich, while large portions, especially near the granite, are rendered unfit for cultivation by the great number of boulders or loose blocks with which they are covered, or by the occurrence of heavy deposits of clay. When, however, these are absent, the soil is capable of yielding a fair return, and within the district are situated a large number of flourishing settlements.

Southern Cambro-Silurian belt.

Distribution.

Surface features.

Lithological features.

The rocks of this southern belt consist almost entirely of slates and hard sandstones or quartzites, of a grey colour, and lack almost altogether the crystalline character so conspicuously seen in portions of the belts already described. Here also, as in the middle belt last noticed, there is an entire absence of the great bands of felspathic, hornblendic and felsitic rocks which form such marked features in the geology of Canterbury, Woodstock and Millville. Yet, leaving out of view these rocks of doubtful origin, and many of which may be igneous or intrusive, there can be no question of the essential identity of the remainder with those of the southern belt under discussion. For although, in part owing to concealment by the drift, their resemblances are somewhat obscured, most of the characteristic features of the one are, at different points, reproduced in the other. Thus the peculiar pink or lilac tint and micaceous or gneissic aspect so common in the rocks of the northern belt, while seen only rarely west of the St. John River, (as near Magaguadavic, Blaney Ridge and the Antimony mines of Prince William), are very clearly marked on the eastern side of the river in the section just south of the granite at Bear Island, about Scotch Lake, and especially in the valley of the Keswick north of Zealand; in each of which localities the first named beds are directly followed by and graduate into the ordinary grey slates and quartzites, while in Zealand both sets of beds double around the granite which terminates at this point and become continuous with the similar beds of the central or Haynesville belt. Again, it is unusual to find in the southern belt anything approaching true gneisses or mica schists, the alteration not extending beyond a change of colour and a partial development of mica in the sandstones; but in the extension of these rocks to the Nashwaak River, there is, just south of the granite at the Napadaugon, a series of schists filled with tolerably well developed crystals of staurolite, and this in turn is followed by a wide belt of dark-grey to black highly micaceous slates which are literally studded with cubical crystals of pyrite. So, as a rule, the ordinary slates and sandstones of the southern belt are less felspathic and chloritic than those seen on the river south of Woodstock; but on the Nashwaak, north of Stanley Bridge, slates and sandstones which are probably of this series are highly chloritic as well as micaceous, and recall in the former respect, as they do in their greenish and purplish colours, the slates of the Meduxnakeag and Acker's Brook. No calcareous strata have yet been observed in any portion of this southern belt.

Comparison of northern and southern belts.

Comparison with rocks of other counties.

In closing the description of the Cambro-Silurian areas of York and Carleton, it is instructive to notice the close parallelism here exhibited with the rocks referred to the same horizon in northern Charlotte and southern Queen's. (See Report of Progress 1870-71). This parallelism may be traced in almost every particular, whether of colour, texture or mineral composition, but is especially noticeable in the apparently similar influence of the causes originating the granite in both instances, determining the same highly micaceous character in each, with the development of the same crystalline minerals, as both are abundantly invaded by granitic and syenitic intrusions.

Granites, Syenites and Intruded Rocks.

These rocks require some further notice if only on account of the extent of the areas which they occupy and the important influence which they are believed to have exerted upon the associated formations. In addition to the granites and syenites the rocks to be described in this place include felsites and felspar porphyries, diorites and dolerite or diabase.

Granite.—The extent to which this rock is represented in central and western New Brunswick constitutes one of the most marked features in the geology of the latter, and, with somewhat varying outlines, has been represented in all the published geological maps of the province. The limits which have been assigned in the preceding pages as well as upon the accompanying map have been very carefully determined, and are probably as nearly accurate as the facts of the case will permit, the exact outlines being often difficult to recognize, first from the extent to which the granite itself penetrates the surrounding formations, and secondly from the great accumulations of boulders and other drift material which cover its surface and obscure the lines of contact. The great number and large size of these boulders is quite remarkable, and it would probably be no exaggeration to say that over large areas, as around McAdam junction, they are so thickly strewed as completely to conceal the subjacent rock and to determine a region nearly or quite destitute of soil. Where, however, the loose material is less abundant and the soil not farther impoverished by forest fires, it is regarded by many with much favor, as being especially adapted for the growth of cereals and for grazing. Many interesting facts relating to the surface geology of the region will be found in the report of Mr. Chalmers.

Granite.

Limits.

Boulder district.

Another circumstance tending to make difficult the correct delineation of the granitic areas is the very irregular distribution over or in connection with them, of the gneissic and micaceous strata already described as Cambro-Silurian, and which are supposed to have derived their crystalline character from the influence of the same causes which originated the granite. The larger of these areas, such as that of Caverhill and Haynesville, have been already referred to; but a number of much smaller areas occur, some of which do not exceed a few rods or even feet in extent. It seems evident that the whole or the greater part of the granite mass has been at one time covered with these rocks, which have since been irregularly removed by erosion; and it is worth noticing in this connection that the belts of crystalline Cambro-Silurian rocks already described form generally a higher and more broken country than that of the adjacent granite, and often rise abruptly from the latter.

Effects of erosion.

The granites in question are usually of coarse texture, containing quartz, felspar and mica in nearly equal proportions, with the felspar, which is commonly orthoclase, often in crystals of large size (sometimes three inches by two) which project conspicuously upon weathered surfaces. The colour is usually grey, but sometimes nearly white, or on the other hand, as on the St. John River near the Pokiok, of a rich red, making a rock well adapted for architectural and ornamental purposes. A more noticeable peculiarity, however, is the extent to which the rock is filled with what are evidently imbedded fragments of other rock, sometimes of a dark-green colour and containing much hornblende, but more frequently having the character of a grey or purplish-grey micaceous sandstone or mica schist. So abundant indeed are these enclosed masses in some places as to give to the rock, at a short distance, the appearance of a coarse conglomerate. Their origin is beyond question, not only from their evident identity with the schistose and micaceous rocks which border and in part cover the granitic area, (retaining the colour, texture and foliation of the latter even at great distances from the nearest resembling beds), but again from what is seen at many points along their lines of contact. Among the best places wherein the latter may be observed may be mentioned the mouth of the Sheogomoc River and the hills about the head of North Lake. At each of these localities, but especially at the former, not only is the granite seen extending, in the form of veins, in all directions into the overlying rocks, but within the granite itself occur large numbers of what are evidently detached masses of the latter in cubical and other blocks. In looking at these exposures one can hardly resist the impression that the granite has been in some way injected into an overlying and partially shattered schistose rock, and that the alteration of the latter has been the effect of such intrusion. That such appearances are capable of other explanation is of course admitted, but that the granite enclosing the masses referred to is not of the nature of simple veins and possibly of much later origin than the penetrated rock, is indicated by its entire identity with the main mass of the granite, while the true segregated veins with which both are intersected are readily recognizable by their much coarser charac-

Enclosed masses.

Contact-veins.

The granites intrusive.

ter. It may be again added that in all the points referred to the granites of York show the closest possible resemblance to those of Charlotte county, as seen about the towns of St. Stephen, Milltown and Baring. (See Report of 1871).

In addition to the main belts of granite, limited isolated areas of such rock occur at various points along their borders, as east of McAdam, between the Sheogomoc and Sullivan's Creek and again in the settlement of Zealand, their position and limits being indicated upon the geological map. From the number and relations of these areas it may fairly be inferred that at some depth beneath the surface they are continuous with each other, and the apparent contrasts which the schistose rocks exhibit, both in the amount of their alteration and in the distance from granite outcrops at which they are found, are probably connected with the same fact. On the other hand the singular abruptness with which wide belts of granite terminate without apparent reference to the strike of the overlying sediments, as illustrated in the last of the localities above named, is equally noticeable, and may be regarded as a further indication of their probably intrusive origin. Granite outliers.

Syenite.—This rock, although much less abundant than the granite, is of very frequent occurrence in the region under consideration, and covers some large areas. Of these the most noticeable, both for its extent and relations to the surrounding rocks, is that traversing the southern part of Carleton county, from Eel River about Benton to the St. John River at Bull Creek below Woodstock, having a length of nine and a-half and an average breadth of about one and a-quarter miles; while a second and smaller one but of which the exact limits could not be ascertained, occurs on the eastern side of the river along the course of Gibson's millstream. While in general a true syenite or hornblendic granite, of grey or reddish colour and coarsely crystalline texture, the rock sometimes contains, especially about Benton, a good deal of pale green epidote in crystalline grains, and sometimes chloride, while it is not unfrequently associated with or penetrated by dykes of dark-green diorite, a circumstance nowhere noticed in connection with the granitic region. A more interesting feature, as contrasted with the latter, is the very gradual passage exhibited by these syenitic rocks into the felspathic, gritty and amygdaloidal beds with which they are associated, and which renders it well nigh impossible to draw a line of division between them, while in the case of the granites the transition is in almost every instance abrupt. It would almost seem as though the syenites, in the instances referred to, were only more intensely altered conditions of the associated rocks; but that they are in some instances at least intrusive is shown by the irregular way in which they are often found cutting the slaty rocks, or are enclosed in irregular masses Syenites Woodstock. Graduation into surrounding rocks.

Age.

between the partially opened beds. It is noticeable further, as bearing upon the time of these intrusions, that large syenitic dykes or veins are found penetrating even Silurian strata, (as well exhibited on the shore of the St. John River a few miles above Hartland), while true granites have not been observed apart from connection with the supposed Cambro-Silurian system. At Bull's Creek, south of Woodstock, the syenitesand accompanying beds contain small veins and scattered grains of copper pyrites.

Felsite.—The position of the more considerable areas of this rock have been referred to in previous pages, where also their features and probable origin have been considered. In addition to the true crystalline felsites and quartz-porphyries which occur in connection with the Cambro-Silurian system, felsitic rocks of less crystalline character and which pass into claystones, but which are still porphyritic, occur in connection with the Lower Carboniferous rocks at various points. Some of these, as about Harvey station and Cranberry Lake in York county, have been described in former reports, and similar beds occur about the sources of the Northeast and Southeast Branches of the Beccaguimic River in Carleton. They are of red, purple and lilac colours, and both in character and position resemble those met with at the summit of the same formation in Queen's county. Veins of pure red crystalline orthoclase are also found, as at the Pokiok, intersecting the red granites.

Diorite.—Dykes of this rock are met with everywhere over the region examined, (except in the granitic areas), and in connection with all the Pre-Carboniferous rocks. It is especially abundant and forms large masses, which are partly interstratified, in connection with the Cambro-Silurian crystalline belt of Canterbury. It varies greatly in texture and, as at the localities last mentioned, is sometimes extremely coarse, with large and prominent crystals of hornblende, while the associated beds are also highly crystalline; but elsewhere it is generally fine and even grained, and its presence has exerted no perceptible influence, except perhaps as regards attitude, upon the beds in which it occurs. It is commonly pyritous and rusty-weathering.

Dolerite, Basalt, Anamesite and Diabase.—Rocks belonging to one or other of these species are common in the rocks of the Lower Carboniferous formation, especially along the horizon between the latter and the Millstone-grit. They are dark, heavy and compact rocks, usually fine-grained and breaking either with a broad conchoidal fracture or into sharp angular blocks, and occur both as dykes, beds and dome-like masses, exhibiting at times a distinctly columnar structure; but coarser varieties are also found, some of which are abundantly amygdaloidal. In the latter the minerals chlorite, delessite and red heulandite are not unfrequently met with, as well as pseudomorphs of quartz and calcite.

Economic Minerals.

The following are rocks or minerals which are or may become of economic importance in the district to which this report relates.

Iron.—In addition to the well-known beds of this mineral which traverse the region north of Woodstock and which have been fully described in previous reports, reference has been made in preceding pages to the occurrence of somewhat similar deposits on the northwest side of Oak Mountain near Benton. They occur in the middle of woods and are but imperfectly exposed, but seem to include beds of some thickness following the general trend of the Cambro-Silurian rocks with which they are found.

Antimony.—The occurrence of this metal at Prince William has been noticed in previous reports and full descriptions have been given of its distribution, mode of occurrence and associations. The efforts for its removal during the last few years, although involving considerable outlay, have been of an indeterminate and interrupted character, while the low price of the metal in the market and litigation arising from rival claims have still further tended to check vigorous and systematic working. At the time of our visit (October 1883) about eighty men were employed at the Brunswick mines, the only one then in operation, at wages varying from $1.30 to $1.50 per day, but not long after this the greater number of these were discharged and the work suspended. During the five months from May to October of the last year about twenty-nine tons of ore were sent off, chiefly to Medford, Mass., where the metal is largely employed in the manufacture of all kinds of rubber goods. The original capital stock of this company was $100,000 which was subsequently increased to $500,000, while the value of the plant, including a compressor, steel boiler, hoisting engine, steam pumps, &c., is about $10,000. The freight from the mines to Prince William station on the New Brunswick railway, sixteen miles, is $3 per ton, to Harvey station $2, or to Medford, Mass., $6.

The smelting and reduction of the ore, together with the manufacture of Babbit-metal, at one time carried on at these mines, has been for some time discontinued, and the somewhat expensive works erected for that purpose have been abandoned. It is said that something like $400.000 have been expended by the various companies in this neighbourhood since operations first commenced.

To the facts given in previous reports relating to the geology of the mines, it may be here added that the rock recently removed from the shafts of the Brunswick company is the peculiar dark lilac-grey and micaceous sandstone referred to in preceding pages as generally exhibited by the Cambro-Silurian system where the latter approaches the granite, and may indicate that the latter will be found at no great depth. The nearest exposures of this rock at the surface are near the school-house and corner in the Pokiok settlement, about three miles northwest from the mine, the intervening tract showing only the micaceous sandstones and granitoid dykes, in the former of which antimony has been found at a number of points.

As tending still further to show the wide distribution of this metal within the region examined, it may be mentioned that small pieces of antimony were found by Mr. Broad on the northern side of the granite, in a rock-cutting along the road from Canterbury station to the St. John River, about three miles east of the former.

Copper.—Small quantities of the sulphide of this metal, in the form of copper pyrites and sometimes associated with galenite or lead sulphide, have been observed at several points over the region examined, but chiefly in connection with the intrusive rocks of the parish of Woodstock. At Bull's Creek, a few miles below the latter town, the syenites, which here intersect the Cambro-Silurian slates and sandstones, are so far charged with this mineral as to have led, some years ago, to the opening of a mine at this point, but although considerable quantities of ore were removed was not found to be sufficiently abundant to make further operations advisable.

Gold.—No actual deposits of this precious metal have been met with by us, though special attention was given to its possible occurrence. Some facts, however, may be stated which seem to favor the belief that a part at least of the region examined will yet prove to be auriferous. The most important of these is the close resemblance, both in character and probable age, which may be noticed between the dark slate-quartzite series of Woodstock and Prince William on the one hand and the gold-bearing Atlantic coast-belt of Nova Scotia on the other. In each case the bulk of the formations consists of thick-bedded argillites and quartzites, usually of a dark color, containing little or no lime but often ferruginous, abounding with quartz veins and containing metallic sulphides, such as those of lead, copper and antimony. In each case they are highly disturbed, forming a series of anticlinal and synclinal folds. In each they are associated with numerous masses of intrusive or highly metamorphosed indigenous rock, such as granite, syenite and diorite, and in proximity to these crystalline masses in each case they become themselves more or less highly crystalline, passing into gneisses, garnetiferous and staurolitic mica-schists, &c. Finally, though in both instances nearly destitute of fossils, the weight of evidence is in favor of their Cambrian or Cambro-Silurian age.

To these general considerations it may be added that if we include with the Cambro-Silurian rocks of York the resembling strata of northern Charlotte county, it is in connection with these rocks, and for the most part with these only, that any actual and well authentical discoveries of this metal have been made. Some of these, as regards the region about St. Stephen and the St. Croix River, have been referred to in previons reports. On the other hand numerous finds of gold have been reported from different localities in connection with the great slate and quartzite bands on either side of the granite axis in York. The greater part of these have been upon the eastern side of the St. John river and especially upon its tributaries the Nashwaak and Muniac, in regions which have been as yet only partially surveyed, but there is little doubt that the rocks in which they were found are of the same age and character as those now referred to. So far the gold obtained has been derived only from washings and in small quantities, but careful and systematic search will probably have have the effect of disclosing the beds from which it has been derived, if not also a more abundant supply. Specimens of ferruginous quartz, derived from veins in this series have been submitted to analysis, but so far with only negative results.

Tin.—This is another metal of which the existence in this part of the province is to be regarded as a possible or probable, rather than as a demonstrated fact. It is true that the occurrence of tin in connection with the granites of the Pokiok River was long ago reported by Dr. Gesner, and a specimen obtained by him is now in the collection of the Gesner Museum in St. John; but the precise locality from which this was obtained is not known, and no similar discoveries have since been made. The fact, however, that tinstone has been found near Waterville in the State of Maine, in connection with gneisses and mica-schists which appear to be identical with the Cambro-Silurian rocks of York county, lends much probability to the fact of its occurrence here as well.

Limestones.—Two horizons of calcareous beds have been referred to in the course of this report; the one in connection with the highly crystalline schists and gneisses of Canterbury, the other with the Silurian calcareous slates of Carleton county. The rocks of the former, partaking of the character of the associated beds, are also highly crystalline and in part a true marble, but in general are too impure from disseminated micaceous and sandy material to be of much value either for ornamental purposes or as a source of lime. The purest as well as the thickest beds known are found a mile or so south of Dorrington

Hill. on the road from Eel River to Canterbury, and several quarries have been here opened, but the lime manufactured from them cannot compete, either as regards price or quality, with that derived from the limestone quarries near St. John. The Silurian limestones are more abundant and more serviceable, but the more important beds, those of the Beccaguimic region, are beyond the area to which the present report relates. On the western side of the St. John River, the representatives of these calcareous beds have been referred to as exposed at Ivy's Corner, south-west of Debec Junction, and here also some lime was formerly burnt, but the unfavorable position of the deposits, together with the difficulty and cost of drainage, have led to their abandonment.

Granite, Syenite, &c.—Over the very extensive area occupied by granitic rocks in York county, there are comparatively few points where these are of such a character or are so situated as to be available for economic purposes. Along the main line of the New Brunswick railway, between McAdam and Canterbury, though boulders of this rock, often of enormous size, are thickly scattered over the entire country, few actual ledges are anywhere visible, and the same remark applies to much of the region about the Chepedneck lakes. On the St. John River, however, there are extensive outcrops directly along the waters' edge, and from them any desired quantity might readily and cheaply be removed. Much of the rock is coarsely crystalline and porphyritic, and of the ordinary grey colour, but other portions are finer, more uniform, and of various shades of pink or red. The handsomest varieties were seen just at and below the mouth of the Pokiok, where a rich red granite occurs, quite equal in depth and brilliancy of colouring to any of those now derived from the quarries at St. George, in Charlotte county. The rock about the Nacawicac, south of Millville, though of the ordinary grey variety, seems to be of excellent quality, and is highly valued for local use. From its proximity to the railway it is favorably situated for removal.

The chief band of syenites, and the only one which seems capable of affording material for economic use, within the region examined, is that extending between Eel River at Benton and the St. John River below Woodstock. Much of this rock is highly crystalline, of a bright-red colour and uniform texture, and would answer for many of the purposes to which granite is applied, though little is yet known of its relative durability. Near Benton the rock is peculiar in containing a nearly uniform admixture of a pale grass-green epidote, presenting a handsome appearance when polished.

Felsite, Quartz-porphyrie.—Several belts of this character have been described as crossing the line of the New Brunswick railway, north of Canterbury, and again, on the eastern side of the river, north of Millville. Some of these would doubtless make. if polished, handsome rocks. The finest as well as the largest beds seen by us, however, are those east and northeast of the last named place, about the headwaters of the branches of the Beccaguimic. Here the rock is fine, compact and even-grained, of pale pink to flesh-red colour, and often conspicuously porphyritic. It is, however, unfavorably situated for removal.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

SURFACE GEOLOGY

OF

WESTERN NEW BRUNSWICK,

WITH SPECIAL REFERENCE TO THE

AREA INCLUDED IN YORK AND CARLETON COUNTIES.

BY

R. CHALMERS.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

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ALFRED R. C. SELWYN, Esq., LL. D., F. R. S., &c.

Director Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith my report on the Surface Geology of Western New Brunswick, the result of explorations and surveys made during the two seasons of 1882 and 1883.

Permit me to express my thanks to Prof. Harrison of the University of New Brunswick, Fredericton, for a series of barometric readings, taken at the meteorological station under his charge, which he kindly furnished.

I have the honor to be,

Sir,

Your obedient servant,

R. CHALMERS.

St. John, N.B., March 1, 1884.

REPORT

ON THE

SURFACE GEOLOGY OF WESTERN NEW BRUNSWICK

WITH SPECIAL REFERENCE TO THE

AREA INCLUDED IN YORK AND CARLETON COUNTIES.

The surface geology of the district to which this report relates presents several interesting and unique features. Whether considered in reference to the scientific problems it offers for our investigation, or in relation to the character of the soil and the agricultural capabilities of the country, it is alike important, and affords an inviting field for study. The report now submitted embraces the observations made by me during the two seasons of 1882 and 1883, in the former as assistant to Mr. Wallace Broad, and in the latter to Prof. L. W. Bailey. Mr. Joseph W. Bailey accompanied me during the summer of 1883 in an exploration of the Cheputnecticook, Magaguadavic, Oromocto and other lakes, and in examining the valley-drift of the St. John, between Woodstock and St. Francis. We also ascended the Aroostook and Tobique Rivers together for short distances. In the lake region our attention was devoted chiefly to the study of the trains of boulders (moraines) and other drift deposits which occur there, and in collecting data relative to the origin of lake-basins. Barometric observations were taken on the lakes and at other points as often as possible with a view of deducing their mean heights above sea level. Measurements of the heights of water-falls were also made, notably Grand Falls on the St. John, Aroostook Falls, etc., and some interesting facts regarding these phenomena will be found on a subsequent page. The latter part of the season of 1883 was spent partly with Mr. W. McInnes on the Beccaguimic head-waters, and partly in an endeavor to trace out the Eel River kame—one of the most remarkable in the district—in its supposed extension south-eastward to the Bay of Fundy. A number of facts relating to the fauna and flora of the region will be found in the sequel; and altogether the data now obtained enable me to present a tolerably full report on the glaciation, superficial deposits, etc., of the area examined. It must be understood, however, that large tracts of the district in question are inaccessible owing to its wooded and impassable character, and many facts relating to its surface geology may therefore still remain unnoticed.

Preliminary to a description of the striation and surface deposits, a brief sketch of the topography of the region will be given. This seems necessary from the fact that in many instances its more prominent physical features appear to have influenced the course of the ice-sheet which moved over it, and to have caused the present distribution of the drift materials on the higher levels.

Chief Topographical Features.

Area and character of region.

The area to which the following observations relate embraces the greater portion of York and Carleton counties, and also the St. John valley eastward as far as Gagetown, Queen's county, and westward to the mouth of the Madawaska River. The general surface of the two counties first mentioned may be characterized as an undulating plain, with short hill ranges within the limits of the granitic, Cambro-Silurian and Lower Carboniferous belts on the low water-sheds on each side of the St. John. These hills vary in height from 500 to 1,000 feet above sea-level, and the valleys among them contain numerous lakes, the largest of which are Cranberry, Magaguadavic and the Cheputnecticook and Eel River groups. The south-eastern part of the district under examination being underlaid by Carboniferous rocks, is, for the most part, level, or slightly undulating, but the northern part is more diversified; while still further north along the upper waters of the South-west Miramichi and Tobique Rivers, the country becomes rugged, and mountains of considerable altitude appear, Bald Mountain, the Blue Mountains of the Tobique and others east of these being conspicuous for long distances.

St. John River valley.

The great thoroughfare, the St. John River, extends throughout the entire district. From the mouth of the Madawaska to Grand Falls, forty miles, its course is about south-east; thence to Maductic Falls, seventy-five miles, due south; thence, with many sinuosities to its *débouchure* into the Bay of Fundy, nearly south-east. The depth of its valley below the general level is 300 to 400 feet, and the width varies from a quarter of a mile to a mile or more. Of the many striking and picturesque natural features of the region none surpasses in beauty and interest the valley of the St. John. Regarding its great age, geologically considered, there can be little doubt,—it must have been an important channel-way and drained a large extent of territory ever since Palæozoic times.

Watersheds.

Some of the tributaries of this river, as the Nashwaak, Keswick, Beccaguimic, Meduxnakeag, etc., have cut deep transverse channel-ways into the strata and produced marked features in the landscape. A low water-shed separating the waters of the South-west Miramichi from those of the St. John, extends through the northern part of the district, and another on the southwest side divides the latter from those streams emptying into the Bay of Fundy. The general direction of the low valleys on the south-western water-shed is north and south. In these valleys are many of the beautiful lakes referred to, surrounded by hills and romantic scenery. The Cheputnecticook group is still encompassed by the "forest primeval," and their wild shores are without a human inhabitant. Skiff and Magaguadavic lakes are enclosed by hills, and studded with numerous islets. The elevations of a number of the largest of these lakes, measured barometrically, are given in succeeding pages.

General elevation.

The general level of the surface of the country in the lake region is 500 to 600 feet above the sea, and the height of the hills 750 to 1,000 feet

Character of scenery.

The scenery in many parts of western New Brunswick is quite picturesque. The valley of the St. John, from Gagetown to St. Francis, with its numerous islands, intervales, terraces, and fertile slopes, is unsurpassed in the maritime provinces for quiet beauty of landscape and productive soil. The rolling uplands of Carleton and Victoria counties exhibit a variety of natural features, which are, to say the least, pleasing, and fully maintain the glowing description given of their agricultural capabilities by Dr. Abraham Gesner forty years ago. Much of the region, especially on the east side of the St. John, is still covered by forest, but on the west it is more extensively cleared, and settlements are numerous; and cultured fields contrast with woodland, lake, and stream in giving effect to many a charming prospect. Even the boulder-strewed granite region, although sterile and inhospitable, in an agricultural point of view, is not without interest and variety of scene, being traversed by ridges (moraines), dotted with lakes, and containing many picturesque spots.

Definition of terms used.

In this report some of the terms used in surface geology are to be understood in the following sense:—

1. Ice-sheet, or glacier, to signify a body of ice capable of producing striæ, moraines, till, etc., whether local, or spreading in a solid sheet over wide areas, not determinable from the data on hand.

2. Till, glacial drift, unstratified drift, etc., to signify one and the same kind of deposit, that is, the coarse, gravelly, or stony unstratified clay, or sand and gravel, produced and dropped by glaciers or icebergs, as the case may be.

3. Moraines. Trains of boulders, sometimes intermixed with clay or gravel in the bottom, occurring in lake-basins or depressions on the water-sheds.

4. Kames, or '*horsebacks*.' Ridges of gravel with water-worn stones, often containing beds of sand and clay; usually stratified in the upper part, but occasionally having till beneath.

5. Valley-drift. This term is sometimes used to designate all the unconsolidated materials, stratified and unstratified, occupying a river valley.

GLACIAL STRIÆ.

The following courses of striæ were observed in the area under examination. They are all referred to the true meridian.

No.	Locality.	Course.	Exposure.	Approx'ate height above the sea in feet.
	SOUTHERN PART OF CARLETON COUNTY.			
1	Newburg Junction, summit of hill at.............	S. 20° E.	N.	630
2	Newburg settlement, by Mr. Broad, 2 sets { Oldest / Latest	S. 7° E. / S. 23° E.		
3	Rockland road, near Hartland, 2 sets .... { Oldest / Latest	S. 15° E. / S. 5° W.	N.	450
4	Jacksonville, near Iron Mines..................	S. 10° W.	N.	600
5	" Third Tier........................	S. 10° W.	N.	400
6	Jacksontown, Centreville road	S. 10° W.	N.	550
7	" near Payson Lake	S. 20° E.	N.	
8	Watson settlement	S. 20° E.		
9	Debec Junction, ½ mile W. of..................	S. 15° E.	N.	620
10	Debec, 1 mile S. of station along railway, 2 sets............................ { Oldest / Latest	S. 20° W. / S. 15° E.	N.	600
11	Debec, 2-3 miles S. of station.	S. 10° E.		600
12	Benton station.................................	S. 45° E.	N.	500
13	Kirkland, on Eel River road.....................	S. 20° E.	N.	
	YORK COUNTY.			
14	First Eel Lake, west side......	S. 30° E.	N.	
15	" " in another place	S. 20° E.		
16	North Lake....................................	S. 25° E.	N.	800
17	Hartin settlement..............................	S. 40° E.	N.	
18	Skiff Lake, N. end of Carrol Ridge...............	S. 40° E.	N.	775
19	Shogomoc, near St. John River	S. 30° E.		
20	Upper Prince William, on road along river.......	S. 20° E.		
21	Prince William, 2-3 miles below last............	S. 10° E.		
22	Magaguadavic settlement, E. of Lake............	S. 30° E.	N.	
23	Lake George settlement, near antimony mines ...	S. 25° E.	N.	
24	Harvey settlement.............................	S. 20° E.		600
25	Prince William station, near...................	S. 20° E.		
26	Oromocto Lake, W. side........................	S. 25° E.		500
27	Millville, 2 miles N. of railway station	S. 30° E.	N.	400
28	New Zealand settlement	S. 25° E.	N.	
29	Upper Hainsville road, 2 places	S. 25° E.		
30	Keswick Ridge, S. end..........................	S. 25° E.	N.	350
31	Miramichi road, near Fredericton, 2 places	S. 30° E.		200
32	" " " 1 place	S. 35° E.		200
	CHARLOTTE COUNTY.			
33	Lawrence station, N. of........................	S. 50° E.		

Prof. H. Y. Hind and Mr. G. F. Matthew record a number of courses of striæ observed in the vicinity of Fredericton and in the southern part of York county, which conform closely to those given above.*

General ice movement indicated by striæ.

The lists together give a total of about fifty places where striæ have been noticed within the district—a number sufficiently large to indicate with tolerable accuracy the direction of movement of the glacier or glaciers which passed over it. The average course of the striæ in the southern part of Carleton and western part of York counties seems to be about S. 20° E., but in the vicinity of Woodstock the grooves, in a few instances, show a decided westing, the ice sheet in passing over this place having been influenced by local inequalities of surface, notably the St. John valley. Further to the south and east the striæ exhibit more easting, S. 30° E. being the average course. In the lake region, on the south-western water-shed, the ice-movement appears to have been governed by the low south-east and north-west valleys which cross it. In Prince William, on the banks of the St. John, striæ are found running diagonally up the south-west slope of the valley; but below the Keswick the ice-sheet pursued a still more independent course, crossing the valley at a pretty wide angle. The ice movement therefore seems to have been affected by the St. John valley only in Jacksontown near Woodstock; and where the direction of the valley deviates more than 30° to 40° from the meridian the striæ are found crossing it at various angles without regard to surface contour.

The northern sides of elevations are usually more glaciated and drift-clad than the southern.

Two sets of grooves.

Two sets of grooves occur in some places. The later ones are lighter and have evidently been produced by the passage of ice guided more by the present surface features than the older set. These facts, together with the evidence of a second advance of local glaciers afforded by a study of the drift in the lake-basins (referred to in a subsequent part of this report), indicate that there have probably been two periods of glaciation in this region.

Moraines, Till, etc.

Moraines in the St. Croix River valley.

Evidences of the former existence of glaciers are very abundant in this district from the presence of moraines and till. Moraines occur chiefly in the lake-basins and on the water-sheds. In the valley occupied

*Vide A Preliminary Report on the Geology of New Brunswick, by H. Y. Hind, M. A. 1865. p. 191.

Also, Report on the Superficial Geology of Southern New Brunswick, by G. F. Matthew, M.A. Report of Progress. 1877-8.

by the chain of lakes at the head of the St. Croix River they are well developed, the configuration of these bodies of water being largely due to their presence and arrangement. All the peninsulas and islands are moraines, and the shores are literally rows of boulders. Stretching along the margins of these lakes for miles trains of these granite boulders, weathered white, may be seen rising 20 to 30 feet above the level of the waters, giving the region, by no means, an inviting aspect. So thickly are the lake borders beset with them that we often had great difficulty in getting a suitable spot to pitch our tent upon. Many of the boulders are large, not infrequently 10 to 15 feet in diameter, and occasionally of much greater size —one near the northern end of Birch Island measured 35 x 30 x 25 feet. No rocks were seen *in situ* except towards the northern end of Grand Lake and at North Lake, the shores and bottoms being covered with a thick mass of morainic material, which seems to have been but little modified by water. The general course of these moraines is S. 25° to 45° E. They appear to have been formed at the southern (and sometimes at the northern) extremities of low hills or ridges extending into the lake-basins, which are probably of rock, although none was seen. Where the longitudinal direction of the lakes is not nearly meridional, as at the southern end of the Cheputnecticook and the northern end of Grand Lake, the moraines traverse the basins diagonally, thus forming long points with deep indentations between them. They are usually low, sometimes running under water, or merely appearing above the surface as islets or low trains, until at length they re-appear on the opposite side as headlands or ridges. Several of the islands, however, although composed of morainic material are without definite form or direction.

Other localities of moraines.

Moraines occur also in the vicinity of McAdam Junction; at the upper waters of the Digdeguash River; at Foster and Deer Lakes, and in almost every part of the south-western water-shed occupied by granitic and Cambro-Silurian rocks. The headlands and islets in the Magaguadavic lakes are composed of materials of this character, arranged, for the most part, in trains or ridges with courses varying from N. and S. to S. 45° E. In a few instances, these moraines, although short, are crescentic in form with the convex side to the south.

General character of moraines.

Occasionally it is difficult to determine whether a ridge is a moraine or kame, owing to the presence of stratified materials on its summit; but close examination will not fail to detect till holding large boulders in nearly all the ridges in the lake region of western New Brunswick.

The boulders contained in the moraines are wholly of local origin. In the granite region they are almost altogether derived from the underlying rock, except along its northern limit, where blocks of gneiss, trap, etc., occur. Between Oromocto and Kedron Lakes the morainic drift contains, exclusively, boulders of grey grits and conglomerates.

Collection of boulders.

On the northern slopes of the hills, and sometimes on the southern, great quantities of boulders are found without any arrangement, which have apparently been dropped by the ice-sheet in its passage over them. Noteworthy instances may be seen at the southern ends of North and Oromocto lakes.

General distribution of till.

Till occurs everywhere within the region, always underlying the other surface deposits, and sometimes forming hills or short ridges on the elevated grounds, as well as along the upper part of the slopes of river valleys, where it has escaped denudation. Great beds of till occupy the lake-basins and the valley of the St. John. The depression wherein lie the Cheputnecticook, Grand, and North Lakes, contains large quantities in addition to the morainic material occurring there, so much indeed, that these bodies of water seem to be enclosed and sustained to their present levels by drift—a fact which will be more fully elucidated on following pages. The valleys occupied by the Magaguadavic, Cranberry, and other lakes, are likewise largely drift-filled, although in some instances the till has been denuded and remodelled, constituting stratified beds around their borders. A heavy mass of till fills the old valley of the St. Croix in the vicinity of Vanceboro', the river flowing over it from the foot of the Cheputnecticook lakes for a distance of more than two miles. It is partially stratified and kame-like along the river's banks above the village of Vanceboro', but in railway excavations near this place the ridges are seen to be formed of true till below.

Relation of lakes to drift-deposits.

Second Cheputnecticook and Grand Lakes are separated by a mass of drift partially filling the pre-glacial valley which connected their basins. This drift now dams up the waters of the latter lake 85 feet above the level of the former. Forest City, Me., stands upon a bed of morainic material, and till also encloses Mud Lake. Mud Lake Creek, a new channel which is now being eroded by the drainage of Grand and North Lakes into the Cheputnecticook, lies to the north of the ancient drift-filled passage, and has a cascade and a series of rapids in which the waters descend about 25 feet.

Pre-glacial channels.

To the south of the *thoroughfare** connecting Grand and North Lakes there is a considerable area covered with a thick deposit of till, and some excellent farms have been cleared upon it, although in a granite district.

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* This term is locally used in western New Brunswick to designate a passage or channel between lakes on the same level, frequented as a route of travel.

Heavy deposits of drift, consisting of morainic matter, till, etc., partially re-arranged into kames and terraces, occur on the borders of the Magaguadavic lakes, and at the head of the river of the same name. Considerable quantities of the same materials are found also at Oromocto and Kedron Lakes. A pre-glacial channel connecting these two latter is now choked up with drift.

Till covering watershed regions.

The great bulk of the superficial covering on the water-sheds is till. In the depressions it has been partially modified by the lakes which now, or at some former period, occupied them, and also by the streams; but much of it remains nearly as it was originally deposited.

Glacial filling of St. John valley.

The same partial filling up of the depressions with drift which took place on the higher levels at or near the close of the glacial epoch occurred also in the valley of the St. John. The greater erosion which it has undergone here has swept away or modified large quantities of it, however, so that only along the upper part of the valley slopes, or in places where the river has been diverted from its pre-glacial channel, do any considerable deposits of till appear. At elevations of 100 to 250 feet above the river, it is found on both sides clinging to the sides of the valley either as mounds, ridges, or in a thick sheet apparently dipping beneath the stratified deposits which form the terraces; while at Kingsclear, Queensbury, Woodstock, Newburg Junction, etc., hummocks of till, flanked by water-worn materials, are met with at lower levels, which appear to be remnants left from erosion of the surrounding valley-drift. The dimensions of two occurring in the vicinity of Woodstock are as follows:—

Hummocks of till.

No. 1 is found at the mouth of the Meduxnakeag. Length 300 yards; width 70 yards; height above the St. John 100 feet; above the terrace at its base 50 feet; course of its longest axis S. 75° W.

No. 2 occurs on the Houlton Road. Length, 100 yards; width, about 80 yards; height, 110 feet above the St. John; longest axis nearly at right angles to that of the St. John, and approximately parallel to the course of the Meduxnakeag.

Between Woodstock and Grand Falls short ridges and mounds of till are found above the level of the upper terraces along the valley slopes at Hartland, Florenceville, Bath, Andover, etc. These, in some instances, are liable to be mistaken for kames, but careful inspection will show that the materials composing them have been only superficially acted upon by flowing waters. Their elevation and bulk will appear in the profile sections of the valley-drift given on following pages under the head of "Terraces, etc."

Much till in upper St. John valley.

Till increases in quantity in the valley as we ascend it towards Grand Falls and Edmundston. This is probably due to the fact that it has suffered less erosion on the upper reaches of the river. Between

Andover and Grand Falls, however, a large portion of the valley-drift has been modified by river action. At the last mentioned place drift fills the pre-glacial valley of the St. John for a distance of 1,000 yards, its upper surface being at the height of 225 to 250 feet above the level of the basin at the foot of the Falls. This drift-dam has caused a diversion of the river from its ancient bed, and in excavating a new channel it has produced those magnificent phenomena—the Grand Falls, 74 feet high, and the narrow rock-bound gorge below it, three-fourths of a mile long,—which are the admiration of all who visit the upper St. John. The horse-shoe shaped peninsula on which the village of Grand Falls stands, consists of modified drift to the depth of a few feet, underlaid by 10 to 25 feet of till, the latter resting on the upturned edges of the calcareous rocks (Silurian) which are seen flanking the gorge. Till is found in the banks at the lower basin 225 feet above the water-level of the river. Cause of Grand Falls.

The upper basin is 117 feet above the lower, and the latter approximately 300 feet above the St. John at Fredericton, as deduced from a number of barometric observations.

The St. John valley expands into a lake-like basin above the Falls, and the river has a comparatively tranquil flow from Edmundston to this point, forty miles. Hence there has been less erosion of the original drift here, till being seen everywhere on the slopes and river banks, and the stratified beds are not developed on such a grand scale as below Grand Falls.

In a railway cutting on the river's bank about a mile above the Falls, the following series of deposits occurs:— Section above Grand Falls.

	FEET.	INCHES.
1.—Loam	4	6
2.—Sand with coarse gravel, stratified	10	0
3.—Till, with upper surface laid bare and showing marks of erosion previous to deposition of stratified materials. Thickness unknown. Height above river	60	0
	74	6

Three miles above Grand Falls till was again seen on the left bank, in a railway excavation, rising to a height of 125 feet above the river, and extending over a considerable area from a half to three-quarters of a mile wide and 200 feet high or more. Short ridges and mounds of stratified gravel rest upon it.

While till capped with gravels and loam, therefore, is the chief deposit in the St. John valley at Grand Falls and above for some distance, stratified gravel and sand forming terraces comprise the bulk of the materials below that point, as will be more clearly shown in the sections given hereafter in this report. It is probable the valley between Deposits above and below Grand Falls compared.

the mouth of the Madawaska and Grand Falls formed a lake expansion of the river after it became dammed at Grand Falls, and previous to the excavation of a new channel there.

Above Edmundston the St. John is more rapid than immediately below it, the valley being narrower; hence the drift has undergone greater erosion. Till in considerable quantities occupies the higher parts of the valley here also, with terraces or intervales between it and the river. Beyond the valley the country is elevated and rugged.

Modification of drift in St. John valley.

The examination of the St. John valley above Fredericton has led to the conclusion that it was largely drift-filled in early Quaternary times, and that this drift has undergone considerable erosion and remodelling since from river action—the amount of erosion varying at different points and depending upon the quantity of material originally deposited therein, the slope of the valley, force of the current, etc. Where the descent of the river was greatest, erosion and the formation of terraces seem to have been more extensive, as, for example, between Grand Falls and Andover; where the valley was dammed by drift, however, causing the formation of lake-like expansions above, only a partial modification of the drift has taken place. This rule holds good also with reference to the principal tributaries. In these till likewise constitutes the original deposit and has been subsequently eroded except where it has choked up the valleys, causing a diversion of the stream from its pre-glacial bed.

Drift-dammed channels.

The falls of the Aroostook, three miles from its mouth, have a descent of 75 feet in a series of cascades, one of which is 17 feet high. The old drift-dammed channel is clearly traceable on the right of the river along the line of the New Brunswick Railway, a hill intervening. The "Narrows," near the mouth of the Tobique, form another example of a new passage excavated by a drift-dammed river. This passage is about a mile long, 150 feet wide, and not less than 150 feet deep, and has been cut through calcareous slate of Silurian age. To the west, the ancient course of the river is seen, blocked up with till to a height of 150 feet above its present level at the head of the "Narrows."

Lake Basins.

Several weeks of the summer of 1883 were spent by Mr. Joseph Bailey and myself in exploring the lake-basins in Western New Brunswick. Starting from Vanceboro', we first visited the Cheputnecticook, Grand and North Lakes, thence returning by the Eel River and Skiff Lakes to Canterbury station, afterwards spending a fortnight at Oromocto, Kedron, and the Magaguadavic Lakes. A number of interesting facts were collected relating to their origin and the mode of occurrence of the drift around their borders to which I shall now refer.

The upper part of the St. Croix valley for the space of two to three miles is, as previously stated, partially filled with drift, over which the river flows. This drift is stratified in the upper part and thrown into a kame on the west side, 50 feet higher than the river. This kame contains large boulders and is evidently morainic in the bottom. The barrier which the drift forms in the valley here dams up Cheputnecticook and Palfrey Lakes, and is undoubtedly the cause of their origin. The height of these lakes above tide level at Fredericton, deduced from a number of barometric observations is 414 feet.

Drift-dammed lakes.

The geographical depression occupied by the chain of lakes at the head of the St. Croix known as the Cheputnecticook group, is crescentic in form, the southern portion extending nearly south-east and north-west, while at the northern extremity it sweeps round nearly to a north-east and south-west course. Its length is about forty-five miles, width from a half to five miles. Hills rising 200 to 500 feet above the level of the lakes border them on the east and west. The conformation of the headlands, or tongues of land projecting into these lakes, with deep inlets between them, has already been referred to, and their delineation on a good map would show that they traverse the lake-basins diagonally, maintaining their north and south direction in the Cheputnecticook as well as in the northern part of Grand Lake, irrespective of the course of these depressions. The great quantities of drift disposed around the margins and underneath these sheets of water in the manner described, give them their peculiar configuration. The moraines, ridges of drift, and islands are, however, usually low, seldom exceeding a height of 10 to 25 feet above their surface.

Relations of drift to lakes on St. Croix.

The navigation of these lakes is very intricate, owing to the numerous islets, promontories, deep inlets and narrow passages. We first examined Palfrey Lake, which has a narrow entrance from First Cheputnecticook through a gap in a long narrow ridge separating them. In the central part of this lake lies an islet which was found to be the summit of a north-to-south moraine. Palfrey Brook, draining Skiff Lake, empties into the northern end through a valley extending several miles in a north and south direction, and bounded by hills the sides of which are strewed with granite boulders and drift. High hills are seen northward in the vicinity of Skiff Lake.

Peculiar character of these lakes.

Returning from Palfrey to Cheputnecticook Lake, we touched at Indian Island, the largest in the group, which is irregular in form and likewise composed of morainic materials; thence proceeding to Second Cheputnecticook through a narrow passage strewed with blocks of granite. Here, in addition to the difficulty of threading our way among these boulders, many of which are scarcely covered by the waters, we found booms filled with logs stretched entirely across the entrance. Dragging our canoe over a submerged bog, through a tangled mass of ericaceous plants and shrubs, we succeeded, however, in reaching the Second Lake without any serious mishap.

Second Cheputnecticook is a beautiful sheet of water, surrounded by hills and studded with islets, which are clad with evergreens. These and the headlands are all morainic. As we approach the northern end, a moraine or low ridge covered with granite blocks may be seen stretching along the western margin for several miles nearly in a north and south direction. The hills in the vicinity of North and Eel Lakes are visible in the distance, and have evidently shed local glaciers, which deployed in these basins at the close of the Ice Age.

Grand Lake. Grand Lake is held up by a barrier of drift, as stated on a previous page, to a height of 499 feet above sea level, or 85 above that of the Cheputnecticook Lakes. It also contains a number of moraines extending longitudinally north and south, or to points between that and S. 45° E. As in the other lakes, all the sunken trains of boulders, islands and promontories are of this description, Long Island and the peninsula between Haley and Big English Coves being the most remarkable.

The northern part of Grand Lake expands into a circular basin, which is bordered on the south by an irregular shore line covered with masses of boulders and drift. On the north and north-west the land slopes upward from the water's edge, with an even surface, to a height of 300 or 350 feet above the lake This tract is occupied by Cambro-Silurian rocks, or mica-schist of Hitchcock*, and the difference between the surface deposits on it and the granite is at once apparent. This sloping area which now comprises a number of good farms, well cultivated, has been a sort of inclined plane in former ages for the descent of local glaciers into the basin occupied by Grand Lake.

North Lake. North Lake is on the same level as Grand Lake, a thoroughfare which traverses a low, swampy district connecting them. The first mentioned sheet of water lies longitudinally east and west, and a glaciated hill 400 feet above its surface borders it on the south. To the north, a low, flat area extends for many miles, drained by Monument and Meadow Brooks into it. Hills, whose summits are 300 to 400 feet above this lake, rise on the east, with drift-encumbered valleys between them, one of which, judging from the amount of water-worn *debris* in it, appears to have been a former channel-way, or bed of a river. Drift material is found in considerable quantity around the southern and eastern sides of North Lake, but it is without the long promontories and islands which characterize the other lakes of this chain.

Notwithstanding the sterile and inhospitable character of the region just described, these lakes are highly interesting, and the scenery from some points is especially grand. The numerous islets and headlands,

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*Second Annual Report of the Natural History and Geology of the State of Maine, 1862, pp. 309–310.

narrow, intricate passages and deep inlets expanding into broad sheets of water, the dark-green slopes of the surrounding hills, rising with sweeping outlines 400 to 600 feet above,—all combine to form some of the most diversified landscape views in New Brunswick. The wildness and solitude of the scenes also lend them a peculiar charm, the only sound the voyager hears day after day being the weird cry of the loon which frequents them.

First Eel Lake, the longest axis of which extends north and south, has drift-encumbered shores and thick beds of clayey till at the southern end, where a hill rises 300 feet above its surface. It is also dammed at the northern end by drift. A kame, which will be described hereafter, extends along the western side of the outlet a distance of four miles. The elevation of this lake above tide level at Fredericton is 522 feet; that of Second Eel Lake, which lies a short distance to the south of the former, is probably 50 feet greater. Eel Lakes.

The hills on the water-shed between Grand, Eel and Skiff Lakes are the highest in the western part of York county, and are laden with drift, having combed out large quantities from the ice-sheet in its passage over them.

Skiff Lake is elevated 684 feet (?) above the St. John at Fredericton, and girt with hills, studded with rocky islets, and a most picturesque spot. Like the other lakes in western New Brunswick, it seems to occupy a part of an ancient valley of erosion.

Leaving the western lakes, we next proceeded to an examination of the Oromocto and Magaguadavic basins. Two of these bear the latter name, and are connected by a thoroughfare two miles long, running through a bog. Their general direction is north and south. Beds of drift occur also around their borders, some portions morainic, others partially stratified, and thrown into kame-like ridges. The islands in the larger lake are strictly moraines, and the same remark applies to many of the promontories. One or two of the islets are crescentic in shape, with the convex side to the south, and, when taken in connection with headlands near them composed of similar materials, really resemble small terminal moraines. Oromocto and Magaguadavic Lakes.

The Magaguadavic Lakes may be considered merely expansions of the river of the same name, for they occupy the same pre-glacial valley. This valley is now choked up with drift at the southern end of the larger of these lakes, or at the head of the existing Magaguadavic River. Both lakes are on the same level, viz., 424 feet above that of the St. John at Fredericton.

First Cranberry Lake also extends longitudinally north and south, and is enclosed by considerable masses of drift material. An old valley, now drift-filled, seems formerly to have connected it with Oromocto Cranberry Lakes.

Lake. Its elevation is approximately 500 feet above sea level. Lake George occupies a basin lined with till, at the northern extremity of an extensive level tract of the same height, in the southern part of which lie Cranberry Lakes.

Oromocto Lake.

Oromocto Lake, 417 feet above tide level at Fredericton is, in some respects, one of the most remarkable bodies of water in the region. It is about nine miles in length north and south, and from three to four in width, and occupies a basin in the southern angle of the great Carboniferous area of the Province, its surface being elevated 97 feet above the Magaguadavic River in Brockaway settlement, a short distance to the west. A ridge 150 to 200 feet higher than the lake, extends along its western side, separating it from the Magaguadavic valley. The southern margin is rock-bound, except at the southwestern extremity, where several islets composed of drift matter occur, and the entrance of an old channel extending to First Kedron Lake is found. This passage is now drift-filled, and great quantities of boulders and several moraines occur on the area between the Oromocto and Kedron Lakes. On the southern shore of Oromocto Lake conglomerates *in situ* with glaciated surfaces were seen. The eastern shore is lower, and no rocks were found *in situ* till we reached the inlet at the head of Oromocto River, where coarse sandstones are met with on each side in headlands. The river, at its head, flows over a bed of drift, the land sloping to the east at a low angle corresponding to the dip of the strata. At the northern end of the lake Dead Creek flows into it through a narrow valley bordered by glaciated ledges—a kame extending along the bank of the stream for three-fourths of a mile. The district extending towards the source of this stream and beyond, becomes more elevated and hilly, Bald Mountain, York county, rising conspicuously in the distance.

The height of First Kedron Lake above sea level is 414 feet.

The scenery around Oromocto Lake is picturesque; the view looking north from the southern shore being especially fine. The broad expanse of water, the sloping plain, bounded by hills on the west, with the verdant fields of Tweedside in the distance; the hills and dales to the north, in the midst of which Bald Mountain looms up in silent majesty, make a panoramic view of no ordinary beauty.

Lakes being lowered.

Some of the lakes indicate, from the presence of beach material around their borders above high water mark, that they are diminishing in volume. This change is probably caused by the outlets which flow over drift beds eroding their channels to a lower level. Along existing rivers there are evidences of former lake-like expansions, in places where the waters are now confined to a comparatively narrow channel, as for example, between Fredericton and the Narrows below

Gagetown, on the St. John; also between Edmundston and Grand Falls referred to elsewhere. At Brockaway settlement, on the Magaguadavic, there has also been a lake when the river was dammed up by drift at Flume Falls.

Smaller lake-basins.

On the east side of the St. John we find Beccaguimic Lake, at the head of the south branch of the river of the same name, with an old outlet at the southern end, drift-dammed and a new channel excavated. At the confluence of the north and south branches occurs a valley (now partly occupied by the new settlement of Cloverdale), six to seven miles long and three-quarters wide, almost surrounded with terraces and hills, which probably held a lake in Quaternary times, and, if so, was drained by the north-west branch of the Nackawicac River. Several lake basins of small extent occur in the granitic and Cambro-Silurian areas, which are now nearly filled with peat. At the headwaters of the Mactaquac one was seen. It is traversed by a kame described elsewhere in this report.

Heron Lake, a small sheet of water three miles north of Fredericton, elevated 250 feet above the St. John, is a remarkable example of a drift-dammed lake. It is situated in a narrow transverse valley, extending from the Nashwaak to the St. John. A kame, 325 yards long and 25 to 30 feet in height above the lake, has been thrown across this valley in a north and south direction, and the lakelet thus resembles a mill pond artificially dammed.

Age and character of lake-basins.

All the lakes examined in this region belong to the drift-dammed class. The Cheputnecticook, Magaguadavic, Oromocto and others, have their longest axes approximately north and south, and occupy pre-glacial valleys of erosion. The larger number of these valleys may be designated *transverse valleys,* from their position with regard to the Bay of Fundy on the one hand, and the St. John valley on the other, and have probably been formed, in large measure, by the subærial decay of the rocks and the drainage of the area in past geological ages. Their general north-to-south direction may be owing to the fact that such drainage would naturally seek the shortest route, either to the Bay of Fundy or to the St. John River. Whether any of the depressions occupied by lakes have been excavated or enlarged by direct glacial action upon the rocks beneath, it is impossible to determine; although, in reality, there seems no better reason for ascribing their formation to glaciers, than for supposing the upper St. John valley, which we now know was in existence long prior to the Ice Age, to have been excavated by the same agency, The configuration of these valleys has, in many instances, been materially altered by morainic accumulations, and that of the lakes they hold is as often due to the position given to the drift around their margins by local glaciers and atmospheric agencies since its original deposition therein, as to the contour of the rock surface beneath.

Mode of formation.

The general course of events, as regards the origin of these lake basins, seems to have been as follows:—(1) Pre-glacial valleys caused probably by subäerial denudation; (2) a partial filling up of these by drift during the glacial epoch, and (3) a scooping out, or partial removal of this drift subsequently by local glaciers and currents, producing depressions therein, with re-arrangement of the materials into ridges (moraines, kames, etc.), which enclose these depressions and dam up the waters of the drainage areas surrounding the lakes.

Kames, or Gravel Ridges.

Kames of river-valleys.

Kames occur in the St. John valley and along its principal tributaries, but are best developed on the borders of lake-basins and in flat, swampy tracts at the sources of rivers on the water-sheds. They are known in the country districts as "horsebacks," and their peculiar and striking appearance renders them among the most interesting phenomena pertaining to surface geology. Along the river-valleys they exhibit the following features and characteristics:—(1) They are entirely confined to the valleys, although often pursuing a zigzag course, as do the rivers, but never reaching above the highest slopes, nor with their summits more than 175 to 200 feet above the surface of the river to which they belong. (2) They seem to attain their greatest development in places where the rivers have nearly a north-to-south course, as along the St. John between Grand and Maductic Falls; but this may be due, in some degree at least, to the increased velocity of the river and greater erosion and remodelling of the original drift beds in this part of the valley. (3) They seldom occur in continuous ridges for great distances, being generally detached and hummocky, and apparently merge into the upper terraces which usually flank them. (4) They are found immediately below the mouths of tributaries and constrictions or bends in a river-valley in greater abundance than elsewhere.

Kames of highlands.

The kames found on the higher grounds possess certain peculiarities which distinguish them from those of river valleys. (1) Their courses are more generally north and south, or conform more closely to those of the glacial striæ in the vicinity; (2) enclosed hollows or basins are more frequent in them; (3) lesser ridges usually branch off at intervals from the main kame; (4) their summits, excepting local irregularities, are nearly horizontal throughout their whole length; and (5) they seldom have regularly formed terraces flanking them.

Material of kames.

Some of the kames are composed of till in the bottom, which is, for the most part, concealed by stratified water-worn materials on their summits and flanks, and sometimes we find one part bulky, hummocky, and largely composed of till, while some rods off it becomes smaller and seems to consist wholly of stratified deposits. Occasional beds of fine sand occur in them, and a few of the larger have a narrow ridge of rock underneath, whether extending throughout their whole length or not it was impossible to determine.

In the region under consideration none of the kames are continuous for more than a few miles in any one place; although by connecting some of them, or supposing them to have been connected at a former period and subsequently denuded, they may be traced as one kame over long distances. Want of continuity.

Description of the Kames.

I shall now briefly describe these deposits in detail, first treating of kames occurring in river valleys. Their courses, as given below, are all referred to the true meridian, and their heights, unless otherwise stated, to the St. John River at the nearest point.

No. 1. Commencing at Grand Falls and following the St. John southward, we first meet with a kame-like ridge at Rapide des Femmes on the right bank, which is traceable along the river to a point three miles above the mouth of the Aroostook. Although largely composed of till, it exhibits more or less stratified material on the summit, and where interrupted, appears as knolls or short ridges. Length, 12 to 15 miles; height, 100 to 200 feet; course, nearly due south. Rapide des Femmes.

2. In Perth, three miles below Andover on the left bank, another occurs. Length, one-half to three-quarters of a mile; height, 150 feet; course, S. 45° to 50° E. It consists of short ridges in a row, parallel to the river; sand and gravel on top, till underneath, with enclosed hollows behind. Perth.

3. Below the mouth of the Muniac a well-developed kame is seen; length, one-quarter to half a mile; height, 150 feet; course, S. 30° W. A section in a railway cutting shows 10 to 15 feet of gravel, containing pebbles 6 to 9 inches in diameter in upper part; fine sand, obliquely bedded, interstratified with seams of coarser sand underneath; kame steep on both sides, with denuded mounds of till behind. Muniac.

4. From mouth of Pokiok, near Hartland, to Newburg Junction, a series of short ridges is found, which, taken together, extends 4 to 5 miles; height, 100 to 175 feet; course, S. or parallel to St. John. Sections show stratified materials, consisting of gravels, with finer beds of sand underneath. One exposure exhibits a local deposit of tough, brown stratified clay at a height of 75 to 100. Loam has been deposited on the summits and flanks of these ridges to a depth of 2 to 5 feet. At mouth of Pokiok.

5. A similar series of longitudinal hillocks on the same side of the river below Acker's Creek is met with. Length together, one-half to three-quarters of a mile; height, 100 to 150 feet; course, S. 10 to 15° W. Near Acker's Creek.

Near Grand Bar Creek. 6. Detached mounds occur below the mouth of Grand Bar Creek, on right bank; length of all, a quarter of a mile; height, 125 to 150 feet; longest axes about S. 10° W. Terraces of similar materials covered with a few feet of loam surround these ridges at a height of 75 to 100 feet.

7. Along Grand Bar Creek also a kame-like ridge extends from its mouth up stream one mile and a half; height, 100 to 200 feet; course, S.W.; width, 100 to 500 yards. Contains hollows nearly circular, 50 yards or more in diameter and 10 to 30 feet in depth, forming ponds. Thick beds of till from which the gravels have evidently been derived, occupy the upper part of Grand Bar valley.

Meduxnakeag River. 8. On the right bank of the Meduxnakeag River, a mile above Woodstock, occur several detached ridges, which if connected would form a well-developed kame. Length taken together, a mile and a quarter; height, 120 feet, or 110 to 115 feet above Meduxnakeag; course at north-western end for 450 yards from river's bank, S. 50° E.; thence curving round, it trends for some distance nearly due E., beyond that running N. 75° E. to the bank of the Meduxnakeag again, thus describing roughly an arc of a circle. The summit is 25 to 30 feet above the general level of the valley.

9. On the left bank of the same river, above Bellville, several short ridges occur longitudinally parallel thereto; course of all approximately S.E.; height above Meduxnakeag, 65 to 80 feet. These mounds of gravel seem to stand upon the terraces which here skirt the stream.

Lower Woodstock. 10. Between Lower Woodstock and the mouth of Eel River a series of ridges extends along the St. John valley close to the banks of the river on one side or the other, which seem as if they had once been connected. Length, 4 to 5 miles; height, 125 to 175 feet; course, S. 40 to 50° E. In the longitudinal valleys behind these ridges terraces of similar materials flank them at a height of 50 feet below their summits.

Upper Southampton. 11. At Upper Southampton, along the left bank, a kame is seen; length, nearly a mile; height, 125 to 150 feet; course, S. 45 to 65° E., or approximately parallel to the river. This kame is a typical one, with steep sides and regular outline, and lies immediately below and in a direct line with a reach of the river. Just at the upper end of the kame the river takes a sweep round to the south, and the materials composing it seem to have accumulated below the bend.

Sullivan's Creek. 12. Below the mouth of Sullivan's Creek, on the right bank of the St. John, there is a short ridge; height, 175 to 200 feet.

Shogomoc River. 13. Stretching along the same bank at the Shogomoc River a wide irregular ridge, fully a mile and a quarter long, is found; height, 140 to 150 feet; course, S. 65 to 70° E.

14. On the left bank, some rods further down, a ridge half a mile in length, 175 to 180 feet high, and with nearly the same course as No. 13, occurs. A number of detached mounds of gravel are seen at its northern end.

15. Near the mouth of the Nackawicac, on the same side of the St. John, a short ridge stands on a terrace, its summit about 180 feet high; course, nearly north and south. Nackawicac.

16. The confluence of the Nackawicac and St. John waters has developed a well-marked kame on the left bank of the first named stream. Length, a mile and a quarter; course, S. 40° E.; height, 150 feet; average width at the base, 175 yards. Summit nearly horizontal; at the northern end kame merges into upper terrace of the Nackawicac valley.

17. On the right bank of Coac Creek a kame is met with. Length, a mile and a quarter, with a curving course; height, 150 to 175 feet. Part of it has a terrace-like summit at a height of 150 feet. Coac Creek.

18. In Upper Queensbury two or more short ridges are found, which, taken together, are half a mile long; height, 175 feet; course curving; outline irregular, apparently much denuded. Southern termination known as Hay's Hill. Upper Queensbury.

19. Three to four miles below Bear Island P. O., in Lower Queensbury, several longitudinal mounds of fine gravel underlain by till, occur. General course, S. 60° E.; height, 90 to 100 feet.

20. On the same side of the valley, three miles above the mouth of the Mactaquac, occurs another curving kame. The upper portion strikes off from the river's bank at a course of S. 70° to 75° E. for the space of 400 to 500 yards; thence curving round to a south-east course, it almost disappears in the higher slope of the valley; thence running in a southerly course towards the river further down it appears as short ridges. Whole length, fully a mile; height, 175 to 200 feet. Denuded in places, but upper portion complete and well defined. Near Mactaquac River.

21. Opposite Cardigan station, on the right bank of the Keswick River, the valley-drift takes kame-like forms. The largest of these is fully half a mile long and 100 to 500 yards wide, the northern extremity forming a conspicuous gravel hill in the centre of the valley, round which the river winds. Height, 75 to 100 feet above the Keswick. Keswick River.

On the left bank a small isolated kame-like hill occupies a prominent position in the valley just below the mouth of Jones' Creek.

22. Between Burnside and Upper Keswick stations on the same river, a number of ridges on the left bank run parallel thereto, or from S. to S. 20° E.; height above the Keswick, 60 to 65 feet; length, 2 to 3 miles. These ridges merge into the terraces at Burnside station, the latter being at the same height.

23. On Keswick Branch several short ridges parallel to the stream occur; length, 2 to 3 miles; height, 50 to 60 feet. The material composing them is almost entirely granitic *debris*, the river here flowing across the granite belt.

Lincoln.

24. In Lincoln, near the confluence of the Oromocto and St. John, irregular sand-hills are met with. One of the largest has a course nearly S. 20° E.; length, about half a mile; height, 75 to 100 feet. The course of another is S. 10° W. They are composed chiefly of blown sand, and are short and sinuous. Behind them lie peat bogs.

Burton.

25. At Burton, Sunbury county, a ridge a mile and a quarter long composed of similar materials to No. 24 occurs on the right bank of the St. John; height, 30 feet; course, N. 85° E. A sphagnous bog fills the hollow behind it.

Upper Gagetown.

26. At Upper Gagetown, Queen's county, a gravel ridge stretches 2½ to 3 miles on the right bank of the St. John. Height, 50 to 100 feet; general course, S. 60 to 65° E. Near the upper end it encloses ponds, around the borders of which are peaty swamps. Rock *in situ* protrudes through the kame in several places, and it is evidently formed along a rocky ridge.

Nashwaak River.

27. Half a mile above Marysville, on the right bank of the Nashwaak River, a kame occurs. Length, 500 yards; height, about 100 feet above the Nashwaak, 60 feet above the valley in which it stands; course, nearly due south.

28. A mile above Nashwaak village, on the same side of the Nashwaak River, a curving ridge about 600 yards long extends. Height above the stream, 100 feet; course, S. 25° W. in northern part, S. 5° W. in southern part.

29. Half a mile above this last ridge, on the same side of the river, another stretches 500 yards along the side of the valley; height, 90 to 100 feet above the Nashwaak; course in upper portion, north and south, in lower S. 25° W. nearly.

30. In Carlisle settlement, Beccaguimic River, a short kame occurs about half a mile below Shaw's Mills. Length, 380 yards; height above the Beccaguimic, 50 to 60 feet; course, nearly north and south. This is an isolated ridge in the valley with its longest axis parallel to the river.

31. Above Shaw's Mills there is another on the right of the same stream. Length, about 250 yards; height, 60 to 75 feet; course, S. 40° E. This kame lies close to the valley slope, the upper end joining it.

Kames noted by G. F. Matthew.

Kames likewise occur in the river-valleys on the southern side of the south-western water-shed, but most of them have been described by Mr. G. F. Matthew (Report of Progress, 1877-78, pp. 13-14, EE.). I shall note some met with in the Magaguadavic valley, however, which he omitted.

32. Along the eastern side of Lower Trout Brook, which joins the Magaguadavic at the dividing line between York and Charlotte counties, longitudinal mounds of gravel and fine blown sand extend up the stream from its mouth for some distance parallel thereto, or with a course of S. 40° E. Mr. Davis, a hunter living in this vicinity, states that these gravel-hills run midway between the two Trout Brooks nearly to their sources. I shall refer to them again. Magaguadavic River.

33. Along the Magaguadavic, below Lower Trout Brook, as far as Flume Falls, a distance of 5 to 6 miles, a kame was traced; course, S. 30° to 40° E.; average height above the Magaguadavic River, 50 feet. This would seem to be a continuation southward of the Trout Brook kame. Mr. Davis informs me that it extends down the Magaguadavic valley 15 to 16 miles. About 10 miles above Upper Falls, Magaguadavic, it becomes broken and hummocky, and no regular ridge is found below that, although deposits of gravel occur all along down to Upper Falls. Beyond that, however, they seem to leave the valley of the Magaguadavic and follow the Lake Utopia basin.

34. On the right bank of the Magaguadavic, between Upper Trout Brook and Nutter settlement, short gravel ridges are met with. One having a course of about S. 10° W. was paced half a mile.

Kames of the Water-sheds, etc.

Following is a description of the principal kames observed on the water-sheds, lake-borders, etc.:—

No. 35. This is the most remarkable kame in the district. It is first seen near the Maine boundary, in a low tract lying to the north of Monument settlement, York county. Thence it runs nearly southeastward, with some interruptions 2 to 3 miles along Bull Creek, a tributary of Eel River, to within a short distance of the confluence of these two streams. Here it is intersected by a small branch of Bull Creek flowing from the south-west. Beyond this point it becomes much higher, and more bulky, with rock-bosses protruding, and swerves round to a southerly course, which it follows for about three miles. In this space it encloses several hollows, dams up a lake—Bell Lake—on the west, and sends off parallel branches with intervening hollows open to the south. The southern portion trends about S. 40° E., and finally disappears under the waters of First Eel Lake a few rods west of the head of Eel River. Length on the New Brunswick side of the boundary (for it is supposed to extend northward into Maine), 7 to 8 miles; height above First Eel Lake, 100 to 150 feet, above sea level about 675 feet, and above the general level of the district 50 to 60 feet. From its large dimensions this kame forms a conspicuous feature in the landscape, and is known for miles around as "The Horseback." Kame known as "The Horseback."

Fish Creek.

36. Is another well-developed kame, running along Fish Creek. The northern end is in the vicinity of Pocawagum Lake; thence it extends S. 20° to 25° E. 3 to 4 miles to Dead Water Creek. Here it seems to bifurcate, or join another kame extending along that stream. The latter is seen at intervals between this point and the mouth of the creek; it also extends up stream some distance. A kame following Dead Water Creek appears on the two roads running from Skiff Lake to Canterbury, which may be the same, but owing to the almost impassable condition of the country could not be traced out to the west. The general course of the Dead Creek kame is S. 65° to 70° E.

Magundy Brook.

37. On Magundy Brook, a branch of the Pokiok, York county, a kame is found. Length along the stream two miles or more; height above it 30 to 40 feet; course about S. 20° E.

Oromocto Lake.

38. At the northern end of Oromocto Lake, along a small stream called Dead Brook, a kame three-quarters of a mile long occurs. Course, S. 30° to 35° E.; height above Oromocto Lake at southern end, 75 feet, at northern end 90 feet. It runs out from a mass of till in the hill-side and terminates in the lake.

Other kames of S.W. watershed.

Several other shorter ridges of stratified gravel, etc., usually with till underneath, are met with in many places on the south-western watershed, of which the following may be mentioned:—(1) Below Harvey station; (2) on the southern shore of Magaguadavic Lake; (3) in the valley between Magaguadavic and Blaney Ridges, on the road leading from Prince William station to Lake George, etc.

In the vicinity of McAdam Junction, and along the line of railway north and south of it for some distance, also at Foster Lake, First and Second Digdeguash Lakes, ridges and mounds of stratified gravel and sand are found in connexion with the moraines which are so common in that region. Some of the moraines are, on this account, liable to be mistaken for kames, as they generally have a north-to-south direction and a regular outline; but they are wide and flat on the summit, and invariably contain large boulders in abundance, in this respect differing from the kames described.

Kames on E. side of the St. John.

39. On the east side of the St. John, kames were also discovered on the higher levels. The most remarkable is one occurring at the head waters of the Mactaquac (noted on Mr. Charles Robb's MSS. map of the district prepared for the Geological Survey in 1870). Rising in a swamp, it was traced about two miles down stream, following a course of S. 45° E., the river intersecting it once within that distance. On the Staples' settlement road it appears as two parallel ridges of equal height and bulk, being about 25 feet above the level of the valley. The exact length of this kame could not be ascertained, as it traverses, for the greater part, a wooded swamp. Mr. Vanbuskirk, a trapper in this neighbourhood, informed me that it is about five miles long.

40. Along the New Brunswick railway west of Millville two lakelets are separated by a short kame-like ridge of gravel, damming one 20 feet higher than the other. General course of ridge S. 45° E.; height above surrounding level, 10 to 20 feet. Glacial striæ were observed on rocks underlying these gravels.

Short ridges.

Gravelly knolls and short ridges occur in other localities on this side of the St. John—(1) at Millville, near the hemlock extract factory, on Hainsville road; (2) on the easternmost of two roads leading from Millville to Temperance Vale, etc.

41. At a lakelet—Heron Lake—three miles from Fredericton on the Miramichi road, a narrow ridge 325 yards long crosses a transverse valley, holding up its waters like an artificial dam. Course, S. 20° E.; height above the lakelet, 25 to 30 feet, above the St. John 275 feet. It is morainic at the northern end.

Difficulty of tracing kames continuously.

The kames in this district, it will be seen, are short and broken, and in this respect unlike the kames of Maine, as described by New England geologists. Little or no attempt was made to connect them into systems, or long continuous ridges, by linking them together and supposing them to have been detached by denudation. The writer did endeavour, during the autumn of 1883 to trace out the connexions of the Eel River kame, the largest in the district, southward, by following it from its southern termination at First Eel Lake up Dead Water Creek and across the granite belt to the Trout Brooks which flow into the Magaguadavic River, thence down the Magaguadavic valley to the Bay of Fundy, but the result was not satisfactory. There does appear to be a connection between Nos. 35 and 36, and also between 32 and 33, although wide gaps occur in several places; but no regular ridge, or series of ridges, seems to connect them across the water-shed.

Moraines and kames contemporaneous.

From the fact that many of the kames contain morainic materials and till, and also that the moraines on the south-western water-shed often have stratified gravels and sands in their uppermost parts, and are kame-like, I am inclined to regard the two, especially on the higher levels, as contemporaneous deposits.

The Terraces of the St. John and its Tributaries.

Terraces of upper St. John.

One of the most interesting and picturesque features of the upper St. John is its terraces. They are seen stretching along the valley from Fredericton to St. Francis, sometimes on one side, again on the other, rising like gigantic steps on the slopes and giving a beauty and finish to the landscape which no pen can adequately describe. The highest terraces consist of stratified gravel and sand, intermingled with water-worn pebbles, and cross-sections show them to be the same height on both sides of the valley, generally 75 to 150 feet above the river. Longitudinally their summits are seldom horizontal, having about the same slope down stream as the river. The lower terraces and intervales have not been levelled off at the same height on both sides of the valley; and while, at the depth of a few feet they are found to be of similar materials to the upper terraces, yet the gravels are more water-worn, and generally have a capping of loam or river silt. Instances of these having channels eroded on the surface previous to the deposition of the loam were noticed. Local beds of stratified clay and also of fine sand occur in the terraces.

Materials of terraces.

The materials of the upper terraces and kames of river-valleys are identical, showing they have been derived from a common source. Such of the kames as occupy the middle of valleys appear to be portions of the upper terraces left from denudation. In this respect they differ from those kames or ridges which extend along the upper slopes of the same valleys, the latter being usually underlaid with till.

Relation to velocity of streams.

Terraces seem to have attained their largest development along valleys where the velocity of the rivers was greatest. For example, between Edmundston and Grand Falls, a distance of forty miles, the descent of the St. John is inconsiderable, and consequently the valley-drift is stratified only in the upper portion along the banks of the water-course, till being seen underlying the stratified beds wherever sections are exposed. From Grand Falls to Woodstock, however, a distance of more than sixty miles, the average descent is about three feet per mile, but is much greater in the twenty-four miles between the Falls and Andover than below, and it is here that we find the largest and finest examples of terraces occurring along the St. John.

Sections of valley-drift and terraces.

The sections given below illustrate the character and position of the valley-drift, stratified and unstratified, as well as the dimensions of the terraces at several of the more important points. The heights are referred to the lowest summer level of the St. John River on the line of the section, unless otherwise stated; and the widths of the St. John given signify from bank to bank.

The sections are given in the order of their occurrence proceeding up the St. John valley.

Woodstock.

1. At Woodstock, near the hemlock extract factory, on the right bank, the following measurements were made in a westerly course, magnetic, beginning at the river.

(1) Intervale, 12–15 feet high; 330 yards wide; transversely crossed by a channel-way, 5 feet deep and 25 yards wide at inner margin, or margin farthest from river. The materials are—loam on top, sandy loam underneath.

(2) Terrace, 30 feet high, 350 yards wide. Loam on top, 2–5 feet deep; gravel and sand of unknown depth underneath.

(3) Terrace, 50 feet high, 350 yards wide. Composed of (1) loam on surface, 1–2 feet deep; (2) alternate strata of loam and sand, 5 feet; (3) gravel and sand, depth unknown.

This terrace No. (3), is the highest on the line of section and abuts against the valley slope.

Width of the St. John here about 350 yards, with an islet in the middle. A hill several hundred feet high rises sheer from the bank on the opposite side.

2. At Grafton. opposite Woodstock, similar deposits occur as follows: Grafton.

(1) Intervale, 10 feet high; width, 100 yards, increasing further down river. Materials—loam changing to clay.

(2) Terrace, 30 feet high; width, 25, increasing below to 150 yards. Loam, 1–2 feet deep on top, gravel and sand underneath.

In an excavation at a brick yard on the inner margin of this terrace, fine-grained, tough blue clay of unknown depth is exposed, overlain by 5 to 10 feet of brown clay, the whole stratified. Calcareous nodules occur in the brown clay.

(3) Terrace, 90 feet high; width 10–25 yards. Contains beds of fine sand, used in brick-making, and gravel; but is much denuded.

3. Half a mile below the village of Hartland the following section Hartland. was measured from the left bank in a course of N. 75° E. magnetic, the river at this point being about 300 to 350 yards wide. An islet occurs a short distance below, and the opposite bank is without terraces, sloping up gradually to a height of 200 to 300 feet.

(1) Intervale, 5–7 feet high; 100 paces wide. Loam, in ridges parallel to the river.

(2) Terrace, 25 feet high; 110 paces wide. Loam on top, gravel beneath.

(3) Terrace, 50 feet high; 65 paces wide. Chiefly gravel, capped with loam.

(4) Terrace, (just north of a sub-railway crossing) 110 feet high; 90 paces wide. Gravel and sand, somewhat hummocky and uneven on the surface. Where it is intersected by streams loam covers the slopes. This is the upper terrace, the land rising gradually behind it, till being the surface deposit.

4. At Hartland a section was measured in a course of S. 85° E. and Hartland. N. 85° W. magnetic, on both sides of the valley. A wire ferry (wire 1,250 feet long from bank to bank) here crosses the river at the foot of an islet.

On East Side.

(1) Intervale, 7–8 feet high; 120 paces wide. Loam.

(2) Terrace, 25–30 feet high; 275 paces wide. Loam on the surface, gravel underneath.

(3) Terrace, 95 feet high; 80–100 paces wide. Gravel and sand with a thin capping of loam in places.

(4) Terrace, or mounds flat-topped in places, resembling a denuded terrace, 125 feet high; width, 100–150 paces or more, with ascending surface beyond. Gravel and sand with till underneath.

On West Side.

(5) Terrace, 50 feet high; 45 paces wide. Lower 10–15 feet, rock *in place*; above it 30–35 feet of gravel, about 5 feet of loam on summit, which is clayey and distinctly stratified in lower part

This terrace is 5 to 10 feet lower at the inner margin than at the outer. Behind it the land ascends for 500 to 600 paces to a height of 200 to 300 feet, the rock cropping out in places, overlain by hummocks of till.

Florenceville. 5. Measurements at Florenceville on left bank, course east magnetic.

(1) Terrace, 25 feet high; 20 paces wide. Sand and gravel, the pebbles 3–6 inches in diameter, capped by 3–5 feet of loam. Extends along river half a mile or more.

(2) Terrace, 40–45 feet high; 400 paces wide. Materials same as last with 2–5 feet of loam in the hollows on surface. Extends along river 2 miles; principal terrace of district.

(3) Terrace, 50–55 feet high; 20–30 paces wide. Same material as preceding terraces, with less loam on the surface.

(4) Terrace, 75 feet high; 90 paces wide. Same, with scarcely any loamy covering. A very pretty terrace, but only about a quarter of a mile long.

(5) Terrace, 80 feet high; 55 paces wide. Same materials. A small terrace but well defined, length only 100–125 yards. Occupies a sinus in next higher terrace.

(6) Terrace, 100-110 feet high; 275 paces wide. Chiefly gravel. This is highest or upper terrace; very pretty as seen from opposite bank of river. Length not known, but must be several miles.

Behind the last the land is still terrace-like, but has a gradual ascent, following the same course, for half a mile, reaching a height of 175 feet; beyond that rising more rapidly. The surface deposit here is chiefly till, but rolled pebbles are strewn about in profusion, and loam occupies denuded hollows.

The terraces just described have manifestly the same continuous bed of gravel underneath them all, and are levelled off with loam on the surface.

The St. John at this point is about 300 yards wide. On the western side there is a bluff 100 to 150 feet high, composed chiefly of till with rock underneath which crops out in the bank.

6. Below the mouth of the Munquart, at Bath village, the dimensions of the terraces on both sides of the river are as follows: course S. 30° E. or N. 30° W. (mag.); width of the St. John about 325 yards. Bath village.

On East Side.

(1) Terrace, 20–25 feet high; 125 paces wide. Gravel, with 5–10 feet of loam on top. Longitudinal hollows 5–8 feet deep are eroded in this terrace. At the inner margin one hollow 20 paces wide, is 10 feet deep. Others are filled with loam.

(2) Terrace 55 feet high; 210 paces wide,—has a gentle slope towards inner margin, being 5–7 feet lower there. Gravel with loam on summit. Has ridges and hollows parallel to river.

(3) Terrace, 125 feet high; 175 paces wide. Gravel; coarse on top.

(4) Terrace, (measuring in an easterly course) 130–135 feet high; 150 paces wide. Same material as last. The inner 20 paces are 3-5 feet lower.

(5) Terrace, (following last course) 140 feet high; 285 paces wide, reaching upper slope of the valley. Apparently same material as two last, but with many angular boulders near upper slope.

On West Side.

(6) Terrace, 55 feet high; 90 paces wide. Gravel and sand with loam on top, capping rock 15–20 feet high *in situ.*

(7) Terrace, 120 feet high; 95 paces wide. Gravel, with a few feet of loam on the surface. This terrace has a slight inward slope, being about 5 feet lower at innermost margin.

The two last Nos. (6) and (7) are short and local. Above them there is a rolling surface sloping upwards to a height of 175 to 200 feet. Materials, chiefly till overlain by a thin covering of water-worn gravel, and in some places loam.

The great development of terraces, Nos. 3, 4 and 5, of this section is evidently due to the Munquart River, below the mouth of which they lie.

7. Just above the mouth of Rivière Des Chutes, the following section was made on the right bank of the St. John; course E. and W. (mag.) Width of the St. John about 300 yards. Rivière Des Chutes.

(1) Terrace 40 feet high; 50–75 paces wide. Gravel, covered by 8–10 feet of loam.

(2) Terrace, 80-85 feet high; 50 paces wide where measured, but a few rods above 300--400 paces. Same materials as last, but with less loam.

(3) Terrace, 100 feet high; width unknown, covered by forest. Gravel and sand,—seen in alternate strata 1–2 feet thick at height of 50–60 feet.

On East Side.

(4) Terrace, 60–70 feet high; 400–500 paces wide. Gravel. Beyond that the land ascends for 300 yards to the base of a hill.

Muniac River. 8. The following section was measured just below the mouth of the Muniac; course, S. 35° E. (mag.) Width of the St. John 250 to 275 yards.

On East Side.

(1) Kame, or gravel ridge (Kame No. 3 of this report), height 150 feet; 50–60 paces wide. Gravel and sand; materials becoming coarser towards summit.

(2) Terrace; 90 feet high; width, 200–250 yards, ascending to 100–125 feet. A small stream intersects deposits here, showing till underneath, gravel and loam on top. Behind the stream a hill rises 300–400 feet high.

On West Side.

(3) Terrace, 45 feet high; 75–100 paces wide. Gravel, with loam on surface.
Behind rises a bluff of gravel and sand with till underneath, to a height of 100–125 feet; surface rolling; width, a quarter of a mile.

Perth. 9. In Perth, three miles below Andover, the following cross-section of the valley-drift was made; course, S. 70° E., and N. 70° W., (mag.) Width of the St. John, 250 yards.

On East Bank.

(1) Terrace, 25 feet high=15 feet of gravel and sand + 10 feet of rock in bottom; 15 paces wide.

(2) Terrace, 43 feet high; 30 paces wide. Gravel and sand, with loam on summit.

(3) Terrace, 58–60 feet high for 47 paces, then it sinks to a level of 55 feet for 40 paces on inner margin. Total width 87 paces. A bog in lowest part. Gravel and sand with loam on top to depth of 2–4 feet.

(4) Terrace, kame-like (Kame No. 2 of this report), 150 feet high; 30 paces wide. Gravel and sand. Sinks behind 25 feet below summit. Enclosed hollows and mounds.

(5) Terrace, 125 feet high; 80–100 feet wide. Till with gravel on summit and uneven surface.

On West Bank.

(6) Terrace, 40 feet high; 350 paces wide. Gravel. Abuts against a pretty steep hill 250–300 feet high.

10. A mile and a half below the confluence of the Aroostook and St. John another section exhibits the following series: Course, N. 50° W. (mag.); width of the St. John, 350 yards or thereabout. Confluence Aroostook and St. John.

On West Side.

(1) Terrace, 40 feet high; 170 paces wide. Coarse gravel and sand, with loam on summit.

(2) Terrace, 25 feet high in middle, sloping up gradually on both sides towards the adjacent terraces; 160 paces wide. Same materials as last.

(3) Terrace, 70 feet high; 125 paces wide. Same materials.

This last terrace abuts against a bank of till, 100 to 150 feet high, covered with some stratified material, forming the upper slope of the valley.

On East Side.

(4) Terrace, 50 feet high; 75–100 paces wide. Gravel, overlain by loam. Abuts against foot of hill.

The terraces of the last section extend in the form described a distance of two to three miles below the mouth of the Aroostook.

11. Section at Little River, from three to four miles above the Aroostook. Course, E. and W. (mag.); width of the St. John, about 300 yards.

On East Side.

(1) Terrace, just above mouth of Little River, 125 feet high; 650 paces wide to base of a hill. Gravel and sand, underlain with till near hill.

On West Side.

(2) Terrace, 50 feet high; 250 paces wide. Gravel, with loam on surface.

(3) Terrace, 40 feet high; 155 paces wide, sloping up to height of 50 feet at rear margin. Same materials as last.

(4) Terrace, 75 feet high; 75–80 paces wide. Gravel.

Behind these are hillocks of till on upper slope of valley.

12. This section exhibits some of the prettiest terraces on the St. John. Locality—about two miles above the mouth of Salmon River; course of section, N. 50° E. and S. 50° W. (mag.); width of the St. John, 250 to 300 yards. Near mouth of Salmon River.

On East Bank.

(1) Terrace, 80–85 feet high; 190 paces wide. Extensive terrace, much wider above, stretching along valley for miles. Materials—gravel, with a few feet of loam on top, sandy strata underneath. Abuts against hill.

On West Bank.

(2) Terrace, 45 feet high; 155 paces wide. Gravel with 3–5 feet of loam on summit. Surface sloping gently away from river.

(3) Terrace, 70 feet high; 260 paces wide. Same as last.

(4) Terrace, 100 feet high; 60 paces wide. Gravel with 2–5 feet of loam on top. This terrace is a short, local one, but flat on summit and well-formed.

(5) Terrace, or kame-like ridge (Kame No. 1), 170 feet high; 35–50 paces wide on top. Chiefly till with some stratified material on summit and river-ward slope, but hummocky and with angular *debris.* Contains boulders of local rock of all sizes up to 12 inches in diameter. Behind it the surface, which has evidently been swept by river-floods in early post-glacial times, sinks to a level of 155–160 feet, thence ascending with a gradual slope. At a distance of 200 paces from ridge No. (5) the height is 225 feet, with the surface still rising.

The subjoined (*Fig.* I.) woodcut illustrates this section.

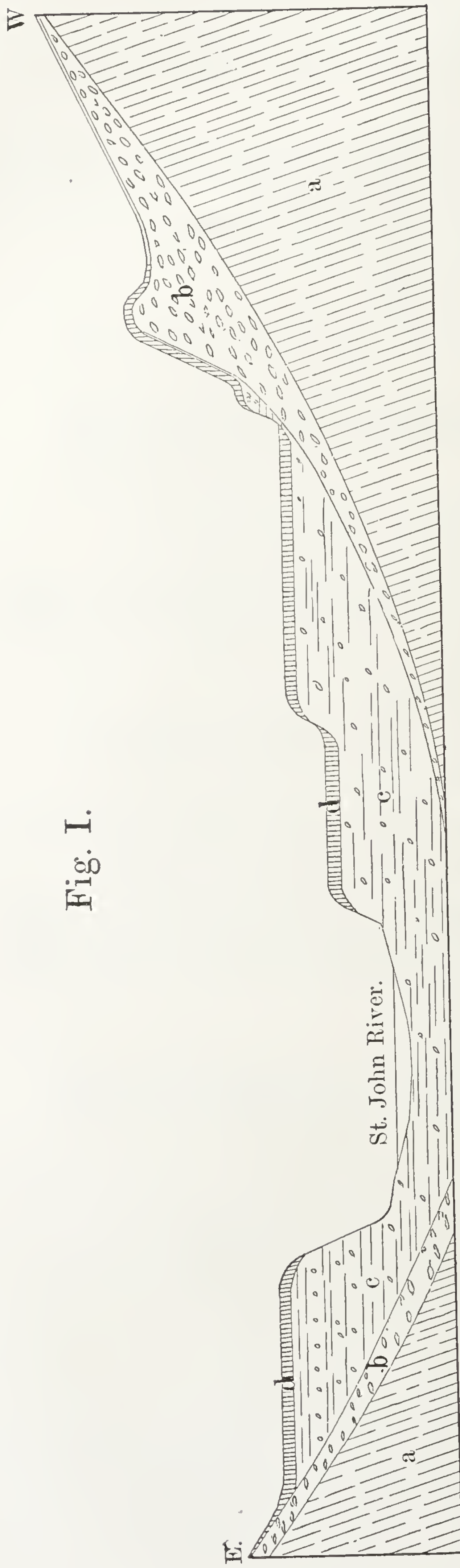


Fig. I.

a, *Calcareous Slate.* b, *Till.* c, *Stratified Gravel.* d, *Loam.*
Horizontal Scale—1 Inch to 440 Feet.
Vertical Scale—1 Inch to 150 Feet.

13. Section, a mile below Rapide des Femmes. Course, S. 70 W. and N. 70° E (mag).; width of St. John, 250–300 yards.

On East Bank.

(1) Terrace, 90–95 feet high; 400–500 yards wide. Loam on summit; at depth of 10 feet a layer of pebbles 2 feet thick occurs, diameter of largest, 6–9 inches. Underneath this, sand and loam, latter changing in places to clay.

This is a continuation up river of No. 1, Sec. 12.

On West Bank.

(2) Terrace, 40 feet high; 320 paces wide. Gravel in bottom overlaid with loam.

(3) Terrace, or kame (Kame No. 1), 150 feet high; 100 paces wide. Till underneath, coarse gravel and clay containing boulders on summit, stratified in places. Behind there is a slight descent to a rolling surface for 100–200 yards, beyond that the upper slope of the valley.

14. Section at Rapide des Femmes. Course, E. and W. (mag.); width of St. John here about 300 yards. Rapide des Femmes.

On West Side.

(1) Terrace or intervale, 25 feet high; loam, with gravel underneath.
(2) Terrace, 110 feet high. Same materials as last.
(3) Terrace, or kame (Kame No. 1), 180 feet high. Largely till, with water-worn materials on summit.

Beyond this the upper slope of the valley.

On East Side.

(4) Terrace, 120 feet high; a quarter to half a mile wide, abutting against rising ground. This is a continuation of terrace No. 1, Sec. 12 and 13, which rises higher and higher above the river as we proceed up the valley. All the terraces from Rapide des Femmes to Grand Falls (3 miles) ascend longitudinally more than the river.

15. Section half a mile below Grand Falls. Course, E. and W. (mag.); width of river, about 300 yards. Near Grand Falls.

On East Side.

(1) Terrace, 120 feet high; 110 paces wide. Gravel and sand.
(2) Terrace, 165 feet high; 350 paces wide. Same materials.
(3) Terrace, 180 feet high; 130 paces wide. Slightly descending towards margin farthest from river. Contains till, but has a sprinkling of water-worn materials on summit.

On West Side.

(4) Terrace, 120 feet high; 75 paces wide. Gravel and sand.
(5) Terrace, 165 feet high; a quarter of a mile or more wide; covered by forest. Abuts against ridge of till along upper slope of valley.

In the gravels of these terraces the coarser materials appear towards the top, and most of the larger pebbles have a coating of calcite. The ower terraces show stratified gravel down to the level of the river and have the same height on both sides.

Grand Falls.

16. Section at Grand Falls.

(1) Commencing on the western slope of the valley behind the railway station at a height of 300 feet above the lower basin and following a course of N. 80° E. (mag.), we descend 200 paces, reaching the margin of the terrace on which the village of Grand Falls stands.

(2) Thence 275 paces reaching old channel of river. This channel here is 150 paces wide and 65 feet deep.

(3) From Eastern side of channel 1000 paces in same course, across village site; height above lower basin, 225 feet, reaching brow of slope near suspension bridge.

(4) Thence N. 15° E (mag)., descending 150 paces to a level of 160 feet above lower basin, we reach suspension bridge across gorge.

(5) Thence across bridge 87 paces, in same course, and an abutment 100 paces to turn of road on east side.

(6) Thence ascending road to the right; course, S. 70° E. (mag.); 120 paces we reach brow of terrace on east bank of gorge, same height (225 feet) above lower basin.

(7) Thence following the original course, N. 80° E. (mag.), 75 paces to the eastern limit of the terrace.

(8) Thence ascending a low slope with till underneath, 125 paces, reaching a height of 250 feet; beyond which surface is ascending and covered by forest.

Nos. 2, 3, 4 and 7, denote the extent of the highest terrace at Grand Falls. Only the uppermost 10 to 25 feet are stratified, the remainder being till resting on rock *in situ*, except in the pre-glacial channel, where the bottom of the till was not seen.

Near Grand Falls.

17. Section at railway bridge about half a mile above the Falls; course, N. 55° E (mag).; width of river, 900 feet.

On East Bank.

(1) Terrace, 350 paces wide; 95 feet high above upper basin = 212 feet above lower basin; ascending gradually behind to summit of valley slope. Till underneath, with thick bed of loam on top.

On West Bank.

(2) Terrace, 180 paces wide; 60–65 feet high = 182 feet above lower basin. Till below, 40–50 feet high; some gravel and a thick covering of loam on summit,

(3) Terrace, with uneven surface, 90 paces wide; 95 feet high = 212 feet above lower basin. Thick bed of loam on surface.

(4) Ravine, 45 paces wide, then a mound of till, covered with gravel and loam, 100 paces wide; 150 feet high.

(5) Terrace, 200 paces wide; 125 feet high. Beyond this another mound higher than the last, after which the brow of the valley slope is reached.

The occurrence of till on the river banks, and the small amount of water-worn gravel, covered by a heavy deposit of loam, are the peculiar features of this section, and show the difference in the valley drift above and below Grand Falls.

About three miles above the last section stratified clay occurs in the river's bank 40 feet high. Color, grey with brown layers of tougher clay 1 to $1\frac{1}{2}$ inches thick interstratified. Dip of the strata N.W. 10 to 15°, or up river. The fine clay is capped by 2 to 6 inches of gravelly clay, holding pebbles from 1 to 6 inches in diameter. Overlying the whole is a bed of loam $4\frac{1}{2}$ feet thick, the lower strata of which are clayey.

Till therefore seems to be the prevailing deposit in the St. John valley above Grand Falls, apparently much less of it having been modified there than below.

The foregoing sections (1 to 17) show that, in the St. John valley, the stratified gravels nowhere exceed 150 feet in height above the river, except immediately below Grand Falls (Section 15), the usual height of the upper terraces, which is nearly the same on both sides of the valley, being from 75 to 140 feet. The longitudinal, or down-river slope of the terraces, is much greater immediately below Grand Falls than elsewhere on the St. John, and their height, relative to the river, exceeds that above the Falls. Height of stratified deposits in the St. John valley.

Terraces of the Tributaries.

On the tributaries of the St. John there are also many beautiful terraces, but they are not as high above the streams to which they belong as those just described, except where the valleys appear to have been dammed by drift or ice during the glacial age. Other examples of terraces.

At the confluence of Cold Stream and Beccaguimic River, a terrace 125 feet above the water occurs, capping the slates which form an escarpment behind the village of Rockland. At Shaw's Mills also the banks of the Beccaguimic are terraced.

Along the Keswick valley there are noteworthy examples of terraces. One was traced from Burnside station to Lawrence, a distanec of eight miles, skirting the valley. At the former place its height above the Keswick River is 60 feet, but at the lower end 115 to 120 feet. The descent of its surface in that distance is only 15 to 20 feet, while that of the river is approximately 75 feet. The width of this terrace at Zealand station is not less than from a half to three-fourths of a mile on each side of the valley. Below Lawrence station none of the terraces exceed a height of 40 feet above the Keswick. A drift or ice-dam would seem to have formerly existed in this valley, in the neighborhood of where Lawrence or Cardigan station now stands, probably at the mouth of Jones' Creek, to cause the accumulation of such a mass of deposits as that described.

SECTIONS SHOWING THE COMPOSITION OF THE TERRACES AND INTERVALES.

Material of Terraces.

In addition to the foregoing sections illustrating the arrangement of the deposits constituting the valley-drift, others were made showing more particularly the structure and composition of the terraces, intervales, etc., especially in the wider river-valleys.

Fredericton.

1. On Smyth street, Fredericton, at a brick-yard near the foot of the hill, the following series was observed in descending order. Height of the beds above the St. John about 25 feet.

	FEET.	INCHES.
(1) Sandy dark tough bluish clay containing plaut remains	1	0
(2) Peaty material, holding seeds of plants and scales of seed-vessels in abundance	0	2
(3) Dark tough blue clay, containing vegetable matter towards the top, depth unknown	0	0
	1	2

Mr. W. T. L. Reed, of Fredericton, found wings of insects, apparently those of beetles, in No. 2 of this section, in addition to the plant remains.

Insect and plant remains.

2. At the Trotting Park, Fredericton, on the terrace on which the city stands, Mr. Reed made the following section—it is descending:

	FEET.	INCHES.
(1) Sandy loam, sand increasing towards summit	1	10
(2) Friable sandy clay	1	4
(3) Rusty spotted clay, firm and sandy, slightly tenaceous	0	.,
(4) Rusty greyish-brown sand	1	0
(5) Same as (7), but rather lighter in color, and without distinct vegetable remains	0	7
(6) Fine sandy clay, with remains of plants as in (7)	1	0
(7) Coarse dark slate-colored sand, somewhat tenaceous from intermixture of clay; contains cones of spruce and fir trees, seeds of elm, and fragments of the wood of birch, maple, etc. Depth unknown; exposure in bottom	2	0
	8	6

Approximate height of the beds above the St. John River 12 to 15 feet.

3. Mr. Reed also examined some of the Nashwaak terraces for me. The two following sections were made at Gibson's cotton mill by him. The series is also descending in each. Gibson's cotton mill.

(1) Bluish clay, with fragments of wood, bark, etc.

(2) Sand.

(3) Sand and gravel, with numerous boulders.

(4) Sand, 3 feet.

(5) Clay, becoming loamy towards upper strata.
Rock in place.

4. This section does not reach the bed rock, going down only to the upper part of No. (5) of the above series.

(1) Sand.

(2) Sand and gravel, with boulders.

(3) Sand.

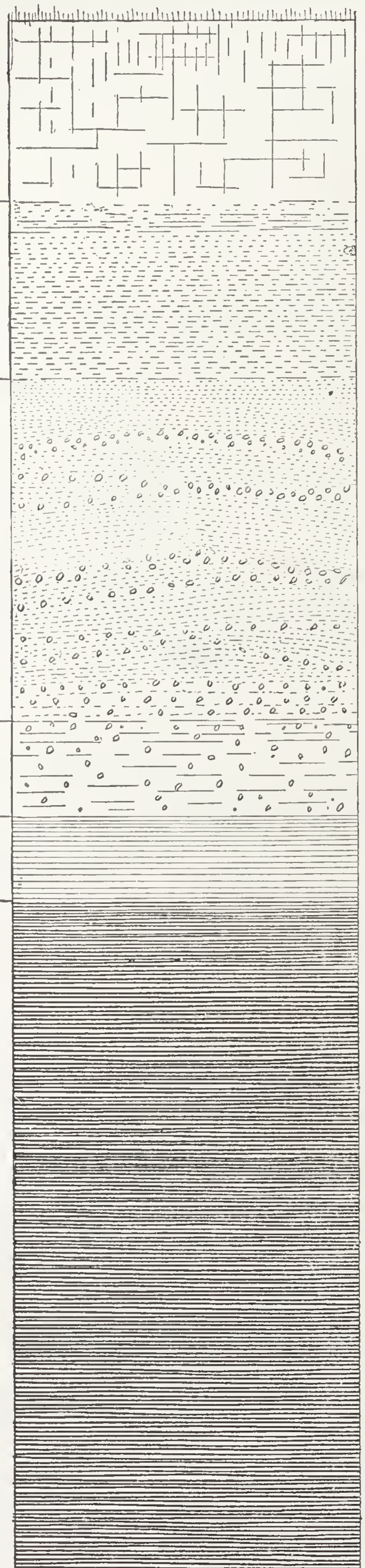
(4) Dark slate-colored sand.

The upper member (bluish clay) is also wanting. Mr. Reed states that division 3, Section 3, terminates abruptly in the river's bank, and contains glaciated stones. The height of No 5, Section 3, is about 50 feet above the Nashwaak.

5. At Keswick Village, near the mouth of the river of the same name, a typical section of the stratified beds of river-valleys is exposed near the bridge. In descending order it is as follows: Keswick village.

	FEET.	INCHES.
(1) Loam or river silt	2	0
(2) Loose grey sand, regularly stratified	1	3
(3) Sand, irregularly stratified with diagonal dip and coarser ochreous strata at intervals, 1-2 inches thick, containing pebbles	3	0
(4) Gravel, containing slate, quartz and granite pebbles 1-2 inches in diameter; strata, rusty brown in places	0	9
(5) Clay, colored brown from ochreous matter in overlying sand and gravel	0	10
(6) Dark grey, finely stratified tough clay, containing vegetable matter. Thickness exposed above river level	5	10
	13	8

Fig. II.



Scale—One Inch to Two Feet.

This woodcut (Fig. II) represents an actual section of these deposits. The ochreous matter in the sands seems to be derived from decomposed iron pyrites.

A few rods below where the above section was taken, the sandy divisions Nos. 2, 3 and 4 had been removed, and No. 1 was found resting on the clays of Nos. 5 and 6. Here the loam contained a considerable quantity of vegetable matter, besides fragments of spruce wood (*Abies*), and the bark of the hemlock (*A. Canadensis*), etc.

6. On the Nackawicac River, at Temperance Vale, the following series also occurs in descending order:—

	FT.	INS.
(1) Gravel, with stones a foot or more in diameter, becoming larger towards the surface ..	6	0
(2) Sand, impregnated with ochreous matter in lower strata	1	0
(3) Dark, finely stratified clay, containing vegetable matter, and in the upper part stems and roots of plants and pieces of wood. Interstratified are black layers ⅛ inch thick or less, ½-1 inch apart. Tolerably pure and tenaceous clay in bottom, but sandy and with ochreous streaks in upper part. Thickness above the river level	17	0
	24	0

The coarse gravels of No. 1, Sec. 6, cover the whole district in this neighborhood, at the forks of the Nackawicac The gradual passage of the series from fine clay in the bottom to sandy clay, then to fine sand next to coarser sand, and near the surface to coarse gravel, is a noteworthy feature of the deposits here. The height of the beds above the St. John at the mouth of the Nackawicac is probably 150 feet.

7. At the confluence of the Aroostook and St. John, a terrace occurs on the left bank of the former river composed of the following materials in descending order :— Confluence Aroostook and St. John.

	FEET.	INCHES.
(1) Coarse gravel and sand stratified	12	0
(2) Loose pale grey sand	3	0
(3) Sandy loam, so tenaceous as to project in a horizontal ridge from the face of the bank	3	0
(4) Alternate bands of loam and sand 1-3 feet in thickness with gravelly seams dividing them. Thickness above river level about	37	0
	55	0

8. In a railway excavation in the same terrace, some rods above the last section, the series is again exposed. Height of the terrace here above the St. John 50 feet. Section descending.

	FEET.	INCHES.
(1) Coarse gravel with sand in bottom, and 1-2 feet of loam on top, forming surface of terrace	12	0
(2) Sandy loam, loose at top, becoming more clayey towards bottom	3	2
(3) Dark grey clay and sand in alternate layers, $\frac{1}{8}$ of an inch to 2 inches thick, the whole presenting a banded appearance. Thickness unknown; visible in bottom of cutting	2	0
	17	2

The general succession of the stratified deposits forming the intervales and lower terraces of the wider river-valleys, especially near the mouths of tributary streams, seems therefore to be, in descending series; (1) loam or river silt; (2) gravel and sand, usually containing water-worn pebbles and sometimes large boulders, and (3) clay of varied texture in the bottom. The loam, however, is occasionally absent, or is replaced with fine-grained sand In the terraces of the narrower valleys, however, we usually find gravel prevailing in the upper part, often with a capping of loam, and sand underneath, the clay beds and sometimes also the sands in these being merely local deposits.* General arrangement of terrace deposits,

No fossils, except the fragments of wood, bark of trees, etc., referred to in some of the sections given above, have yet been found in the Fossils.

*It may be stated that my working theory in regard to the origin of the terraces and kames of river valleys is essentially as follows; At the close of the glacial age the river valleys of New Brunswick were largely filled with drift; that of the St. John appears to have been choked up in several valley-drift of the Upper St. John or its tributaries, although diligent search has been made for them.

Agricultural Character, Flora, Fauna, Etc.

Influence of underlying formation on soil, &c.

The soils of the district under consideration are varied, and partake in a large measure of the character of the underlying rocks, except in the river-valleys where alluvial deposits prevail. The country covered by granite rocks is extremely rugged and uninviting, being everywhere strewed with boulders and coarse gravel, and therefore contains very little land fit for cultivation beyond the river banks. The areas occupied by the Cambro-Silurian belts comprise considerable tracts of arable land of fair quality, and some thriving settlements have been located upon them, as for example, Caverhill, Hainsville, Millville, Good Settlement, etc., east of the St. John, and Howard, Debec, Hartin, Lake George and other settlements on the west side. A large extent of this land, however, is elevated and rocky, and the tract between Millville and Newburg, along the New Brunswick Railway, east of the St. John, and especially that portion of it lying within the northern limits of the district, is barren and unpromising. Among the hills at the head-waters of the Nackawicac and Keswick Rivers, there are numerous bogs and "cariboo plains," and thousands of acres totally useless for agricultural purposes. The south-western part of Carleton county and the area on both sides of the St. John, north of Victoria Corner, are occupied by Silurian slates which are more or less calcareous and yield excellent soil. The surface is undulating with sufficient slope to afford good drainage, and the minor valleys often contain a loamy deposit, probably washed from the hills, which gives them almost the fertility of the river intervales. On the elevations also the covering of soil, although comparatively thin, is fertile,

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places to a height nearly equal to the general level of the country on both sides, i.e. 150 to 200 feet above the present water course. Proofs of this still exist at the Grand Falls of that river and elsewhere. These drift-dams would, on the retreat of the ice, hold up the waters and form lakes, or chains of lakes along the valleys; and the rivers would begin to flow at levels considerably above their present beds, the height of each depending upon the size of the valley, the volume of water, etc. A re-excavation of the drift occupying the valleys would then commence with consequent transportation to lower levels and the formation of terraces. The materials of the higher terraces would be deposited in and around the borders of these lakes, or lake-like expansions, and along the sides and bottom of the currents which flowed into and through them, the accumulations forcing the rivers from one side ot the valleys to the other as the process of erosion and deposition went on. But it is inferred from the depth of the stratified materials in many of the terraces (often 50 to 75 feet), that the waters, especially of the St. John River must have coninued at a height of 150 to 200 feet above their present level for some time.

The earliest formed terraces, according to this theory. ought to be underlaid with till, and such, on examination, we find to be the case. The lower terraces have probably been remodelled more than once by the rivers.

The kames of river valleys, that is the ridges composed of stratified sand and gravel, seem, as already stated, to be portions of terraces left from denudation of the beds once surrounding them of which they formed a part.

due in some measure to the quantity of lime it contains. This part of the province comprises many well cultivated farms, and for agricultural and horticultural purposes generally is not surpassed, even by the far-famed Annapolis valley, in the sister Province of Nova Scotia. Along the band of Lower Carboniferous rocks which traverse the district through the central part of York county there is excellent land. The sandstones of this group, like the slates of Carleton county, contain a considerable quantity of lime, and when pulverized by subærial agencies, furnish rich, friable soils which are easily cultivated, and produce fine crops. The areas occupied by rocks of this age, wherever they occur in the province, if they have good drainage, afford the most fertile uplands.

The Middle Carboniferous series, occupying the eastern and southeastern part of York and that part of Sunbury included in the district under examination, contains some good land; but the country covered by these rocks is generally flat, and while some portions of the surface are dry and gravelly, others, owing to imperfect drainage, are swampy. With lime and compost applied to the soils of the drier clayey and sandy districts, especially those along the slopes of the river-valleys, they make good farms and bear excellent crops of hay and cereals. Underlying the peaty surface deposit of the low level tracts, however, there is a clayey hardpan almost impervious to water, and extensive draining would seem to be the first requisite in reclaiming them.

Soils of intervales and terraces.

Among the soils best adapted for general agricultural purposes in southern and western New Brunswick, those skirting the rivers, such as the intervales or meadows, including the terraces and the islands, hold the chief rank. They have a considerable area in the region in question, especially along the St. John and its tributary streams. On the main river, between Oromocto and Keswick, and also along the valley of the Nashwaak, quite extensive intervales occur elevated only a few feet above the river level. At the mouth of the Keswick there are a number of islands and intervales, the latter extending up this stream eight or ten miles, and occupying a considerable area. Intervales and terraces skirt the St. John, indeed, throughout its entire course, and while much wider below than above the mouth of the Keswick, yet on the latter part of the river, they often attain a width of a quarter of a mile or more and comprise a large extent of valuable land. It would be difficult to compute their area with any degree of accuracy, but from the mouth of the Oromocto to the St. Francis River there cannot be less than sixty thousand acres of alluvial land within the province along the St. John and its tributaries. The lowest intervales are periodically overflowed by freshets and a thin stratum of silt deposited on them which enriches them and maintains their productiveness year after year. The loam which covers these intervales and islands to the depth of several feet is also rich in decayed vegetable matter and contains all the elements of a fertile soil. As a proof of the almost inexhaustible fertility of these alluvial lands, the writer was informed that hay has been raised on the islands at the mouth of the Keswick for forty years in succession without any sign of their deterioration.

Flora, trees.

The flora of the region, while of much interest, possesses no peculiarities worthy of note; nevertheless a few trees and plants are met with which are rare or unknown in other parts of the province. The American Linden (*Tilia Americana*) found along the St. John in a few localities grows a stately tree in the vicinity of Woodstock, and the Butternut (*Juglans cinerea*) occurs in groves on the hill-sides along the Meduxnakeag, 15 to 25 feet in height. The chief sylvan forms on the more elevated and drier grounds are grey and white birch, two or three species of maple, beech, poplar, hemlock-spruce, black and white spruce, fir, white pine, etc. The hemlock-spruce is abundant on the dry, gravelly soils of the granitic and Cambro-Silurian areas; and small forms of the red and white pine also grow freely in clumps on the granite. Of the evergreens the black spruce (*Abies nigra*) is probably the most abundant tree in the district, occurring in groves of large extent, as well as intermixed with other trees on the upper St. John waters. The dying out of great numbers of this species is reported of late years, and considerable discussion has arisen as to the cause, but no scientific investigation of the subject, so far as the writer is aware, has yet been made in Canada.

Hemlock.

Hemlock (*Abies Canadensis*) is, perhaps, next to the black spruce, the most abundant of the large trees of the district growing on the elevated grounds everywhere as far north as Grand Falls. The wood of this tree was, until late years, considered of no value, but it is now manufactured into boards, scantling, etc., while the bark has become a valuable article of commerce in western New Brunswick since the establishment of factories for the preparation of the tanning extract therefrom. Large quantities of the wood, after the bark has been stripped off, are still not utilized, however, but left to rot on the ground, or serve as fuel for the fires which every summer devastate the forests.

The habitat of this tree is somewhat peculiarly restricted, at least so far as New Brunswick is concerned. Rarely is it found on the southern side of the Baie des Chaleurs, north of Bathurst, or on the Restigouche, or to the north of Grand Falls, St. John; while in the interior of the province, south of an almost direct line extending from Bathurst to the mouth of the Tobique River, it is one of the commonest and largest trees. It attains its fullest development on the gravelly soils of the granitic and Carboniferous areas. Most hemlock trees seem to have reached their maturity, and seldom is a young or growing one seen; consequently when the present growth is destroyed this tree will become practically extinct.

On the low and swampy grounds of the district the chief trees are cedar, hackmatac, white birch, ash, poplar, a scrubby form of black spruce, alder, willow, etc. Elms are common along the banks of rivers and on alluvial soils, often attaining a large size. One growing in the Nashwaak valley, about thirteen miles from its mouth, is reported to be upwards of 20 feet in circumference above the roots.

Shrubby plants.

Shrubby plants are abundant in the low wet areas covered by the granitic, Cambro-Silurian and Carboniferous rocks. The sweet fern (*Comptonia*) is common on gravelly ground, especially granitic soil. Rhododendron, Ledum, Kalmia, sweet gale, wild roses and many forms of heath plants are seen everywhere decking with their gay flowers in the spring months the otherwise barren wastes. The staghorn sumach (*Rhus*), the elder (*Sambucus*), beaked hazel (*Corylus*), producing small filberts in great quantities, honeysuckle (*Lonicera*), viburnum, dogwood, wild currants, etc., occur abundantly in all parts of the district.

Herbaceous plants.

The native herbaceous flora exhibits no marked characteristics, but several western and southern species occur here not hitherto collected in other parts of the province. *Pedicularis Furbishiæ*, Watson, allied to *P. Canadensis*, was found on the Upper St. John in 1882, and is a new plant; *Polygala Senega* also occurs there, and *Tanacetum Huronense, Vaccinium cæspitosum, Sanguinaria Canadensis, Verbena hastata, Oxytropis campestris, Caulophyllum thalictroides*, etc., are found along the shores or in thickets bordering its waters. *Pontederia cordata, Nymphæa odorata, Nuphar advena* and other water plants were seen in great profusion in ponds and sluggish streams. The rare ferns, *Scolopendrium vulgare, Aspidium Goldianum*. and also a new species of *Botrychium* have been discovered quite recently within the region.

Zoology.

The zoology of New Brunswick has hitherto received but little attention, not by any means as much as it seems to deserve. The late Dr. A. Gesner, about forty years ago, collected and mounted a number of the mammals, which are now in the museum of the Mechanics' Institute, St. John. They comprise the bear, moose, cariboo, Virginia deer, fox, raccoon, lynx, otter, beaver, sable, weasel, etc. Although in a poor state of preservation, it is the only collection of the native animals of the province existing. Scarcely anything seems to have been done in that direction since. The birds have been assiduously studied by a number of enthusiastic young ornithologists belonging to the Natural History Society of St. John, who have succeeded in collecting probably nearly all the species frequenting the southern counties. But a good deal of scientific work remains to be done before anything like an accurate knowledge of the fauna of the province will be attained. Many of the wild animals are becoming rare, especially the fur-bearing species, and in a few years probably some of the latter will be difficult to obtain. The moose, cariboo, deer, etc., have been hunted so incessantly that only in the interior wilds are they now to be found, indeed the latter was reported to have disappeared altogether, but Mr. Davis, a hunter in Brockaway settlement, and the writer, saw a pair in the Magaguadavic valley in the autumn of 1883.

Fish.

Fish abound in the lakes and streams of western New Brunswick. The common pickerel (*Esox reticulatus*) inhabits the Cheputnecticook Lakes and the St. John River, and white and yellow perch are common in all the waters of the interior. Trout (*Salmo fontinalis*) occurs in nearly every lake and stream except those frequented by pickerel, which are said to destroy them; and Skiff, Oromocto, Kedron and other lakes are favorite resorts for sportsmen. The common eel (*Anguilla Bostoniensis*) is plentiful in Oromocto Lake; chub (*Leuciscus, sp. ?*), shiners (*Plargyrus Americanus*), red-fin (*P. cornutus*), the bream (*Pomotis vulgaris*), the horned pout or catfish (*Pimelodus catus*), etc., are also very common in some of these waters.

Molluscs.

Fresh water mollusks are abundant in nearly all the lakes visited, but the species are few, belonging chiefly to the genera *Unio* and *Limnæa*. In North Lake great numbers of *Limnæa decollata* were found in the month of July (1883), adhering to the boulders which fringe the shores just below the surface of the water. *Unio* (*Complanaria*) *complanatus* and *U.* (*Lampsilis*) *radiatus* occur abundantly in all the lakes, their shells being found in heaps along the margin of the water, whence they had been taken by muskrats, the belted kingfisher, etc. Several species of *Helix* are common on waste grounds, and the woodtortoise (*Glyptemys insculpta*) occurs in the district, having been seen on the Nashwaaksis and other streams.

Materials of Economic Importance.

Bog iron ore.

The only minerals of economic importance known to exist in the superficial deposits are bog iron ore and wad. The former occurs at Burton and Maugerville, Sunbury county, and is also reported from Queensbury, York county, and elsewhere. The deposit at Maugerville was examined during the past season, and its mode of occurrence seems to be as follows:—The ore-bed consists of a mixture of loamy and boggy or peaty materials of the depth of from one to three feet below the surface, underneath which is a clayey hardpan. The ore is found in the form of cakes, or loose flattened aggregations, few of them more than six to twelve inches in diameter, although sometimes two to three feet. An intervale, or alluvial terrace of considerable extent, occurs here at a height of about ten to twelve feet above the level of the St. John River, and the ore-bed occupies a longitudinal belt in it parallel to the river about fifty yards in width and three to four miles in length.

Wad is found in a gravelly bank near Government House, Fredericton, the deposit evidently being of considerable extent. It is also reported from Queensbury, York county, and Lincoln, Sunbury county, but these localities were not examined. Bog Manganese.

Peat is abundant in the Carboniferous, Cambro-Silurian and granitic areas, usually occupying depressions which were formerly shallow lake basins of small extent, but sometimes covering tracts on the flat surface of the first mentioned formation comprising many square miles. No attempt was made to measure the superficial content or depth of the beds, as many of them are difficult of access, at certain seasons being saturated with water, and often covered with thickets of tamarack, scrubby black spruce, and dense masses of ericaceous plants. From the abundance and comparative cheapness of wood, no one has yet thought of utilizing peat for fuel. Deposits occur at Lincoln, Sunbury county, Oromocto and Magaguadavic Lakes, also at North and Eel River Lakes. In the parishes of Douglas and Bright, York county, especially about the headwaters of the Keswick and Nackawicac Rivers, there are beds of considerable area, as well as in many other parts of the district. Peat.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

GEOLOGY

OF

NORTHERN CAPE BRETON.

BY

HUGH FLETCHER, B. A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1884.

ALFRED R. C. SELWYN, ESQ., L.L.D., F.R.S.,

Director of Geological and Natural History Survey of Canada.

SIR:—The report presented herewith describes the work of the seasons of 1880-81-82, and relates to that part of the island of Cape Breton which lies north of Judique and River Denys Basin in Victoria and Inverness counties and which has not been described in previous reports.

To obtain materials for the construction of a map of this region, detailed surveys were made as in former years, the courses being taken by prismatic compass and the distance being measured on the roads by the odometer, and in the brooks by pacing. Some of these surveys were plotted on a scale of twenty chains, and the remainder on a scale of forty chains to an inch; all were afterwards reduced by the eidograph to a scale of one inch to a mile. Certain points were adopted from the Admiralty charts of the coast, and between these our surveys were laid down. The long rivers in the north are only approximately correct, as they were surveyed by pacing in a very rough country, by several different persons, and without a connecting base line, except on the shores. To expedite the survey of these rivers, main camps or depots for provisions were established at the headwaters of the N.E. Margaree, the North River of St. Ann's and the West river of Baddeck, thence traverses were made down the neighboring brooks to the settlements, and thence back again to the camps.

In preparing the map I was aided in 1880 by L. R. Ord, D.L.S., and in 1882 by E. R. Faribault, C.E. My assistants in the field work were William Fletcher, B.A.,* D. M. Christie and Dr. McPhedran, John McMillan, Professor Fletcher, A. Armstrong, B.A., and E. W. Sawyer, B.A., E. R. Faribault, C.E., J. A. Robert, A. Hare and M. H. McLeod.

To the gentlemen named below our thanks are due for many acts of kindness, hospitality and assistance:—Malcolm McLeod, Kenneth McKay and William R. McKenzie, Big Intervale; Joseph Ingraham,

* Unfortunately drowned on Nov. 5th, 1881, while fording the Northeast Margaree River, at Big Intervale.

Northeast Margaree; John Y. Gunn, school inspector, Donald McKay, Isaac McLeod, George McLeod and Squire McLennan, Strathlorne; Rory McLennan, Upper Middle River; Philip McDonald, Indian Rear, Whycocomagh; Lieut.-Col. Bingham and Alex. McLeod, Englishtown; Donald McLeod, North River St. Ann's; Sheriff Dunlop, Alexander Cameron, Hon. C. J. Campbell, M.P., and Judge Tremaine, Baddeck; Angus McLean and M. Doherty, Lake Ainslie; Thomas E. Fraser and Dr. Cameron, M.P., Mabou; A. B. McDonald, Meat Cove; Rupert G. Zwicker, Timothy Y. Nichols, Angus McDonald and Rev. J. McNeil, of Cape North; Angus McIntosh, Pleasant Bay; Reuben Phillips, Walter Lawrence and Henry Ladd, Cheticamp; Fred. S. Brown, John Dauphiney and Rev. Peter Forgeron, Ingonish; Archibald McDonald, Mabou Coal Mines; Thomas Evans, Chimney Corner; James McFarlane, S.W. Margaree; Joseph LeBlanc, East Margaree; Henry Taylor, Margaree Harbor; Rev. George McAulay, Port Mulgrave; Hon. John Bourinot, Hon. E. T. Moseley, S. E. Burchell and H. C. Burchell, Sydney; Marshall Bourinot, Hawkesbury; Alexander Wright, Moncton; E. G. Millidge, C.E., and Sheriff Hill, Antigonish, and James H. Austen, Halifax.

I have the honour to be,

Sir,

Your obedient servant,

HUGH FLETCHER.

OTTAWA, 1st June, 1883.

REPORT

ON THE GEOLOGY OF

NORTHERN CAPE BRETON.

TOPOGRAPHICAL FEATURES.

The country presents a very varied surface. On the western coast as far north as Cheticamp, on the borders of the Bras d'Or Lake, in the valleys of Lake Ainslie and of the Mabou, Broad Cove, Margaree, Skye, Middle and Baddeck Rivers, it contains the best farming land in Cape Breton, productive, thickly-settled and seldom rising to a great height above the sea, whereas the northern, or Cape North district, is high, sterile and uninhabited, except at certain points on the coast and for some miles up the rivers flowing into Pleasant, St. Lawrence, Aspy, Ingonish and St. Ann's bays. Outside these settlements this northern region is but little known, being intersected by wild, rocky gorges, through which streams with numerous falls flow from the barrens, marshes and small lakes in which they originate. They present, however, the best means of exploring the country, and some of them, like the North Aspy, Black, Ingonish, N.E. Margaree, St. Ann's, Barasois, and Indian Rivers, are easily followed in the dry season, whilst the Cheticamp, for ten or twelve miles of its course, and in several of its tributaries, flows in gloomy, dangerous and all but impassable defiles, shut in by high mural cliffs.

Character of the conntry.

Rivers fit for exploring the northern wilderness.

The same difference exists between the northern mountainous and the southern cultivated districts, in the prevalence of certain rock formations, as elsewhere characterizes such differences in surface aspect, the latter being underlaid by Carboniferous strata, with the exception of a few isolated Pre-Cambrian hills, also for the most part cultivated

Dependence of the aspect of the country on its rocks.

because they are in the Carboniferous area; and except in the valleys mentioned above, the whole northern peninsula is occupied by Pre-Cambrian rocks.

A fringe of Carboniferous rocks occupies all the outer coast, except near Cape Mabou, between Cheticamp River and Pleasant Bay, between Poulet and Lowland Coves, at Cape North, between White Point and Ingonish, at Smoky Cape and parts of St. Ann's Harbor and the Great Bras d'Or, where the older rocks come bluffly to the ocean.

Campbell's description of Cape North.

Owing to the different distribution of the rocks the hills are not arranged with the same regularity and parallelism as in the eastern and southern portions of the island. The Cape North district has been described by Mr. John Campbell in his report on the Nova Scotian gold fields, 1865, as an elevated plateau having a mean altitude of 1200 feet above the level of the sea, and attaining at some points an elevation of 1500 feet, comparatively level, although cut by deep valleys and narrow defiles along all its water courses, and supported toward the shores by a bold rampart of rounded or conical mountains. This description is true; but it must at the same time be borne in mind that very little of the land is quite level, the hilltops and barrens being of small extent, while the brooks and defiles are very numerous. Special reference will be made in the course of this report to the characteristic scenery, and other features of interest connected with different parts of the country.

GEOLOGY.

Classification of rocks.

The geological systems met with correspond with and are, indeed, the extension of those described in the Report for 1879-80, namely:

A.B. Pre-Cambrian. { Syenitic, Gneissoid and other Felspathic Rocks. Crystalline Limestone.

G. Carboniferous. { 1. Lower—Conglomerate, Limestone. 2. Middle—Millstone Grit, Coal Measures.

M. Post Tertiary.

A. B.

PRE-CAMBRIAN.

Syenitic, Gneissoid and other Felspathic Rocks.

Pre-Cambrian areas.

In the southern part of the district, small areas of Pre-Cambrian rocks occur at Whycocomagh, Mullach, Bucklaw, Lake Ainslie, Cape Mabou and Middle River. A large area, beginning at the east branch of Trout Brook, extends west in tongues to Lake Ainslie and north to Lake

Law;* and to the eastward of Lake Law begins the main area, which extends to the northward, and joining others from Margaree and Cheticamp, at length occupies the island from shore to shore. As will be seen in the sequel, there is even greater variety in the character of these rocks than in other parts of Cape Breton. Great variety of rocks.

Whycocomagh and Mullach Felsites.—Coarse red syenite, often micaceous, occurs in various parts of Skye Mountain Northeast from this mountain and separated from it by Skye River, is a patch of diorite and felsite, surrounded by Carboniferous rocks; and about a mile further the Mullach area, is in part occupied by crystalline limestone, quartzite and other banded rocks and partly by syenite and felsite, well exposed in the brooks flowing into Glen Ainslie and the head of the lake. Compact and granular quartz-felsite are found in McKay's mill brook, with syenite and epidotic felsite. Skye Mountain McKay's Brook

The Salt Mountain, east of Whycocomagh, seems to consist entirely of conglomerate, but that it has probably a nucleus of older rocks is shown in the brooks to the eastward. On the shore, about two miles further east, felsite and diorite appear in two outcrops; and at the shingle mill beyond, underlying sandstone and conglomerate, there are grey and light-colored felsites and quartz-felsite in thick beds, with fine, strongly coherent laminæ, containing talc, with calcspar and serpentine in the numerous joints, which dip S. 55°, E.<50°. These form a fall 18 feet high. They resemble certain Coxheath rocks, but are more micaceous and schistose. The quartz is often distinct, in irregular blotches and veins. Salt Mountain. Pre-Cambrian bosses among Carboniferous rocks.

Bucklaw Felsites.—Among the sandstone and grit of the cross-roads on the north side of Little Narrows, banded, contorted and slightly micaceous quartzite and quartz-felsite form numerous rocky falls.

Near the shore, several knobs of Pre-Cambrian rock come through the conglomerate; and in McPhedran Brook and other streams of the neighborhood, grey, sparkling, compact quartzites and banded quartz-felsites, sometimes assuming a columnar form, are cut by veins up to four inches thick, of quartz holding iron pyrites. The quartz-felsite passes into granite or compact syenite and syenitic gneiss with small specks of hornblende. In another brook, grey, fine granite with silvery or black mica and greenish-grey fine diorite underlie conglomerate and reddish-grey grit. The Bucklaw area does not extend to Hume River, but its northern boundary is undefined. On top of the mountain, pits have been sunk in the quartzites in search of gold. Search for gold near Hume River.

* A corruption, as I am informed by Mr. Samuel Macdonnell, Q.C., of Port Hood, of *Luggelaw*, the name of a small village in Wicklow County, near the gloomy and romantic Glendalough, the scene of one of Moore's Irish Melodies.

Felsites of the South Side of Lake Ainslie.—Separated from the Mullach area on the northwest by the beautiful Ainslie Glen is another wooded hill of red and reddish-grey syenite, brecciated quartz-felsite and felsite, bounded on the east by Lake Ainslie, of which it forms the shore for about two miles, and on the southwest and north by two large brooks.

Mabou Felsites.—On the highlands, which stretch from Mabou Harbor to Broad Cove and attain an altitude of 1000 feet, felsite, quartz-felsite, syenite, diorite, aluminous shales, porphyry, breccia and other rocks, which might be described in exactly the same words as those of the Coxheath hills,* underlie Carboniferous conglomerate, grit and sandstone. These have been carefully traced and examined in the beautiful valleys of this region. At the most southerly point, on the hill behind McMaster's forge, the rock is a bright red porphyry, like that of the Coxheath "big barren." In a beautiful glade and pass, between the headwaters of branches of Rankin and McAulay Brooks, shales like those of Louisburg are mixed with syenite, while a few blocks of limestone, probably Carboniferous, also mark the former extension of rocks which run far up many of these glens. Below this pass, in Rankin Brook, similar outcrops occur; but in another tributary, finely foliated hornblende-gneiss passes into compact, banded, splintery felsite, like that of Capelin Cove, associated with diorite.

Similarity to the felsites of Coxheath.

Rankin and McAulay Brooks.

Obscurely gneissic rocks in other brooks dip as shown on the map. In a branch of Broad Cove River they are corrugated and micaceous, blotched and streaked with milky and light-brown quartz.

Broad Cove River.

At Mabou Coal Mines, grey, pearly, graphitic mica-schist, felsite and quartz-felsite, veined with quartz, contain also hornblende, chlorite, calcite and hematite; and pits have been dug in a dark, friable, graphitic felsite, which on weathering resembles slack coal. The mill brook displays fine bluish-grey porphyritic, hematitic and jointed, Coxheath felsite, passing into fine-grained, flesh-colored syenite, with a small percentage of hornblende. The scenery of the Mabou highlands is justly admired, the glens on both sides of the range being very beautiful, and the hills coming steeply to the sea in imposing headlands.

Search for coal in graphitic felsite.

Mabou Highlands.

Lower Middle River Felsites.—Another felsite area lies west of Middle River, between the east branch of McNaughton Brook and the Gairloch Mountain road. At the iron mine in Lauchlin McQuarrie's clearing, and in the brook below, quartzite and soft, greenish chloritic schist are in contact with conglomerate and grit. In Black Brook, below its confluence with this stream, occur compact, granular and

Gairloch Mountain iron mine.

* Report for 1875-6.

brecciated, red and grey quartz-veined felsite, pearly, felspathic schists, and fine, fragmentary Louisburg shales, with great pieces of compact flinty felsite or porphyry, which weather white and show their granular or fragmentary structure on the surface, like the breccias of Coxheath and Louisburg. These fragments yield traces of copper pyrites and green carbonate, as well as of epidote and iron ore. Above the confluence of McKenzie Brook, the Carboniferous conglomerate and sandstone are succeeded by banded felsites and Louisburg shales, pearly and contorted, often micaceous and serpentinous. The wild and beautiful falls at the contact are easily accessible from McKenzie's mill.

Traces of copper and iron ores in the fragmentary felsites.

Falls.

The most northerly outcrop in this area comprises the soapy, felspathic shales seen on the Gairloch Mountain road where it begins to ascend the hill. In McNaughton Brook, dark greenish, granular chloritic diorite occurs.

A second Precambrian boss.

A smaller patch of banded felsite, breccia and diorite is seen in the Black Brook valley west of that just described.

East Lake Ainslie Felsites.—Several areas or tongues of Pre-Cambrian rock, the extent of which is shown on the map, occupy the eastern side of Lake Ainslie and nearly connect the Mullach areas with the larger one further north. They consist of compact and granular felsite, quartz-felsite, syenite and diorite.

Big Brook, Middle River and Lake Law Area.—A belt of Pre-Cambrian rocks, of variable width, extends from the head of the east branch of Trout Brook nearly to Northeast Margaree, the southern portion of which displays syenite, purple vesicular porphyry and other felsites on the Gairloch Mountain road. Where the Black Brook cuts this belt, compact porphyritic felsite and vesicular and amygdaloidal trap, veined and blotched with epidote, quartz and calcite, stained with hematite, and evidently of igneous origin, are in contact with bright red and purple, fine, Carboniferous sandstone, grit and conglomerate, dipping S. 5°, W. $<$ 25°. The amygdules, sometimes $\frac{7}{8}$-inch long, consist of calcspar, felspar and chlorite, spotted with carbonate of copper. Higher up the brook there are compact and fine-grained hematitic felsite and diorite of reddish or brownish colors, like those of Cape Rhumore. Above the falls which these give rise to, grit again comes in.

Black Brook, Trappean and epidotic rocks.

Stains of iron and copper.

In ascending McKenzie Brook above McKenzie's mill at the Gairloch road, grit and conglomerate composed of syenite debris occurs for some distance, followed by sandstone in contact with beautiful greenish, reddish and grey compact Coxheath shales, reddish and greenish, mottled, fine-grained trappean rocks, like those of Cape Rhu-

McKenzie Brook.

more, and mottled, epidotic felsite and diorite, with hematite in the joints. In the gorges and ravines further up there are coarse varieties of diorite, and these are associated with compact, grey, porphyritic felsites in the branch which flows from Malcolm McDonald's mill.

Hematitic syenite, often gneissic, prevails in McRae Brook, but laminated, pearly, micaceous and talcose felsites also appear. On the barren between the head of this brook and Pine Brook the syenite is coarse and reddish.

Barrens between McRae and Pine Brooks.

In Morrison Brook, syenite and diorite, all more or less chloritic and quartziferous, are associated with the mica schists of the Middle River gold brooks. In the north branch the gold-bearing rocks, as well as cliffs of quaternary gneiss and red compact quartz-felsite, are succeeded higher up by red syenite. In the south branch are dark, massive, finely crystalline diorite or pure hornblende rock; red and grey compact or granular, flinty felsite and quartz felsite, obscurely banded, in which the quartz is often distinct as veins and blotches, or forms minute crystals in cavities of the compact rocks, and bluish-grey syenite in which hornblende is abundant.

Morrison Brook gold-bearing rocks.

Lake Law.

In the little brooks of the Lake Law valley similar rocks are frequently seen underlying the Carboniferous strata, and also on the western slope of this inlier.

Tompkins' Brook.

In descending Tompkins Brook from the barren out of which it rises, schistose rocks are succeeded by the syenite which forms the steep, red face of the Round Mountain. In Angus Brook and other neighboring streams, syenite, hornblende schist, laminated felsites and diorite occur with other rocks, while in Pine Brook syenite prevails, as well as in the brook to the southward and Coady Brook, in both of which, however, it is succeeded in the lower part by hornblende schist, laminated felsite, quartz felsite and epidotic, calcareous diorite, holding masses of flinty quartz.

Mount Pleasant Brook.

Mount Pleasant Brook, a succession of falls and cascades, cuts another ravine through massive diorite, showing great variety of texture; pyritous slates, like those of Middle River; grey, flinty, Coxheath felsites, syenites and chloritic rocks, enclosing masses of milky quartz several feet in diameter. Numerous outcrops of felsite, syenite and diorite underlie Carboniferous grit and conglomerate in the Matheson Glen and Cooper Brooks. Cobb's Brook displays, near the fork, dark, banded syenite and glittering, crystalline quartzite. In one branch, dark grey amygdaloidal trap occurs in small knolls, and being coated with hematite, which gives a metallic lustre to its surface, attempts have been made to work it as an iron ore. Similar rocks are again seen in contact with Carboniferous strata further up Lake Ainslie. The traps which seem to be confined to the neighbor-

Iron ore.

hood of this contact are, perhaps, all of Carboniferous age, but have not been separated from the Pre-Cambrian.

Glenmore Brook.

In the south branch of Glenmore Brook, immediately north of the Gillanders Mountain road is a small inlier of red, fine syenite, with quartz in small crystalline aggregations, in vugs, associated with dark-bluish-grey hornblendic felsite, stained with hematite. At the bridge on the Gillanders Mountain road, banded felsite containing hornblende, mica and quartz, dips S. 63°, W. $< 45°$, and higher up are felsite, quartzite, quartz-felsite and syenite. To the northward of this brook the felsite has not been traced, but it does not reach the road, and perhaps, as in other cases, is confined to the valley of the brook, which has thus been cut down through the covering of Carboniferous rocks. Higher up, the brook, which is a fine open one, cuts through reddish-grey, coarse, Carboniferous grit.

East side of Lake Ainslie.

On the east side of Lake Ainslie, between the church and the end of the Gillanders Mountain road, the felsite in the hill is red and compact, like that of Coxheath. On the Gairloch Mountain road, near the lake, it is bluish-grey.

Trout Brook.

At the head of the north branch of Trout Brook, where it crosses the Gillanders Mountain road, calcareous amygdaloidal trap of various colors is found; and near the lake, coarse, heavy-bedded, red, chloritic syenite, weathering purple. The valley is here a quarter of a mile wide, wooded with beech, small spruce and black birch, and the bed is bouldery gravel.

Northern Pre-Cambrian Area.—This area, the boundaries of which have already been described in a general way, extends from Hunter's Mountain, near the mouth of Baddeck River to Cape North, and long spurs stretch from it into the Carboniferous country of St. Ann's and Baddeck. It is separated from the St. Ann's felsite area on the coast by a narrow, beautiful glen, and from that of Middle River by the Lake Law valley, where the closeness of the hills (not more than half a mile apart), their height and beauty, and the presence of several deep lakes, give rise to weird and magnificent scenery.

Beauty of glens of St. Ann's and Lake Law.

Gold and copper mines.

This northern area is everywhere high, rugged and uncultivated. Within it are the gold mines of Middle River and the copper mines of Cheticamp and St. Ann's. The rocks comprise every variety of felsite, syenite, granite, schist, gneiss, etc., which may hereafter be shown to belong to more than one series; hence a somewhat minute description may not be out of place. Beginning at the south, these rocks are traversed by the Crowdis Mountain road, and by Rice, Harris, Adelaide and other brooks, which expose greenish granular syenite, diorite and felsite. Similar rocks occur in the lower part of McRae

Rocks of Hunter's and Crowdis Mountains.

Brook, nearer Middle River, whereas at the head, gneiss and mica schist prevail. In the next brook to the northward the felsite in one place shows bedding, but is succeeded higher up by massive diorite.

Baddeck River. For about four miles from its source the north branch of Baddeck River, flowing through hay marshes in small creeks and ponds, displays few outcrops; it then becomes rapid and in the lower part is rough with gorges, beautiful cascades and deep, dark pools. At its head, blocks of mica schist are found in the hills; near the camp, felsite and greenish, fine diorite, succeeded lower down by greenish-grey syenite and fine, obscurely bedded hornblendic, and other slaty rocks. Three miles below the camp, diorite appears in cliffs, with gneiss and banded felsite, capped near the settlement by Carboniferous rocks.

New Glen. Near the springs at the source of Sam's Brook, a clear, cold stream at the head of New Glen settlement, bluish-grey gneiss and mica schist are found; while lower down steep cliffs and cascades of red syenite and dark-greenish diorite are cut by threads of quartz. Grey coarse syenite and diorite underlie Carboniferous rocks in the little brooks on the opposite side of this glen, which is fertile and well-cultivated, and are associated in the main brooks with obscurely laminated rocks, containing masses of quartz. Above a very pretty twenty feet fall, with a fine trout pool below it, the brook runs through narrow, sloping alder-marshes and level, scraggy spruce land. All the Baddeck rivers are celebrated for trout and salmon, the glens are picturesque, and a magnificent view can be obtained from the top of Ben Breac (Spotted Mountain), at the head of Big Glen.

Ben Breac.

In the Northeast Baddeck River, as far as its source above the lakes, syenite predominates, blocks of which also occur among the gravel on the shore of the lakes, which are often visited by fishermen. In Christopher McLeod's Brook, bluish-grey, very quartzose gneiss, stained with hematite, succeeds the Carboniferous rocks, and in the first small tributary contains lenticular veins of quartz. On the path from Big Glen to the North River of St. Ann's, and in the brooks crossing it, syenite and diorite are well exposed, with an occasional outcrop of gneiss. The eastern boundary of the syenite, felsite and quartz-felsite of North Gut and Goose Cove Brook is probably more irregular than shown on the map, none of the brooks having been followed into the Pre-Cambrian area.

Northeast Baddeck River and lakes.

Quartz veins.

North River of St. Ann's. Scarcely less beautiful than the glens of Baddeck are those of the North River and Tarbet. In John McDonald's Brook, the first branch of North River, the highest rapids near the small lakes show coarse syenite. Lower down, are pearly, micaceous and chloritic schists, greenish fine diorite, laminated felsite and quartzite in great falls and cascades. Among these also occur the rocks described in the Report for 1876-7, p. 427. On the right bank, a short distance above John McDonald's house, is a high, naked, rocky peak.

Above the camp, in the middle branch of the North River of St. Ann's, and in the adjoining branch of the Northeast Margaree River, micaceous and hornblendic gneiss and mottled red and yellowish, compact, obscurely banded felsite with scales of mica accompany coarse, grey granite. In the small tributary half a mile above the camp occurs a bluish-grey hornblende gneiss meshed with felspar veins. Mica and hornblende schists, diorite and syenite, with veins of white quartz, sometimes several feet thick, for nearly four miles below the camp occupy North River to a large branch from the westward, where it is still near the level of the surrounding country, but below which it is turbulent- the gneisses giving place to red and grey coarse syenite, both in the river and its tributaries. But with the coarsest syenite are often intimately associated quartziferous schist, gneiss and quartzite. At the head of the branch above mentioned, blocks of bluish-grey, very quartzose gneiss are found; lower down, chloritic schist and quartzite, with a northeasterly strike; while for a mile above the main river, syenite is in place.

St. Ann's camp.

Intimate mixture of the foliated and non-foliated rocks.

In the east branch of North River similar alternations occur, and one of the finest falls in the country, about three miles above the fork, is over bluish-grey and reddish diorite and syenite, which also continue to the labyrinth of ponds, marshes and creeks out of which this branch issues.

North River Falls.

In the west branch , syenite, diorite and mica schist occur. Here, also, about one mile from the settlement, there are a magnificent fall and wild cascades, above which the river, being sluggish, yields few exposures.

Below the confluence of these three branches several bosses of Pre-Cambrian rock lie in the bed of the river among red Carboniferous conglomerate and sandstone, which, near the church, are associated with grey flaggy sandstone holding carbonized plants.

Irregular distribution of the Pre-Cambrian and Carboniferous rocks.

In the Timber Brook and adjoining streams there are interesting outcrops of gneiss, syenite, hornblende-schist, felsite and diorite, into which the brook has cut, through the Carboniferous mantle the remains of which still lie on the slopes.

For more than two miles from its source, the Barasois Brook flows among marshes, showing only blocks of coarse diorite; laminated quartzite, diorite and gneiss occur down to a large branch from the eastward, in which, above some large marshes, whitish and grey, fine and coarse quartzite and granite strike, N. 75° E., the quartzite greatly predominating, while most of the brook below this branch is occupied by diorite and syenite, occasionally foliated, blotched with

Barasois River.

quartz and containing a large quantity of silvery mica. Greenish granular felsite-slate occurs in a narrow belt about five miles above the settlement, and mica schist is found in a tributary from the westward. In the brook above John Morrison's, syenite alone is found, whereas, in that further south, as well as in the main stream down to the lower bridge, felsite predominates, containing, like all the rocks of this district, much iron pyrites and associated in the McKay branch with diorite. The Smith Brook "silver mine" is in syenite, but above the Tarbet road felsite prevails for some distance, succeeded again by syenite at the source.

Smith Brook silver mine.

Tarbet road.

On this road and on that along the shore, diorite and felsite accompany syenite, and near the base of the Englishtown sand bar, porphyritic felsite forms the hill. On the shore opposite Englishtown a similar porphyry contains metalliferous veins of calcspar and quartz, but is succeeded further south by bright red syenite, also veined by diorite and quartz, which extends to the mouth of the North River.

Metalliferous veins near Englishtown.

Silver mine of North River.

The syenite of Elder Brook has an obscure westerly dip or jointing with which the dykes coincide, but higher up alternations of epidotic porphyry, diorite and other Coxheath rocks contain the "silver mine."* Similar felsites also occur in the brook flowing down the opposite slope of the mountain, whereas, in those further north, syenite prevails. It is a noteworthy fact that the brooks of this mountain are in pairs, with sources only a few feet apart, the water flowing both ways from a marsh or slight depression in the hill-top.

Indian Brook.

At the head of the west branch of Indian Brook, below the barren, blocks of mica schist and quartz are occasionally seen, although for a distance of five miles the brook is sluggish, and shows few exposures. About three miles from the source, syenite and milky quartz occur, and half a mile lower, mica and hornblende schists, which, with quartz-felsite, syenite and granite, extend to McMillan Brook. Among these rocks is a light-grey, finely laminated, somewhat granular quartzite, containing many grains of white and black mica, and passing into mica schist. The layers seldom exceed a few inches in thickness, and are often separated by veins of white and colorless vitreous quartz, sometimes of large size and holding a few specks of hornblende. The mica schist in some places contains talc, and large, prominent grains of quartz. In the McMillan branch, finely foliated mixtures of quartz and mica occur, both near its confluence with the main brook and also among the marshes at its source. Similar rocks are found with syenite and granite as far as a marshy brook from the northwest, in which syenite is succeeded up stream by whitish granular quartz-

McMillan Brook.

*Report for 1876-77, p. 452.

ite, with a few small specks of black and silvery mica and crystals of quartz and felspar often a quarter of an inch in length; a nearly compact, greenish diorite, in which the grains of felspar and hornblende are distinct, and a quaternary granite with both hornblende and mica scarce. A short distance above the fork are coarse, granular mixtures of felspar, hornblende, quartz and mica, with epidote and quartz in blotches. Large rocky pools abound along the river. The syenite of the cliffs below the fork is cut by diorite dykes and blotches, and prevails also on the road from the upper settlement to the church. Above the shore road, syenite, gneiss and felsite form the wild cliffs, deep pools and foaming rapids which guard the passage to the inaccessible gorge above, and occur also in Eel Brook, the steep, rocky tributary at the foot of this gorge.

East Branch of Indian Brook.

In the east branch, granite and gneiss fringe the shore of Gisborne Lake, and, above the confluence of the brook from the lake, coarse syenite and quartziferous mica-schist, are associated with epidotic hornblendic rock. Below the confluence the river becomes rapid, the banks higher, and coarse, reddish granite or quartz-felsite is seen at intervals, passing into syenite, diorite and epidotic felsite with quartz veins. About a mile and a half above the fork fine-grained gneiss is met with.

Brooks of the North shore of St. Ann's Bay.

The beautiful and precipitous little brooks which dash down the mountain between Indian Brook and Little River expose only syenite, but in this river syenite is accompanied by coarse granite and banded, granular felsite, veined and blotched with calcspar and epidote. At the first fork there is an outcrop of Carboniferous conglomerate, above which, in the wild branch from the west, syenite, containing mica and cut by diorite dykes, is succeeded by felsite. French River, and all the streams north and south of it falls roughly over similar rock, in gorges and beautiful falls, at the foot of one of which is a cave.

Carboniferous outlier.

The conglomerate of the shore is succeeded at McLeod Brook by grey diorite, bluish felsite and coarse, grey syenite. Unlike others of this region, this brook is an easy one to ascend, the banks being low and its valley wide and timbered with hard-wood and a few pines to the small barrens at its source.

Syenite and felsite with veins of pyritous quartz underlie the Carboniferous rocks in the stream between McLeod and Path-end brooks, the former containing large crystals of felspar and a fissure three-quarters of an inch wide filled with hematite. In this brook is an immense landslide, which has filled the narrow gorge with trees and broken blocks of felsite. Path-end Brook shows soft and crumbly chloritic syenite with bands of granite and dykes of bluish diorite containing veins of calcspar with a minute quantity of iron pyrites and red hematite. For a mile above the road cascades abound; then begins a wild,

Traces of iron.

bouldery gorge with high walls of syenite, ending abruptly against a perpendicular fall.

Smoky Cape.

The massive cliffs of Smoky Cape are of syenite, which prevails also on the road across the mountain and in the neighboring brooks.

Ingonish River.

Coarse, red and greenish syenite and granite occupy the bed of Ingonish River as far as McKinnon Brook, and extend half a mile up the two brooks flowing into the river from the south, beyond which they are replaced by felsite and gneiss. At the confluence of McKinnon Brook, syenite is associated with a thick-bedded grey, and greenish rock containing hornblende, serpentine, chlorite and strings of white quartz. Blocks of crystalline limestone were also seen, but not in place. In this brook, diorite with small quartz veins, reddish coarse Louisburg breccia and red syenite with chloritic and epidotic streaks are succeeded up stream by bluish-grey gneiss, granite and diorite, and these, again, by syenite.

Limestone,

A belt of syenite occupies two miles of the river above McKinnon Brook, followed by two miles and a half of gneiss and crystalline limestone, beyond which syenite continues to the source of the river, but gneiss appears immediately on leaving it, in the brooks on either side.

Contact of Pre-Cambrian and Carboniferous rocks.

The distribution of the syenite and overlying gypsum around the ponds at the mouth of Ingonish River is shown on the map. The former is sometimes foliated, and associated with friable granite and very massive, steel-grey, banded diorite.

Garnetiferous granite.

Power Brook shows diorite, syenite and bright red, garnetiferous granite. The syenite contains large veins of quartz and is associated higher up with felsite, quartz-felsite, mica-schist and gneiss, with large blocks of crystalline limestone.

Limestone Ingonish.

The cliffs on the headland between the north and south bays of Ingonish display syenite, gneiss and felsite, capped in places by conglomerate, sandstone and gypsum. Ingonish Island consists of dark, bluish-grey felsite or diorite, except at the western point, where Carboniferous limestone appears.

Clyburn Brook.

The hill north of the mouth of Clyburn Brook is composed of granite and syenite, but the greater part of the brook is occupied by slaty and gneissic rocks. Not far above the settlement are pearly, aluminous slates, felsite, and hornblende schist. In Curtis Brook, near the barrens, syenite is mixed with obscure gneiss containing blotches of quartz. Reddish-grey quartziferous granite and gneiss then alternate in a series of cascades and falls, the granite being apparently interbedded with the gneiss, which is often almost wholly composed of silvery mica. The brook is alternately very smooth and very rough. The cliffs and gorges below the fork contain greenish and bluish felspathic slates with large blotches of quartz, generally more or less pearly, and not unlike certain Louisburg rocks, except in the absence of the brecciated structure. At the junction with Clyburn Brook they are extremely coherent, obscurely granular, and largely composed of quartz. Between Curtis Brook and the south branch of Clyburn Brook, light bluish-grey and greenish slate, mica and hornblende schist, syenite, felsite and diorite occur among falls and cascades, pools and gorges, the brook being exceptionally rough throughout. In the north branch, above the fork, foliated rocks occupy more than half a mile, beyond which red, coarse, quartz-veined syenite, with specks of white, black and golden mica, shows obscure bedding in the wild gorges as far as its source near the head of Cheticamp River. The quartziferous slate, gneiss and mica schist, with twisted quartz veins in the bedding, which occur everywhere in the south branch and in the adjoining tributary of Ingonish River, form, near the fork, cliffs and pools and, higher up, flat-topped hills occupied by barrens. Some of the schists consist largely of mica, and the gneisses are irregularly mixed with syenite and felsite, which are often in the form of lenticular streaks or veins.

Isolated area in the North Bay.

In the north bay of Ingonish is a patch of red porphyritic granite, in which the felspar largely predominates, occurring in crystals sometimes two inches in length, or in veins two or three inches wide. The quartz is in large, nearly colorless grains, the mica in small, black, scattered crystals, and hornblende also sparingly present. The felspar veins contain small particles and streaks of quartz, and resemble the reddish quartz-felsite of Benacadie* and other places, which is supposed to be of igneous origin. Light-grey, nearly compact porphyritic felsite also occurs in a mass or in small spots in the granite.

Cameron and Dundas Brooks.

Graphite.

Cameron Brook, as far as it was followed, shows a similar epidotic granite, but in Dundas Brook the massive syenite immediately underlying the Carboniferous rocks is succeeded by gneiss, greenish hornblende schist and dark slates blackened with graphite and spotted with calcspar. The slates are associated with irregular masses of grey, gneissic rock, and with greenish and reddish, finely laminated felsite, very like that of Capelin Cove* and Gabarus. Quartz in blotches and lenticular veins abounds in the bedding planes of the felsite, which contains also patches of red syenite. For about a mile above the first lake, reddish and grey syenite and granite occur, but above this point gneissic rocks again prevail.

Warre Brook.

For the first mile above the junction of the Carboniferous and Pre-Cambrian rocks, Warren Brook shows red syenite, greenish and grey

*Report for 1876-77, p. 408.
*Report for 1877-78, p. 9 F.

diorite and obscurely foliated, chloritic and hematitic, mixed rocks. Above the fall is a belt about equally wide of foliated rocks, some of which are for the most part composed of mica and others of milky quartz. Higher still, red syenite and granite form very rough cascades, but on the dry, broken, hummocky barrens east of the Lake of Islands, a gneissic mixture of quartz and mica is seen, while on the lake shore is a coarse, porphyritic granite, full of minute garnets.

Garnetiferous granite.

Red Head.

South of the mouth of Warren Brook an inlier of syenite and felsite forms the rocky promontory of Red Head. A short distance north a rocky shore of granite and syenite succeeds the Carboniferous strata on the beach and extends past Green Cove and Neil's Harbor; and similar rocks occupy the road from Ingonish to Halfway House, and thence to Aspy Bay. Many of these are essentially quartz-felsite, some portions of which contain black mica, while others consist principally of mica and flesh-red felspar. Red syenite predominates in Mary Ann's Brook and in the branch of Warren Brook south of it, occasionally displaying foliation. In Neil's and Halfway Brooks, red coarse syenite and granite with large blotches of mica appear, and on a barren at the head of the latter is the "mica mine."

Ingonish to Aspy Bay.

Mica Mine,

Black Brook.

The more or less foliated syenite and granite of Black Brook, between Sunday Lake and Snipe Brook, are not well exposed, the brook being sluggish, but similar rocks in Snipe Brook contain much silvery mica. Three-quarters of a mile lower, another feeder enters from the south. In the main brook, between the two, are cascades over legdes of fine and coarse granite and syenite, often containing only a small percentage of hornblende and mica, sometimes foliated and intersected by seams of white and flesh-red quartz in all directions, but more especially in the planes of bedding, and containing pockets of flesh-red felspar. Coarse, red, porphyritic syenite with flakes of silvery mica appears in the feeder, below which and in the small brook from the north it is associated with chloritic, hornblendic and hematitic rocks, and contorted dark, and light-grey mica schist, cut by dykes of diorite and syenite. Lower down belts of intervale line the sides, and the brook is easily followed. In the branch called Doherty Brook, syenite in thick beds is variegated with large blotches of milky quartz and flesh-red felspar. At the falls, a dark, contorted gneiss contains silvery and golden mica, and quartz veins holding mica and black metallic specks. In the dark gorge between Doherty and Donovan brooks, and below the latter, coarse, quaternary granite is mixed with grey syenitic gneiss and mica schist, often contorted, with bands, blotches and veins of quartz, some of the laminated rocks containing crystals of andalusite or hornblende in the form of a star. Still wilder gorges occur below Pine Brook, the perpendicular walls of red syenite being cut in places by dykes of diorite and grey vesicular trachyte.

Porphyritic syenite and granite occupy the iron-bound coast between Neil's Harbor and White Point, and extend from South Harbor to the road between Glasgow Brook and South Aspy River, but at French Cove, north of New Haven, and at a few other points, they are accompanied by fine gneiss. In Glasgow Brook and that south of it, and in the South and Middle Aspy Rivers, light-grey, black and reddish, fine and coarse gneiss prevails, containing a variable proportion of mica and hornblende. Coast between Aspy Bay and Neil's Harbor.

Succeeding the red and grey conglomerate, grit, sandstone and marl of the Little Southwest Brook are the banded rocks with blotches of quartzose limestone already described in the neighboring brooks. The hill on the north side of the magnificent glen of the North River consists, for the most part, of massive syenite, granite, diorite, felsite and quartz-felsite, often chloritic and hematitic, like the rocks seen in Blair River, Gray's Brook and the streams to the eastward. North Aspy Glen.

For a considerable distance above the top of the glen, the river bed is wide, sometimes rough, but never very steep, descending over a succession of small rapids and exposing dark bluish-grey and mottled red and green hematitic, serpentinous, pyritous and calcareous, friable, glistening, laminated, contorted felsites and quartz-felsites, which resemble some of the River Denys strata, like which they also include bands of limestone, one of them a foot and a half thick, dividing into strings among the other rocks. In the Big Southwest branch, laminated, chloritic felsite, quartz-felsite, mica-schist and syenitic gneiss form an exceedingly rough brook, rocky and full of gorges from end to end, the water being also dark-brown, unlike thatof the main river, which is clear and from springs. Above the Big Southwest, laminated, contorted felsites and quartz-felsites are met with. Crystalline limestone.

In Wilkie Brook above the road, is a grey, compact, splintery, micaceous felsite, passing into syenite. The Zwicker branch flows over red compact quartz-felsite containing veins of quartz, succeeded higher up by bluish and reddish-grey mica-schist and gneissic rocks with white quartz veins, one of which is five feet thick. Beautiful micaceous rocks follow, with red and grey granite, including an outcrop of pyritous, crystalline limestone, which is, perhaps, a vein and is again followed by red granite and gneiss, the whole series resembling that of Middle River hereafter to be described. Above the Carboniferous rocks in the main branch near the shore, granite and hornblende-rock occur, the granite containing quartz veins surrounded by chloritic and hornblendic rock. The greater part of the wide valley of the brook is, however, occupied by grey, micaceous sandstone, like that of Wilkie Brook. Limestone.

Traces of iron and copper ores.

Bay St. Lawrence, underlaid by syenite and diorite, the former being cut by quartz veins, the latter full of streaks of red hematite and calc-spar; and at the head of the brook, which rises in a small, scraggy spruce barren, mica-schist and gneiss appear, although red syenite and granite form the precipitous slopes of the hill behind the church. In many of the rocks and veins of this neighborhood traces of copper ore have been discovered.

Cape North.

The road between Aspy Bay at Wilkie's and Bay St. Lawrence follows a very pretty valley, traversing a pass from which the sea, the Sugar Loaf and the mountains of Cape North are in sight. Syenite, purple felsite, micaceous and hornblendic felsite and contorted, friable, aluminous slates, like those again seen in the brook at Bay St. Lawrence, cross this road, red granite being on the backlands road halfway between the two shores.

Limestone and serpentine.

North of Wilkie's, red syenite forms the steep and rocky eastern shore to Cape North. The track from Bay St. Lawrence to Money Point shows syenite, diorite, gneiss, quartz-felsite and felsite, and these rocks are also seen in Salmon River, in the Black Point, Wreck Cove, Meat Cove and Lowlands brooks. The felsite is for the most part bluish-grey, but also purplish, sometimes granular, contains quartz, and is associated with crystalline limestone and serpentine in Meat Cove Brook and near Cape North.

Coast from the Lowlands to Pleasant Bay.

The coast from the Lowlands to Poulet Cove was not examined. It is high, precipitous, and probably all occupied by these rocks. In Otter Brook, bluish-grey felsite and syenite underlie Carboniferous sandstone and conglomerate. Among the gorges and cascades of the Red River, obscurely bedded quartz-felsite and quaternary syenite contain a little hematite and veins of quartz. At one point the rock is distinctly laminated, has blotches of crystalline and semi-crystalline limestone, and is in part made up of limestone, quartz and felspar, all white in color.

Limestone.

Pleasant Bay.

In the little brooks on the south side of the glen of Grand Anse River, syenite predominates, but granite also occurs. At the head of the settlement it is foliated and associated with gneiss and banded felsite. On the steep ascent of the road and nearly all the way across the mountain, banded felsites are met with; at the foot of the mountain, in the river above Norman McIntosh's, these are associated with coarse quartz-felsite and syenite, blotched with white quartz and limestone, and broken through by dark diorite. Similar rocks continue to the source, and are again seen in McIntosh Brook, in which, also, streaks, blotches and masses of crystalline limestone several feet in width occur among syenite and gneiss.

Limestone.

Mackenzie River.

At the head of Mackenzie River, grey granite, granular quartz-felsite, syenite and light and dark-grey, pearly, micaceous, contorted syenitic gneiss are cut by quartz veins running parallel with the bedding, some of which are vesicular from the decomposition of iron pyrites. Some of the cascades lower down are over indian-red coarse quartz-felsite, colored with hematite, with here and there specks of mica. Large, intrusive masses of bluish and greenish diorite, sometimes porphyritic, with numerous large and small crystals of felspar, occur among the quartz-felsite and syenite of the lower part of the river, which is very rough and shut in by high hills; and among the coarsest rocks gneiss appears at intervals. At the mouth of the river, imperfect gneiss is veined with calcspar containing bright green and purple patches of fluorspar and specks of galena. South of the last house on Pleasant Bay and at a boat landing on the shore, fine gneisses with a steep northwesterly dip are cut, along and across the bedding, by large veins and masses of bright-red coarse syenite, quartz-felsite and compact felsite. There is often no distinct line of separation between the syenite and gneiss, but rather a passage of one into the other.

Diorite dykes.

Fluorspar and galena.

Syenite veins.

Fishing Cove River crosses bluish felsite, reddish quartz-felsite and other similar rocks, bands of syenite, granite and diorite blotched with quartz, and micaceous and hornblendic gneiss. In the main branch above the fork these rocks are generally foliated, but sometimes very coarse. North of the Cove the granite, gneiss and syenite are garnetiferous. The syenite on the hill near the Cove, perhaps underlies the Louisburg shales seen further south, which occupy the road from the copper mine to the Presqu'îsle Beach and for a considerable distance north. They are bluish-grey and indian red, mottled, fine, pearly, foliated, sometimes fibrous, splashed, or seamed with quartz or calcspar. In places they have a bird's-eye appearance, being covered with small, hard spots, for the most part garnets. On the steep road up Cape Rouge Mountain, mixed gneisses prevail and form a bold hill with deep gulches, on the top of which the aluminous shales again appear associated with a laminated quartz-hornblende rock containing crystals of hornblende a quarter of an inch long. Jumping, Corney, Trout and other brooks of the vicinity expose micaceous talcose and hornblendic schists, diorite and syenite, often traversed by quartz and calcspar veins, and overlaid by the light-brown sandstone and red marl of the Carboniferous belt that skirts the shore.

Fishing Cove River.

Garnetiferous rocks.

Cape Rouge.

Cheticamp copper mine.

Jerome Brook comes to the sea in a deep valley showing a narrow belt of conglomerate and sandstone, succeeded almost immediately by Louisburg felsites, which, a short distance up stream, give place to the syenite which occupies the head of the brook. Immediately north

Cheticamp River.

of Jerome Brook are quartz-veined syenite, dark, laminated rock, compact red felsite, and a diorite in which copper pyrites has been mined.

On a review of all the facts relating to these rocks it is difficult to come to any satisfactory conclusion concerning the relation of the stratified or foliated to the massive portions, nor does it seem possible to separate the two.

Cheticamp River, the upper part of which is strikingly beautiful, for three miles above its mouth flows in a valley occupied by Carboniferous rocks. The Robert branch, for more than a mile from its confluence with the river, cuts through compact, massive felsite and amygdaloidal trap mixed with syenite, above which red syenite and quartz-felsite extend three or four miles further to the gneiss and mica-schist of the head of the brook. The Faribault branch near the lakes and marshes at its source passes over pearly hornblende schists and other laminated rocks, associated lower down with coarse quartz-felsite, syenite, very micaceous gneiss and whitish coarse granite, the whole series resembling the auriferous rocks of Middle River. The schists occasionally contain talc, mica and gash veins of quartz, generally in the bedding but also crossing it. Below the little feeder, two miles and a half up, the brook is very wild and descends rapidly; in the lower part are falls, gorges and caves cut out of the pearly schists. In the next branch—an easy brook to follow, with the exception of some high falls at the upper fork—hornblende schists and slates dip S. 70° W. $< 45°$. For about two miles higher the river is comparatively smooth and mica and hornblende schists prevail, but above this point for nine miles is a deep and dangerous, almost impassable ravine, with high falls and pools, occupied by syenite, granite and diorite, often gneissic, and cut by quartz veins. At Fern Brook, reddish syenite and granite are in the river, while in the tributary they are accompanied by mica-schist and gneiss; and in the gorges, higher up strike vertically northwest, in thick beds, associated, with beautifully banded rocks, blotched with quartz, felspar, chlorite, mica and hornblende in patches. Half a mile from the river Artemise Brook flows sluggishly not far below the level of the adjoining country, exposing quartz-felsite with a small percentage of mica and hornblende and generally banded. For about a mile and a-half above Artemise Brook the river continues to rush wildly through gorges, then for the rest of its course through marshes. Grey and red micaceous syenite and gneiss, cut by quartz veins, some of which hold traces of galena, continue as far as any rocks are seen, but for the first four miles among the barrens and marshes none are exposed. The grey syenite is, as a rule, more distinctly banded and finer in texture than the red.

Roughness of the river and its branches.

Traces of lead ore.

Au Coin Brook, which empties near the mouth of Cheticamp River, passes over bluish and purplish felsite, diorite and syenite, veined with calcspar. Greenish and reddish syenite and diorite come in between the outliers of Carboniferous sandstone and trap and occupy most of Fisset Brook, but near the head of the south branch bluish-grey and greenish quartz-veined slates show a very variable dip. Fisset Brook.

At the beautiful fall in the Farm Brook, reddish felsite and quartz-felsite succeed the sandstone, while higher up dark diorites, full of calcspar and curiously spotted green and red, occur in patches with red syenite, intersected by irregular quartz veins. Another outlier of trap and altered grit similar to those of Fisset Brook occurs near the head of Farm Brook, and in the same neighbourhood pearly felsitic shales or schists contain masses of milky quartz. In the first branch above the settlement coarse light-brown felsite and quartz-felsite occur; and in another branch higher up, quartz-felsite with diorite dykes and quartz veins is succeeded by sandstone and shale and these again by banded felsite. The Farm Brook. Carboniferous outliers. Veins and dykes.

In the Factory Brook another small outlier of Carboniferous rock lies far up among the red and grey coarse syenite and granular quartz-felsite which occupy the remainder of this brook as well as those of Grand Etang, where they contain traces of hematite and calcspar.

Galant River Area.—South of the Pre-Cambrian rocks just described, and separated from them by the narrow Carboniferous belt forming the Forest Glen, is a large Pre-Cambrian area bounded on the east by the Carboniferous rocks of Northeast Margaree and on the west by those of the shore; and cut by branches of the Galant and Northeast Margaree Rivers. In the lower branches of the former, reddish felsite and syenite occur with diorite. In Mink Brook and that north of it, bluish and greenish epidotic and hematitic diorite associated with mica schist, compact felsite and quartz-felsite underlie quartz-veined grits and sandstones. In the main river to northward are outcrops of dark bluish-grey thick-bedded felsite, compact and coherent, sometimes chloritic; a flesh-red mixture of quartz and felspar, the latter predominating; and a mixture of quartz in somewhat large granules with specks of golden and silvery mica. The river, which is easy to ascend throughout its entire length, is here rocky and rises rapidly. Galant River. Contact of Pre-Cambrian and Carboniferous rocks.

The hills near the fork on the Marsh-brook road are not well defined, and many of the rocks are probably Carboniferous traps rather than Pre-Cambrian felsites, the grits and associated rocks of the neighbourhood being also greatly altered. A bluish-grey granular diorite containing specks of iron pyrites is found on the hill west of the road. Carboniferous traps cutting Pre-Cambrian felsites.

At the head of Coady Brook is a quartz-felsite passing into syenite, followed lower down by greenish-grey or blackish amygdaloid with Coady Brook amygdules of calcspar, quartz and a blackish chloritic mineral. Lower still are bluish-grey flinty felsite and dark-grey fine trap with cliffs of purplish, compact, porphyritic, Coxheath felsite and breccia.

Above the road in the next small brook, grey granular syenite with threads of quartz is associated with diorite and a curious quartz:felsite in which the felspar and quartz are nearly separate, the felspar being in large grains and blotches through which the quartz runs in irregular streaks or in veins an inch thick and downward. This rock passes into an ordinary quartz-felsite or syenite; in color it is reddish or whitish according as the felspar or quartz predominates. The upper part of the brook is rough and steep, reddish-grey coarse syenite and dark-green fine diorite being well exposed in great cliffs.

Limestone of McLean Brook.

McLean Brook displays reddish and greenish-grey syenite, but no laminated rocks, although blocks of whitish and grey crystalline limestone occur not far above the road.

Blackrock.

Between McLean and Ward Brooks the hills close in to form the beautiful gorge through which the river here runs, and at Blackrock come so close to the river that the road has to be embanked, dark-greenish, calcareous, epidotic, often slaty diorite accompanying felsite and syenite.

Big Intervale

Ward Brook and the steep hill west of Big Intervale display peaks and crags of dark-grey epidotic rock, chiefly felsite full of white quartz. On the mountains behind the post office, a more coherent quartzose felsite is found and to the westward a large exposure of milky quartz. The top is tolerably level, clothed with hardwood and about 950 feet above the river, while further back the land rises to a still greater height. Behind the schoolhouse,reddish, granular, porphyritic, Coxheath felsite occurs.

Copper ore and limestone of Stewart Brook.

In the rough valley of Stewart Brook greenish-grey quartzite, bluish felsite and micaceous, pyritous diorite are succeeded by hornblendic- and mica-schist in which occur small specks of copper pyrites and veins or beds of crystalline limestone, followed at the head of the brook by diorite, quartzite, quartz-felsite and coarse granite.

Forest Glen.

Peter Stewart Brook, which flows from large hay-marshes into Forest Glen two miles above the river, exposes reddish felsite. On the road through the glen coherent sandstone and grit are generally in place, associated near Pembroke's with dark trap, and in Pembroke Glen with trap and felsite of various kinds.

Felsites of the Margaree Sugarloaf.—East of the Galant River area is that of the Margaree Sugarloaf, also surrounded by Carboniferous rocks. At the northern end this mountain, which is three miles in length and 900 feet above the river, is composed of flesh-red, fine and coarse syenite, diorite and thick-bedded quartz-felsite containing specks of hornblende and mica. In the small brook which comes to the road at the school-house near Widow Peter Ross' are grey and white granite, red syenite, mica and hornblende schists wth milky quartz. At the south end compact and amygdaloidal felsites come near the road whilst higher up syenite and quartz-felsite appear with occasionally dark epidotic diorite.

Peter Ross Brook.

Northern Felsite Area—Resuming the description of the main Pre-Cambrian area we find in the Turner Brook of Forest Glen purple and grey, compact, vesicular and porphyritic, epidotic and hematitic felsite, succeeded by chloritic, calcareons and talcose aluminous shales, and fine mica schists with patches and veins of quartz. The schists are sometimes hollowed out into caves twenty feet deep and six feet wide, the largest of which occurs at the foot of one of the high and beautiful falls which this brook makes below the large marshes.

Forest Glen.

Caves.

McInnes Glen.

McInnes Glen Brook above the settlement exposes red syenite, diorite and felsite, not unlike some of the Coxheath rocks, veined with epidote and stained with hematite and calcite in the joints. They are of various colors, obscurely laminated, often flinty, with pearly surfaces and contain threads and masses of quartz.

Northwest Margaree River.

The bed of the Northeast Margaree River for some distance above John Murray's, and the bare red hills, on the top of one of which is Cape Clear barren, are occupied by red, very coarse quartz-felsite and syenite, some of the crystals of felspar being more than an inch in length, the grains of quartz smaller, those of hornblende very small and scarce, while some interesting varieties contain a large proportion of quartz. Most of these rocks are devoid of lamination, but some parts plainly exhibit a banded, foliated or bedded structure. From a wild defile, overhung by red syenite the First Fork Brook flows into the river, and for nearly four miles up no other rocks appear except an occasional outcrop of diorite or felsite. At the head of all the branches, however, schists and gneisses are met with.

Porphyritic rocks.

First Fork Brook.

In the Second Fork Brook the coarse syenite also contains mica and is sometimes furrowed by the disintegration of softer parts which run in thin bands, giving the perpendicular walls of the gorges the appearance of huge courses of masonry. Dykes of dark-green diorite and veins of quartz occasionally cut the syenite which is succeeded about a mile from the source by talcose and micaceous schists, the mica being white, golden or dark-brown. Near the fork is a block of crystalline limestone.

Second Fork Brook.

Dykes and veins.

Limestone.

The immense mural cliffs in the river above the second fork display a micaceous syenite, coarse and reddish, with large white imbedded spots of quartz, often mixed with patches of compact felsite with por-

Salmon pools.

phyritically imbedded crystals of felspar. The valley is wide; long wild grass grows along the banks, while at intervals occur the salmon pools which have made this beautiful river so celebrated. Higher still are cliffs of mottled Coxheath felsites like those described before, mixed with and passing into quartz-felsite and syenite and also into rocks resembling the auriferous slates of Middle River. These rocks have an obscure northerly strike, but occupy a comparatively narrow belt among the prevailing syenite.

Rocky Brook.

Red syenite occurs for some distance up the Rocky Brook with reddish and purple, fine, soft amygdaloid, having a few grains of quartz scattered through it and often hematitic and chloritic like the rocks of Cape Rhumore. At the first little tributary of the east branch the rocks resemble those of Gabarus and Coxheath. In the little brook, compact, purplish, reddish and dark, mottled traps and flinty felsites dip about N. 70° W. $<$ 25° and lower. Shaly felsite of various colors follows, becoming grey, compact and papery near the top of the brook where a block of milky crystalline limestone or calcite was also found. Above this feeder the Rocky Brook dashes down a declivity into a wild gorge, with perpendicular walls of greenish shaly felsite, above which it flows for two miles in a sluggish course showing only a few outcrops of felsite.

Limestone.

In the west branch of Rocky Brook, laminated Coxheath felsites, containing a small quantity of hornblende, and soft, pearly schists with traces of hematite are covered with a network of quartz veins some of which are a foot or more in thickness.

Quartz veins.

Iron ore, Coinneach Brook.

Syenite still holds in the river above Rocky Brook and contains a few specks of magnetic iron ore. For some distance up Coinneach Brook it is coarse, has very little hornblende, a few specks of silvery white mica, and passes into salmon-colored, compact, porphyritic felsite. The brook is very picturesque, dashing and foaming in little cascades over bright-red syenite. Higher up, where the syenite comes in contact with contorted mica-schist, the latter is seen to underlie the syenite with a northwesterly dip and to pass into a dark-grey compact felsite traversed by veins of milky quartz and fine-grained, flesh-red syenite, which is again replaced upstream by mica schist, a band of which, five feet thick, is, as it were, intruded among the syenite. A quartz vein runs between the schist and syenite on the northeast side, but becomes in places mixed up with or passes into the schist. At the head of the brook all the rocks are gneiss, micaschist and the like.

Contact of syenite and mica schist.

Calumruadh Brook.

For more than two miles up each of the branches of Calumruadh Brook the coarse syenite of the river prevails, followed in the south branch by bluish-grey fine gneiss and mica-schist traversed by minute veins of red syenite and felsite and associated with hornblende schist, compact reddish-grey and mottled felsite and quartz-felsite with an approach to granular structure. A very quartzose granite is found near the head of this branch and in the barren to the northward, together with finely foliated gneiss and mica-schist. In the north branch, red granular quartz-felsite, compact, mottled, epidotic felsite and fine, chloritic, talcose and quartzose mica-schist are in some places so blotched with quartz as to constitute quartzites. Quartzites.

The high cliffs above the Three Brooks are composed of syenite and granite which often pass into nearly pure felsite. In the Marshpool Brook occur flesh-red felsite, dark, laminated, argillaceous rocks, and pearly shales or slates.

Jim Campbell Brook exposes red and grey syenite, granite and gneiss, diorite and laminated pearly felsite, containing large blotches or veins of greenish and whitish epidote. The syenite is seen to pass into hornblende-schist, felsite and granite. On the shore of the lake is a red, flinty, compact felsite. At the mouth of the brook the following rocks in descending sequence dip S. 70° E. < 70°. Jim Campbell's Lake.

	Feet.	Inches.
1. Dark greenish-grey, laminated, fine syenite with the constituents well mixed	4	0
2. Glittering, quartzose mica-schist	0	2
3. Dark grey syenite and granite with blotches of quartz and flesh-red felspar	5	0
4. A rock composed of quartz and felspar in thin seams which run along the strike with hornblende and mica	3	0
5. Greenish-grey compact syenite, with large irregular bands of coarse granite containing hornblende	12	0
6. Coarse granite; the constituents in irregular blocks and blotches; hornblende present	3	0
7. Similar to No. 6, but rougher	12	0
Total thickness	39	2

Gneissic rocks in great variety and similar to the foregoing, including unstratified patches, occur in both the North and East branches above the Two Brooks. In the East branch both coarse and fine syenites are frequently banded, and in a tributary from the north, three miles above the fork, hornblende-schist and foliated syenite accompany felsite, syenite, granite and diorite. Head of N. E. Margaree River.

Returning to the settlement we find reddish syenite prevailing in Peter Ross, Ranald and other small brooks of the vicinity, although in some cases it is obscurely laminated and contains thin veins of quartz and calcspar; whereas banded felsite, mica-schist, diorite and other rocks accompany the syenite of Charlie's Brook.

The first Pre-Cambrian rock seen in the Nile above the settlement is N. E. Egypt.

a syenite mixed with dark-grey and reddish syenitic gneiss and followed by gneiss and hornblende-schist, dark-grey glistening mica-schist and reddish granular quartz-felsite with large blotches of quartz and films of red hematite. Schistose rocks are everywhere present in this brook.

Lake Law.

The very irregular boundary of the Pre-Cambrian rocks south of North East Egypt has not been traced in as great detail as could be desired. Coarse grey granite and mica-schist were seen in Ryan Brook and the vicinity, and granite, diorite, grey banded quartzite gneiss and mica-schist, in the brook at the foot of Lakes Law.

Behind Lake Law post office a brook shows cliffs of greenish and bluish-grey contorted rock, chiefly laminated quartz-felsite and felsite holding plates and blotches of milky quartz in the bedding and succeeded up stream by schistose rocks like those of the Gold Brooks. In Fortune Brook mica- and hornblende-schist, felsite, gneiss and coarse granite are abundant.

Middle River.

In Middle River, above Kenneth McLennan's, the first Pre-Cambrian rocks met with are fine bluish-grey and whitish mica-schist and gneiss with irregular lenticular veins of pyritous, white, vitreous quartz, a foot thick and under, in the bedding. Above the bright red soil of the settlement, in the First Gold Brook—that from which probably most gold was obtained—come greenish, soft, pearly, micaceous shales and slates, often chloritic and containing masses of quartz. They are essentially felspathic, but have a good deal of very fine mica in the bedding planes and do not cohere very strongly but separate easily, often along lines of oblique cleavage or jointing which break them into pieces of smooth irregular shape. They are followed by ordinary Coxheath felsites.

First Gold Brook.

In a brook from the north, half-a-mile above the First Gold Brook, gneiss, mica-schist, granite, syenite and quartzite occur. Between the mouth of this brook and the Second Gold Brook the following rocks are met with :

1. Dark hornblende-rock associated with flinty, nearly compact gneiss.
2. Decomposed diorite or hornblende-rock in cliffs.
3. Bluish-grey pearly mica-schists, blotched with quartz and dipping N. 35° W. < 45.
4. Dark-green hornblende schist overlaid by light-grey pearly mica-schist and by obscurely granular, twisted gneiss, containing a quartz vein at least one foot thick.

Section in the Second Gold Brook.

In the Second Gold Brook the following rocks are found, the dip being uniform, and the aggregate thickness about 5,500 feet :

1. Light-grey and bluish-grey, fine, pearly, micaceous, felsitic shales, sometimes contorted, thickly covered with rusty spots. The mica is finely divided and sometimes predominates.

2. Schistose diorite and greenish or black hornblende-schist with porphyritic crystals of hornblende.
3. Bluish-grey and greenish obscurely granular, quartz-mica rock, with a light tinge of pink, passing into fine gneiss. A large quantity of calcite is present in the joints, and also as one of the constituents. Calc-schist.
4. Bright-green, chloritic and talcose, pearly schist.
5. Compact and obscurely porphyritic felsite,
6. Bluish-grey felspathic schists, containing both mica and hornblende, and breaking into rhomboidal blocks.

All the rocks contain white vitreous quartz full of cavities filled with iron ochre, part of which at least seems to result from the decomposition of a ferruginous carbonate. Calcite also exists in some of the veins, and the quartz is not unlike some of the gold bearing quartz of the Nova Scotia gold districts. Quartz, carbonate of iron and calcspar.

7. Pearly, felspathic shales with long, dark crystals of actinolite.
8. Light bluish-grey, argillaceous slates containing much finely divided mica; quartz veins in the bedding, one of which, 2 feet thick, has an obscurely laminated structure. Actinolite schists.
9. Grey, flinty slates, perhaps a more altered form of 8.*
10. Bright red syenite, without much hornblende, not included in the above estimate of the thickness and occurring at the head of the brook.

In the river, between the Second and Third Gold Brooks, dark green fine, pyritous diorite, hornblende-schist and flinty, nearly compact, bluish-grey quartzite, containing in places much black mica, are associated with light-grey, finely laminated, granular quartz-felsite.

Third Gold Brook Garnetiferous gneiss.

The hornblende-schists of the Third Gold Brook contain long, porphyritic crystals of hornblende which give the rock a finely spotted appearance, and some of the gneisses are full of garnets, but at the head of this brook also, syenite succeeds the foliated rocks.

Fourth Gold Brook.

At the head of the Fourth Gold Brook syenite is again present, followed downstream by fine mica-schist, schistose diorite and gneiss with quartz veins, and a nearly pure hornblende rock containing masses of milky quartz. Soft, light and bluish-grey argillaceous, micaceous rock is found still nearer the river. Gold is said to have been found in all these brooks. At the mouth of the Fourth Gold Brook is a coarse whitish, crystalline granite, with mica in plates three inches long and an inch thick, and the quartz and felspar in still larger masses. With this is associated a dark, beautifully foliated hornblende, schist or pure hornblende rock, in which the hornblende is sometimes coarsely granular and in radiating bunches, and finely laminated, light-grey gneissic rock with a northerly dip. It will be noticed that the hornblende-schists are sometimes composed almost wholly of hornblende

Porphyritic granite of Middle River.

* These are the strata referred to in the Report for 1876-77, page 453. In this report the Garry was erroneously described as, "on the hills at the source of McLean Brook," instead of *at the foot of the hills between McLean and McLeod Brooks*.

as the mica-schist of mica, and in the granite the quartz may prevail to the exclusion of the other constituents, in which case masses of quartzite stand alone. The changes are well seen in the small brook half-a-mile above the Fourth Gold Brook.

Garnets.

In the river above as far as Duncan Brook talc, hornblende and mica-schists and quartzite form rapids. On the weathered surface there are scattered minute, red crystals of garnet, showing faces of both the rhombic and pentagonal dodecahedron. Some of the hornblende-schists pass into coarse, reddish syenite and contain emerald green spots of quartz and dark brown specks of crystalline zinc blende. Coarse, rough jointed, broken granite and a dark trappean and dioritic rock, specked with quartz, felspar and iron pyrites, somewhat vesicular and traversed by a one foot vein of quartz break through laminated talcose mica-schist and coarse granite.

Zinc blende.

Rocks of Duncan Brook.

The following rocks are met with in ascending Duncan Brook:

1. Quartz-veined, contorted, talcose and glistening mica-schists, passing into granite or an intimate mixture of quartz and mica.
2. Grey syenite and granite.
3. Laminated micaceous quartzite.
4. Coarse granite.
5. Grey quartz-felsite with specks of semi-crystalline quartz.
6. An intimate mixture of quartz and felspar, with occasional blotches of brown and white mica Falls.
7. Banded, fine, grey micaceous syenite, with seams of quartz and hornblende traversing it in an irregular manner.
8. Quartzose mica-schist breaking into long thin slabs fit for hones, fine in texture.
9. Fine, grey, micaceous, hornblendic quartzite, passing into a coarse mixture of quartz and mica with a small percentage of felspar.
10. Banded and laminated quartz, mica and hornblende-rocks with some bands entirely composed of one of these minerals.
11. Syenitic gneiss.
12. Bluish-grey, crumbly, quartz-felsite, with epidote, mica and seams of quartz which, however, show no metals.
13. Red felspathic rock in thick beds, blotched with quartz.
14. Mica and hornblende schists, passing into granite and fine syenite.
15. Coarse semi-crystalline quartzite, broken, dark-brown, containing small specks and blotches of mica and a little felspar; in contact with quartzose mica schist containing a large quantity of golden mica.
15. Coarse mica-schist and quartzite.

Hones.

Very micaceous rocks.

In the river above Duncan Brook, coarse, reddish granite with large blotches of flesh-colored felspar, white quartz and mica shows obscure lines of bedding and is followed by syenite, mica-schist and a rock consisting almost entirely of glittering plates of mica arranged in layers. This passes into fine quartzite and hornblende-schist. These rocks con-

Garnets.

tain garnets as large as peas. The prevailing rock in the river and small brooks from the west is a granite of variable composition.

In Bothan Brook this coarse garnetiferous granite is first seen near the river, and prevails for nearly half-a-mile, forming rough falls, gorges and bald cliffs. It is then associated with schistose rocks usually of a grey color, some of which owing, it is supposed, to their structure, appear as if ripple-marked. When the garnets occur on a quartzose surface, they weather out, leaving small depressions. About a mile-and-a-quarter from the river the granite is succeeded by dark-grey and rusty, jointed, thick-bedded felsite containing a small quantity of mica, and the brook becomes less ragged. Near its source is a very coherent felsite with hornblende in large crystals, and presenting on the weathered surface the appearance of a large chain coral, ribbed and furrowed in all directions.

Bothan Brook.

Weathered rocks similating fossils.

The rocks of Savach Brook and the vicinity will be described in connection with the George River limestone, to which they for the most part belong. Above the limestone, for a distance of more than two miles, coarse, red granite, quartzite, mica and hornblende-schists, all garnetiferous, veined with quartz and resembling the rocks in the vicinity of the crystalline limestones of Whycocomagh, alternate in the river. Higher still, granite and syenite prevail and the river is sluggish.

Savach Brook.

Beneath the red Carboniferous conglomerate and grit in McLean Brook, south of the First Gold Brook, lies a bright indian-red, coarse, friable granite, containing both mica and talc; the color being due in both cases to red hematite, spots of which are abundant. Higher up, rusty or cream colored, compact, splintery felsite and quartz-felsite are associated with beautiful, bright-colored felspathic and micaceous slates and other rocks of the gold brooks, including quartz veins. Above the fork, in the south branch, greenish-grey, flinty, fine, obscurely bedded diorite is succeeded by compact, splintery felsite and quartz-felsite in bands of different colors, and by greenish soft shales containing calcite and hematite. These striped rocks resemble those of Capelin Cove, but have no granular structure. A bluish-grey fine diorite passes into porphyry in which the base is diorite and the crystals whitish or light-grey felspar. At the head of the north branch coarse syenite and quartz-felsite are exposed, while lower down are cliffs of pyritous diorite, banded felsite and micaceous shales or schists with lenticular veins of quartz, one of which, two or three feet thick, has been mined for gold.

McLean Brook.

Auriferous (?) quartz veins.

In the Garry Brook, red syenite, quartz-felsite, felsite, and gneiss occur; and in the adjoining brook at Norman McLeod's, slate, gneiss and dark-greenish granular diorite. Some of the rocks of this district have been already referred to in the Report for 1876-77, page 453.

Leonard McLeod's Brook.

McLeod Brook, above the settlement, displays outcrops of grey compact quartz-felsite, fine and coarse, greenish diorite with films of hematite in the joints which are slickensided, syenite and epidotic, chloritic rocks containing quartz and passing into quartzite. In Gillis Brook the abundance of epidote is remarkable, this mineral sometimes constituting half the rock, while the soapy, calcareous, aluminous shales, Louisburg breccia, flinty quartzite, porphyritic felsite and quartz-felsite are very ferruginous, and a coarse syenite shows many grains of hematite. In a little brook a quarter of a mile higher, diorite occurs with light bluish-grey argillo-felspathic shales and slates; and above this tributary, reddish, compact and obscurely granular felsite with a few grains of hornblende is succeeded by cliffs of red quartz-felsite or syenite.

Quartz veins. Fireclay. Quartz sand.

Higher in the main brook and in the Muskrat branch similar shales are associated with others more like the rocks of Capelin Cove, flinty and blotched with quartz, as well as in a small brook from the eastward, one mile and a-half above Muskrat Brook, in which also masses of milky quartz, two feet thick and downward, run irregularly in the bedding of pearly micaceous and felspathic shales and a decomposed felsite like the fire-clay of Coxheath, but seem to carry only iron pyrites, chlorite, mica and occasionally hematite. On top of the hill at the head of the brook, the sand is very full of quartz; and if the gold of Middle River comes from these shales it may be also expected to occur here.

Micaceous, hornblendic and chloritic schists, felsite, quartz-felsite, diorite and syenite extend as far as the fork near the head of McLeod Brook. In the eastern branch above this fork, diorite, felsite and syenite are exposed at intervals. At the source, and likewise in the west branch, quartz is again abundant in the sand.

McDonald Brook.

In McDonald Brook, south of McLeod Brook, laminated rocks are well exposed, consisting of purple, grey, greenish and other colored, compact or granular, porphyritic or vesicular felsites and felspathic shales, spotted with epidote, calcspar and hematite, hematitic quartzites and syenite. On the Crowdis Mountain road, diorite, greenish syenite and felsite contain spots of hematite.

Great Bras d'Or.

Great Bras d'Or Pre-Cambrian Rocks.—It only remains to notice the rocks which form the mountain lying between St. Ann's Harbor and Glen and the shore of the Great Bras d'Or, the northern part of which has already been described.*

*Report for 1874-75, page 252, and for 1875-76, page 377.

Gneissic rocks occur near the end of the road to Kelly Cove, at the head of St. Ann's Harbor. East of Big Harbor the brooks exhibit hematitic diorite, gneiss and mica-schist, among which veins holding copper ore and supposed also to carry gold, have been worked in several places to a small extent. In the brook immediately south of the post office at South Gut, diorite and felsite appear, while that flowing to the Great Bras d'Or opposite and others further east show similar rock with syenite. Copper ore.

PRE-CAMBRIAN.

George River Limestone.

A general description of the George River limestone has appeared in previous reports.

Craignish Hills Area.—The outcrops in the southern part of the hills, of which Skye Mountain is the continuation, have been referred to in the Report for 1879-80, page 17, et seq. To the south a considerable portion of the hills consists of unstratified rock, whereas the Whycocomagh, or north end, although not everywhere showing limestones,—which would seem to run in a northwesterly direction across the country—is all stratified, and will, therefore, be described in this connection.

At the head of Mull River, in some of its branches, red syenite underlies the Carboniferous grit and conglomerate, and is succeeded by banded, argillaceous, slaty felsites and crystalline limestone, which are again seen with quartzites in Kewstoke Brook. Dark-grey compact felsites, seamed with quartz containing hematite, are associated with quartzite and quartz-felsite at the source of Blue's Brook. Dark and light-grey, argillaceous and talcose, compact, coherent, jointed felsites render the brook, lower down, very rough, high, perpendicular banks, jutting ledges and deep pools occurring in gorges, down which the water rushes with great velocity. Mull River. Kewstoke.

Corrugated mica-schist, containing large patches of quartz, shows in McAskill Brook, above the road at the carding mills. Upstream, micaceous, hematitic, schistose felsite and dark-grey thick-bedded hornblende-rock are succeeded by wavy, crystalline limestone. A curious variety of the latter contains quartz and felspar in veins and bands; and mica, sometimes in specks sometimes in layers. In this brook is a small cave. McAskill Brook. Caves.

On the top of Skye Mountain are dark-grey argillaceous felsites and contorted talcose schists. In the limestone of one of the branches of Bregand Brook is another cave, accessible for about twenty feet. In the next branch east, dark thick-bedded felsites, in part globular, brecciated, vesicular and porphyritic, contain a vein of quartz four Skye Mountain. Igneous rocks. Copper ore.

to six inches wide, which can be traced four feet in one direction, and holds crystals of copper pyrites as heteromorphs of iron pyrites. In the branch which follows a road south from the school at Kewstoke road, white crystalline limestone is associated with brownish-grey compact quartzite, and a dark-grey corrugated limestone, with thin layers of scaly mica, passing into mica-schist, occurs with grey banded felsite and coarse, red syenite, the latter associated, higher up, with a porphyry sometimes containing hornblende and sometimes vesicular and trachytic. In another branch, one mile below the school, compact, thin-bedded, talcose, micaceous and hematitic felsite, seamed with limestone, occurs in narrow gorges with quartz-blotched gneiss full of crystals of iron pyrites. Felsite and quartz-felsite also appear in contact with Carboniferous marl, etc., behind the houses of the Whycocomagh Indian Reserve.

Iron Mine.

At the head of the Iron Mine Brook are large exposures of compact quartz-felsite, felspar mica rock, argillite and pyritous, crystalline limestone containing traces of hematite.

Mullach Crystalline Limestone.—This area is separated from the mountain, on which are the rocks just described, by the valley of Skye River. On the hill near the source of Mullach Brook, bright-red conglomerate is succeeded by massive, grey, flinty quartzite mixed with felsite and softer rocks, traversed by veins of barren, white quartz and passing into gneiss. A dark-grey granular diorite is found in one branch of this brook.

Iron ore with traces of copper.

In another brook of this neighborhood, quartzite, diorite, syenite, compact quartz-felsite, calcareous breccia and crystalline limestone succeed dark Carboniferous shales. A specimen of iron ore, from this locality, analyzed by Mr. Hoffmann,* was found to contain about 50 per cent. of magnetite: and traces of copper pyrites and green carbonate. In the brook immediately east of the village of Whycocomagh is a compact felspar-porphyry, above which appear quartzite, red syenite and coarse granite.

Savach Brook.

Crystalline Limestone of Middle River.—In Savach Brook, after an interval of about a quarter of a-mile of coarse granite, is a dark, greenish-grey mixture of limestone, hornblende and calcspar, with crystals of calcspar and mica, succeeded by a coarse, grey and flesh-red granite, with a six-inch vein of white, crystalline limestone and about ten feet of banded and contorted, impure limestone with a corrugated surface, on which appear thin layers of quartzite. This is associated with gar-

Garnetiferous schists.

*Report for 1879-80, page 174.

netiferous talc, mica- and hornblende-schists. Some of the granite has patches of quartz and felspar one foot square; frequently, however, the constituents are finely mixed. Granite and gneiss then follow for some distance, and scattered through the body of the rock are crystalline and semi-crystalline, minute wine-colored garnets and tabular plates of labradorite, showing the characteristic, sky-blue, purple and violet iridescence. About one mile from the river is another band of white crystalline limestone, above which to the fork the granite and gneiss again appear. In the south branch they are soon succeeded by compact and granular felsite and quartz-felsite—dark-grey, greenish, flesh-red, pyritous, porphyritic, hematitic and jointed, often pearly, epidotic and talcose, veined and blotched with quartz and calcspar, and passing into quartzite, etc. In the north branch the granite and gneiss are succeeded, half a-mile above the fork, by Coxheath felsites, which continue to its source.

Garnets and labradorite.

In the river, half a-mile above the confluence of Savach Brook, granite, syenite and schists are overlaid by an interesting patch of indian red, Carboniferous grit and coarse conglomerate. Immediately below Fionnar Brook a four-inch band of crystalline limestone is interbedded with gneiss and granite; while in the bed of this brook occur alternations of granite, syenite, quartzite, felsite, quartz-felsite, mica and hornblende schists. Half a mile above Fionnar Brook are other outcrops of crystalline limestone. At one point the following descending section is presented, the strata having a nearly vertical northerly dip:—

Sections in Middle River.

	Feet.	Inches.
1. Crystalline limestone	10	0
2. Dark steel-grey, calcareous, fine, micaceous and hornblendic quartzite or schist	1	3
3. Laminated, crystalline limestone with specks and small patches of yellow and silvery mica	0	6
4. Laminated, dark-grey quartzite as above	2	6
5. Crystalline limestone	1	0
6. Quartzite or schist as before	5	0
7. Crystalline limestone in bands	15	0
8. Flesh-red and reddish-white coarse granite, containing a large proportion of quartz and felspar, but little mica. Thickness perhaps	10	0
9. Quartzite or schist as before	2	6
10. Limestone	1	6
11. Coarse, red granite, which seems as if overlying unconformably the foregoing strata and extends from bank to bank	0	0
Total thickness	49	3

Higher up another section of these rocks is presented, the intervening strata being garnetiferous schists, limestone and granite.

	Feet.	Inches.
1. Coarse, white granite and syenite passing into quartzite.	20	0
2. White, semi-crystalline quartzite, in thin beds, full of specks of a light-grey, crumbling, brittle mineral, which yields a dark streak, seamed across the bedding by small veins of calcspar	5	0
3. White, coarse granite with a large percentage of silvery mica	2	0
4. Crystalline limestone with small veins and layers of white, vitreous quartz	12	0
5. Alternating bands, varying from 6 to 18 inches in thickness, of limestone, dark-grey, hornblendic, micaceous quartzite, white and reddish granite and hornblende-schist	12	0
6. Crystalline limestone	4	0
7. Alternate bands of light and dark-grey quartzite and crystalline limestone	9	0
8. Banded, crystalline limestone	6	0
9. Reddish-white granite and crystalline limestone	5	0
10. Dark-grey, micaceous and hornblendic, banded and laminated, soft, crumbly quartzite, with greenish bands	11	0
11. Impure, crystalline limestone, containing quartz and mica; interstratified with mica- and hornblende-schists	25	0
12. Measures concealed. Blocks of schist, slightly hematitic.	0	0
13. Laminated, bluish-grey and white, crystalline limestone.	0	0
Total thickness	111	0

McKinnon Brook.

Crystalline Limestone of Ingonish.—At the highest of the small lakes on McKinnon Brook is an outcrop of whitish, broadly crystalline limestone. After passing over two miles of syenite in Ingonish River, above this brook, a belt of gneissic rock is reached, about two miles and a-half wide, comprising various mixtures of felsite, limestone, quartzite, syenite and diorite in alternate bands, which weather into corresponding ridges and furrows. Layers, from three to eight feet thick, of light-brown felsitic-limestone, serpentinous felsite, pyritous hornblende-rock, slate-colored quartz-felsite, quartzite, crystalline limestone, hornblendic and mica-schists, mottled, chloritic, quartzose syenite and granite, with hematite in the joints, and various combinations of these rocks are mingled in great confusion at the upper part of this belt. In a small brook which enters on the north side, crystalline limestone, diorite and other granular rocks are confusedly mixed with dark-grey diorite or hornblende-schist, veined with red syenite, and containing masses of calcite, which are apparently not continuous. At the foot of a sixty-feet fall, bluish-grey, whitish and reddish, finely corrugated gneiss is completely surrounded by massive rock without foliation.

Power and Clyburn Brooks.

Blocks of crystalline limestone also indicate the occurrence of this formation in Power and Clyburn Brooks, near the settlement. Other outcrops among the gneisses further north have already been referred to.

G.

Carboniferous—Conglomerate.

Conglomerate.—At or below the base of the lower Carboniferous in several places occur strata which like those of Graham River, * have been greatly altered by the intrusion of igneous rocks. They frequently resemble the supposed Devonian rocks of Madame Island and Guysborough county, * but are more probably, for the most part at least, Carboniferous, although they invariably underlie the limestone and plaster. The more important of these rocks as they occur at Mabon Coal Mines, Strathlorne, Southwest and Northeast Margaree and Cheticamp will be first described.

Mabou Coal Mines.

In the brook which follows the road to Mabou Harbor from the coal mines are bluish-grey, purple and greenish shales, vertically interstratified with quartzite and conglomerate, all more or less slaty, very coherent and apparently altered by the felsite breccia and diorite of the neighborhood. Lower down the brook, red Carboniferous conglomerate overlies, perhaps unconformably, and is soon followed by a light whitish-grey limestone.

On the seashore opposite the school is a prominent boss of quartzose rock or quartzite of great variety of color and texture, having on both sides altered red slates which appear as if lapping unconformably round it, in which case there would be two series of rocks in this little outcrop. It is much more probable, however, that the quartzite is the bottom bed of an anticlinal fold which brings the slates all round it, the neighboring conglomerates and grits being also greatly altered. On the southwest side of the quartzite the red slates dip regularly S. 20° W. away from it, as if crossing the stratification of the adjoining gypsum.

Volcanic rocks.

In a branch of Broad Cove River, purplish, somewhat coherent argillaceous shale and grit are broken through by greenish-grey nearly compact trap. Higher up is a coarse conglomerate, with a great cliff of fine diorite and dark, epidotic calcareous, trap, succeeded by reddish

* Report for 1879-80, p. 104 F.
* Report for 1879-80, p. 32 F.

and greenish flinty sandstone and reddish, slaty, friable, micaceous altered shale. Further east, near Strathlorne, is a long steep ridge of trap which has altered the surrounding reddish-grey sandstone, grit and conglomerate in a very marked manner, while at the bottom of the hill soft rocks occur and limestone is present in an adjoining brook. The roads in the vicinity of Murdoch Campbell's are covered with blocks of compact or fine grained sandstone or quartzite.

Broad Cove chapel.

In the brook which crosses the road near Broad Cove chapel, grey and bluish-grey: fine, calcareous shale or impure limestone is first seen with argillaceous shale and shaly micaceous sandstone, succeeded higher up by greenish and rusty-grey, fine and coarse coherent sandstone. Above the grist mill is a hill of similar sandstone or quartzite, associated still higher with roughly bedded grit, forming rapids and falls.

Lake Ainslie.

Some of the streams on the east side and at the head of Lake Ainslie, including Trout and Glenmore brooks, are occupied in part by similar rocks, grits and silicious sandstones being very abundant. In Matheson Glen and near the tannery on the S. W. Egypt road these are accompanied by blocks of vesicular amygdaloid.

Mt. Pleasant Brook.

The soft marls and gypsum of the lower part of Mount Pleasant Brook are succeeded by reddish, flinty, compact, felspathic and quartzose sandstone, grit and conglomerate, resembling those of Hume River and underlaid up-stream by Pre-Cambrian felsites and quartz-felsites.

Margaree Big Brook.

The grits in the glen of the Big Brook are grey, fine and compact, flinty and quartzose. Similar metamorphic rocks lie in and near Galant River; and the amygdaloids on the Marshbrook road in the small brook at John McLeod's are probably, in part at least, Carboniferous.

Forest Glen.

On the road from Big Intervale to Grand Etang through Forest Glen the Carboniferous rocks of the narrow valley between the felsites comprise chiefly reddish and bluish-grey sandstone and grit, associated with trap. In Pembroke Glen amygdaloidal trap and sandstone, occur and on the roads back from Mederic Au Coin's at Cheticamp, altered micaceous sandstone, grit and conglomerate are met with.

Farm Brook.

In the Farm Brook, above the crossing of the road to Tom Pembroke's, is a fine exposure of grey, greenish and reddish argillaceous shale or marl with layers of calcareous, ripple-marked sandstone, beyond which a grit hardly distinguishable from syenite and granite is underlaid by softer, regularly bedded rocks with other bands of the altered grit and very micaceous quartzite. Higher still, after a long interval of Pre-Cambrian syenite and diorite, outliers of trap and sandstone again appear.

Grand Etang.

In the brook flowing into the east side of Grand Etang, light-grey, micaceous, fine, flinty quartzite, sandstone and grit, dipping at a high angle, overlie the Pre-Cambrian rocks and are associated with traps, while the brooks at the head of the pond show grey, reddish and purplish, micaceous sandstone and shale sometimes containing fossil plant remains.

Similar traps and sandstones in the brook at the Cheticamp copper mine, north of the Farm Brook are stained with copper. The lower part of Fisset Brook flows in meadows. It then cuts greatly altered red and green, nearly vertical sandstone and grit, and becomes very rocky and narrow. A short distance higher up stream there are two magnificent falls. With the altered rocks are associated traps and diorites, full of calcspar, and large outliers occur among the syenitic rocks in both branches. On the north side of the Cheticamp River to the head of the settlement, grit, sandstone and conglomerate underlie the gypsum.

Cheticamp copper mine.

Fisset Brook.

Southwest Mabou River, above and below the bridge at the McLeod Settlement, exhibits quartzite, sandstone and coarse, glistening quartz, felspathic grit, light-grey and micaceous, seamed and spotted with quartz and much broken and jointed, dipping N. 31° E. $<$ 18°, but variable. Further down, reddish grit is succeeded by alternations of red and green mottled, friable: argillaceous shale, dark-grey shale and concretionary sandstone.

Southwest Mabou River.

Hume River displays an interesting series. Not far from the shore reddish-grey, coarse, egg-conglomerate, without evident bedding or in massive beds, is associated with grit resembling that of Southwest Mabou. The large pebbles are generally of syenite, the grains of the grit consist of quartz, felsite and silvery mica. Crumbling, red and green, mottled, argillaceous rocks, with harder concretions, are mixed higher up with reddish-grey sandstone, grit and conglomerate intersected by minute veins of highly crystalline quartz. Rapids and small falls abound in the lower part and the beds strewn with great blocks, while the upper part is creeky and yields a considerable quantity of marsh-hay. Between the river and the shore at Bucklaw school-house, hardwood grows on the slopes which are covered with conglomerate, whereas the hill top is a barren, underlaid by Pre-Cambrian felsite and quartzite, a great part of which does not support a single tree.

Hume River.

Quartz veins.

In McNaughton Brook, bluish-grey, jointed. slaty, micaceous, argillaceous shales, with small calcspar veins, are succeeded by greenish shale, concretionary limestone and calcareous sandstone; and higher up, by red argillaceous shale, underlaid by fine, ripple-marked, flinty sandstone, with concretions of reddish limestone. The rocks resemble those of Upper Southwest Mabou, and flinty sandstones

McNaughton Brook.

extend across to Lake Ainslie. In the eastern branch of this brook grey conglomerate and coherent grit are underlaid by diorite and other Pre-Cambrian strata. On the neighboring hills are blocks of trap probably derived from the dykes to which these strata owe their alteration.

Broad Cove Chapel Brook.

In the Broad Cove Chapel brook, above the mill, low land and soft rocks give place to rough hills and the greenish, grey and white fine sandstone or quartzite, associated with purplish, greenish and bluish-grey, flinty, micaceous shale or slate of the falls. In one of the brooks of this neighborhood an obscure *stigmaria* was found, and many of the more friable shales contain minute fragments of carbonized plants. The sandstones are sometimes broken by joints into large rectangular blocks. A back lands road running down a very romantic valley to Southwest Margaree, exposes compact, white-weathering, quartzose and felspathic sandstone. On the main road up Southwest Margaree, from the junction of this road to the Outlet of Lake Ainslie, grey and rusty grit, shale and sandstone crop out, whereas on the opposite side of the river the strata are bright-red, the river being apparently the boundary between the two series. In a brook not far below the outlet, rusty crumbling sandstone contains carbonized plants, but gives place higher up to reddish conglomerate and grit.

Fossil plants.

Southwest Margaree.

Outlet.

The glen and pass through which the post road runs from Southwest Margaree to Broad Cove Marsh is perhaps a basin of soft rocks between the lower rocks of the hills. On this road in the brook near Ranald McLennan's, fine, reddish-grey flaggy, argillaceous sandstone is found.

In Captain Allan's Brook the first rapids and cascades show grey, flinty jointed sandstone, associated with grey conglomerate and reddish micaceous sandstone. Higher up in the different branches and in other brooks towards Southwest Margaree similar rocks contain calc-spar veins in the joints. At the source of one branch is a small rocky dry lake or barren, precisely like those of Grand River and Loch Lomond, the surface blocks being nearly as quartzose. These and similar strata about Lake Ainslie are typical of a great part of the Carboniferous highlands of this district. In a field north of Loch Ban is an outcrop of fine, grey, shaly sandstone; while in Dunbar and other neighboring brooks, grey conglomerate and associated rocks are present.

Lake Ainslie.

Fine, grey, sandstone and grit occur in several branches of Big Brook and reddish sandstone in Angu's Brook. The road to Coady Settlement is comparatively level for about 700 yards from Southwest Margaree showing only a few blocks, beyond which point there is a steady ascent of a hill which becomes much steeper to the north-east in which direction the foot of it runs. Up this hill a short distance

Coady Settlement and Big Brook.

is flinty sandstone, associated further out with conglomerate and grit. The rocks on the road down the Big Brook slope are more friable. The left bank is steep and the hill extends nearly to the Forks. Red marl dips up stream at the bridge in Hugh Gillis Brook, above which it falls steeply over alternations of red, reddish-grey and grey shale and sandstone, often flinty and dipping to the northward as far as the head of the brook. In some parts of these hills the succession seems to be an ascending one to the shore of Chimney Corner, but this is not probable.

Coolavee.

Timmins Brook displays at the road above Doyles' bridge, fine sandstone containing a little mica. The steep, rough track up this brook to Coolavee passes over rocks like those so often described, and in Patrick Munro's Brook similar rocks also occur. From the mouth of Timmins Brook, down the right bank of the Northeast Margaree River to the forks, these rocks form a hill which extends thence far down to Margaree Harbor.

Baddeck.

Less altered rocks, without Traps.—The ridge between the Baddeck River and the salt water of St. Patrick Channel and Baddeck Bay, and the hills near Peter's and Morgan Brooks are for the most part probably occupied by rocks which underlie the gypsum and limestone; but as there are few outcrops from which to determine the structure, this is uncertain. Conglomerate forms the nucleus of the highland east of Baddeck Bay, while gypsum and limestone fold round its base; and it again appears at the North River of St. Ann's.

Coal of Hunter's Mountain.

The coal of the Hunter's Mountain* is found in a brook, among grey sandstone, grit and conglomerate of this age, associated with bituminous shale and marl not well exposed.

Middle River.

Indian-red and grey conglomerate and sandstone overlie the felsites of the Black and McKenzie branches of Middle River. In Morrison Brook similar rocks, are seen in the cascades of the beautiful valleys above the Margaree road, and bluish-grey argillaceous shale in some of the lower branches. In McLeod Brook far up among the gneisses and other Pre-Cambrian rocks is a small, outlier of conglomerate composed principally of pebbles of pearly, aluminous, felsitic and chloritic shale, cemented together in a paste of the same material or of fragments of red argillaceous shale. A similar outlier in the main River has already been described.

The irregular manner in which the Carboniferous and Pre-Cambrian rocks are spread over the hills between Middle River and Lake Ainslie and Southwest Margaree is remarkable. The boundaries have not

*Report for 1876-77, page 454. Mr. Brown in his "Coalfields of Cape Breton," p. 37, assigns this coal its true geological position.

been traced in detail, but can be depended on wherever they cross brooks and roads. In this district the felsite is unconformably covered by Carboniferious strata, appearing only when the latter are cut through on the slope of the hills or in the brooks. The Gairloch Mountain road displays grey and bright-red sandstone and grit.

Mabou River. From the mouth of Mabou River to the lobster factory, blocks are found, of the red and reddish Carboniferous conglomerate, which rises into cliffs in the bay outside the breakwater and forms Green Point, dipping seaward at a high angle. Certain surfaces are striated, perhaps by modern ice, in various directions, some of the striæ being very short. The longer ones run NW. and N. 25° W., and the rocks are also rounded and polished. Massive cliffs of conglomerate then follow the high rocky shore, but at the head of some of the bays the overlying plaster and shales appear. In one of these bays, cliffs of gypsum and marl are backed by red marl and fine sandstone, cut into caves and arches, and containing a mass of greenish, impure, concretionary limestone traversed by thin streaks of green marl. Lenticular dykes of dark-greenish, rusty-weathering, crumbling diorite, varying from ten feet to a few inches in thickness, alter the conglomerate, but never for more than a few inches from the point of contact. Beyond a line of inaccessible cliffs come the coal measures which will hereafter be referred to.

Green Point.

Dykes.

Northeast Mabou. On the hill between the school at Northeast Mabou River and the Mabou stage stables, fine reddish-grey sandstone detritus is found, and reddish soft shales in the river.

Bluish and reddish-grey, rusty and bright-red micaceous sandstone and shale occur near Brook Village. Light-grey and whitish quartzose, flaggy and false-bedded sandstone are found about Mount Young with red sandstone and shale. In one of the brooks similar alternations contain layers of impure limestone. About Hay River glistening quartzose grit sandstone and conglomerate are occasionally met with, dipping, as shown on the map. On the shore of Lake Ainslie, on the headland which forms an extension of the Mount Young highland, between Hay and Black Rivers, are good exposures of bluish-grey rusty-weathering very fine sandstone, and shale like that seen near the bore-holes. The dip is obscure and no carbonized plants were seen here. On the ridge towards Black River rusty-grey conglomerate is well exposed. Gypsum and limestone are very abundant near the shore of Loch Ban, but the greenish-grey argillaceous shale found in the neighborhood resembles that cut in the borings.

Mount Young.

Hay River.

Lake Ainslie.

Mullach Brook. In Mullach Brook, reddish and purplish, fine sandstone extends above the road to the contact of the Pre-Cambrian strata, a high rugged hill being to the southward. The conglomerates about Skye Mountain are for the most part red and friable, holding, among others, pebbles of crystaline limestone and quartzite. In Glen Ainslie a few outcrops occur of light-grey, greenish and brown, slightly rusty, fine-grained, calcareous sandstone. In the beautiful brooks in the neighborhood of Whycocomagh these rocks are well exposed. In that near the tannery, limestone occurs near the shore, with red conglomerate, sandstone, argillaceous and arenaceous shale. Higher up compact, felspathic shale and cherty, greenish-grey and reddish calcareous sandstone and grit form precipitous cliffs. Dark calcareous shales with bands of sandstone are also found in this brook as well as those which cross the road in the village of Whycocomagh. The top of Salt Mountain is conglomerate which also comes to the shore at several points round its base, and on the backlands road between Salt and Lewis mountains, is associated with grey argillaceous shale and light-greenish-grey, white-weathering, nearly compact, felspathic sandstone.

Skye Mountain.

Bituminous shales.

Salt Mountain.

In the large brook east of Salt Mountain are beds of dark-grey, micaceous, jointed argillaceous shale, with obscure impressions of *Naiadites*, dipping N. 84° W. < 15°–65°, with cliffs of conglomerate and flaggy argillaceous rock. Higher up, the rocks become more compact and felspathic, and are intersected by small veins of quartz, in some of which hematite is found. In the upper branches conglomerate prevails, usually containing pebbles of syenite, felsite, quartzite and mica-schist.

Fossils.

Iron ore.

Four miles from Whycocomagh, dark-brown conglomerate is on the shore in contact with contorted, talcose felsite, containing serpentinous matter and mica, these are soon, however, again succeeded by coarse and fine hematitic grit and conglomerate. About three miles above Little Narrows is an exposure of pink, coarse grit and fine red conglomerate, broken, jointed and hematitic. On the shore near Little Narrows, grit and conglomerate are on end striking N. 80° W. On the point are thin beds of light-brown or red sandstone, grit and marl. The sandstone is ripple marked and micaceous, shows a thickness of about ninety feet, and dips N. 44° W. < 35°.

The valleys in the vicinity of Brook Village, Skye and other glens seem to be in synclines of higher rock than appears in the adjoining hills. In McQuarrie Brook grey and greenish-grey, soft, argillaceous, micaceous sandstone, often covered with carbonized plants and fucoids, occurs with shales. Fine grey sandstone is found to the north-eastward on the roads about Malcolm Walker's; and on the shore of Lake Ainslie, at the end of one of these roads, greenish and dark-grey ripple-marked sandstone and shale dip S. 55° E. < 10°. The borings made here in search of oil, indicated by engines, derricks and other apparatus, are probably in this formation. At one of them, on the

Brook Village.

Fossils.

Borings for petroleum.

shore, from which oozes a brackish water, tasting strongly of petroleum, fine greenish-grey sandstone dips N. 73° E. at a moderate, variable angle. Out of others greenish shale debris has been brought, but there is no sign of petroleum near any except the first mentioned.

Lake Ainslie.

At the chapel pieces of sandstone not unlike the millstone grit of the Sydney coal field lie about, while south of the chapel and elsewhere in the neighborhood, grey, reddish and greenish-grey, fine sandstone and shale are occasionally seen. The dip is shown on the map wherever it has been ascertained, but meadows and marshes follow the course of many of the brooks. In that near the postoffice, a short distance above the road, reddish-grey fine sandstone dips N. 65° E.<15°, and is striated in a northwesterly direction. Up stream, banks of grey and bluish-grey argillaceous shale have the same dip; while the wavy micaceous ripple-marked sandstone and shale which alternate higher still have a variable dip. On the lake shore, at the mouth of this brook, grey, greenish, rusty, red and purple argillaceous shales dip N. 15° W.<75°. This anomalous dip may possibly be due to a slide of the high bank, but this is unlikely. In the bedding are two streaks of red hematite, a quarter of an inch thick, which seem to be persistent. The shales are soft enough for slate pencils; sometimes they are coaly and include thin bands of yellowish-grey limestone, while the structure of certain layers is like underclay.

Limestone.

On an adjoining point are cliffs of light-grey, slightly bituminous, shaly, wrinkled limestone, about ten feet thick, probably overlying the shales. Some layers are bluish-grey and purer than others. It is traversed by veins of calcspar and underlaid by conglomerate, grit and sandstone; composed of quartz, felsite and syenite; beneath which lie grey, fine micaceous sandstones, ripple-marked and covered with fucoids.

Fossils.

In the large brook further south which enters the lake north of the syenite hill, layers of greenish, reddish and purple sandstone and shale hold irregular, nodular masses of bluish-grey, flinty, concretionary limestone.

In the millbrook, at the head of Lake Ainslie, conglomerate, grit and calcareous shale contain small veins of quartz and films of red hematite. In McKay Brook the conglomerate is composed of pebbles of syenite and felsite from the size of a hen's egg downward, and occurs in thick beds with jointed grit.

Trout Brook exposes buff-colored fine conglomerate and grit in its rocky valley. The country between the head of the brook and Hume River is barren and full of marshes. Fine argillaceous, sandstone and grit occur on some of the branches; and in the Millbrook are bluish, greenish, grey and red argillaceous, sandstone, shale and conglomerate, jointed, broken, and often calcareous.

Reference has already been made to the rocks of Southwest Margaree River. In the brooks north of Mount Pleasant the rocks of which the dip is indicated on the map are reddish and greenish shale and fine grey quartzose sandstone. In the lower part of some of these brooks occurs an impure, grey concretionary limestone, with black, graphitic surfaces. Below the chapel, red and bluish-grey shales are succeeded in Cameron Brook by micaceous shaly sandstone, underlaid by sandstone, grit and conglomerate. In the vicinity of Collins' Brook sandstone and fine grit are seen. On the left bank of the river, just above the fork, soft, ripple-marked sandstone, shale and marl occur. Southwest Margaree.

Below Margaree Forks good outcrops of mottled shales, grey and rusty fine sandstone and concretionary, calcareous rock are found in Hugh Gillis' Brook, which probably belong to this series. In the brook directly opposite and in others on the east side of Margaree River, bluish-grey felspathic sandstone and argillaceous shale, with minute veins of calcspar accompany grit and conglomerate. Margaree Forks.

In Galant River, below the Marshbrook road, limestone is found with greenish and reddish micaceous sandstone, and shale, grit and conglomerate. In the tributary which enters just below this road, grey calcareous sandstone, grit and shale are associated with black calcareo-bituminous shale, covered with fish-remains, shells, etc., succeeded higher up by red marl. Above the Marshbrook road, grey, coarse, heavy-bedded sandstone, fine, micaceous, crumpled grit, indian-red conglomerate and bluish-grey argillite overlie the reddish syenite and felsite which occur higher up. Throughout nearly its entire length this river flows among these rocks, which also occupy the hills between it and the shore road. Galant River.

The patches at the mouth of Trout and Jumping Brooks are thus described by Professor Hind:—"Mottled sandstones and conglomerates rest unconformably on white and mottled sandstones and bituminous shales, supposed to be of Lower Carboniferous age. These latter rest unconformably, the first on red metamorphic rocks, the second are seen in close proximity to red, green and black corrugated schists, supposed to be of lower Silurian age."* The first group here seen represents the limestone series, the second the conglomerate, while the schists have been described as Pre-Cambrian, although Professor Hind has not included them in his "gneissoid series." but concludes that they represent the summit of the gold-bearing rocks of Nova Scotia. Prof. Hind's description of the contact of unconformable series at Jumping and Trout Brooks.

* Sherbrooke Gold District, 1870, p. 71.

Pleasant Bay.

Some of the strata at the head of Grandanse and Red Rivers of Pleasant Bay represent the conglomerate series probably. To the northward, sandstone, grit and conglomerate extend along the shore, the sandstone containing many carbonized plants. Near Poulet Cove reddish-grey, coarse, compact grit, altered, quartzose sandstone and conglomerate are interstratified with black crumbling, micaceous shale and fine sandstone. The boundaries of the formations on this coast are defined on the map, and require no particular remark.

Meat Cove.

At Meat Cove light and dark-grey, rusty and greenish, heavy-bedded, fine-grained sandstone and grit, semi-crystalline and micaceous; dark grey and black micaceous argillaceous shale and grey calcareous sandstone are veined with calcite and serpentine, and the finer beds are very much contorted. Similar rocks occur about the Lowlands. In Meat Cove Brook bluish argillaceous shale and reddish micaceous, fine sandstone, are accompanied by conglomerate and grit.

Salmon River exposes reddish sandstone, grit and conglomerate, with calcareous shale, overlying the felsites. In the lower part limestone and sandstone are found.

North Aspy Glen.

In the upper part of Cape North glen the conglomerate comes from beneath the limestone and gypsum; and in the beautiful valley of Wilkie Brook, strata probably of this age, consisting of grey, micaceous sandstones, like those of Bay St. Lawrence, with bluish-grey and blackish bituminous shale, containing coaly matter, cap the red syenite and other Pre-Cambrian rocks. They are fine, micaceous, flinty and friable, sometimes calcareous and cut by calcspar veins.

Ingonish.

The Carboniferous limestone appears on the shore at Ingonish, while further inland the conglomerate runs far up the glens in narrow belts. In the brook running into the north side of Warren Lake fine grit, conglomerate and sandstone, reddish and grey, crumbling and nearly horizontal, pave the brook for a considerable distance, and are succeeded by reddish-grey granite and syenite.

North River of St. Ann's.

The distribution of the Carboniferous rocks about the Tarbet, Oregon and North River will be understood from the map. At several points in the Elder's Brook blocks of red conglomerate occur, although the country rock is syenite; and as the valley is wide and level, it is probable that they indicate a former extension of the conglomerate up this brook. Above John Morrison's also—the highest settler on the Barasois River—a narrow belt of level land occupies the western bank for about three miles, cut here and there by runs of the river, and affording pasturage for cattle. This has probably been at no very distant date occupied by Carboniferous rocks. Near John Morrison's, bright red soil extends for a considerable distance up the glen, indicating that these still overlie the syenite at this point; though the river runs over a rough bed of Pre-Cambrian rocks.

Limestone.

The general characteristics of the marine limestone, gypsum and associated crumbling marls, sandstones and other rocks of this series have been described in previous reports, and their distribution will be better understood from the map than from any lengthy enumeration of the various outcrops.

Little Judique Brook.

About one mile south of Rear Judique post-office, in Little Judique Brook reddish and grey, fine-grained, crumbling, flaggy sandstone is in place with mottled argillaceous shale and marl, wavy and spotted, sometimes grey and concretionary. But the exposures in this neighborhood are not numerous.

Unconformable series of Port Hood Island.

Smith Island displays interesting outcrops unconformably overlaid by the lowest beds of the coal measures. The strata first obscurely seen north of Smith Point are grey sandstones dipping S. 61° W. $<$ 15° to 25°. Further west, red rocks forming cliffs and reefs are followed by plaster cliffs, and the country from shore to shore is broken by pits. The plaster appears in great masses among soft shales, and at one point a three feet bed of grey, bituminous, fossiliferous limestone is interposed between two layers of gypsum, a fibrous selenite being between the limestone and the upper bed. The gypsum seems to strike against a bed of oolitic limestone, 12 feet thick, running vertically N. 15° E., and succeeded on the west side by alternations of gypsum, marl and limestone. The red marls contain masses and irregular beds of gypsum and limestone, and are traversed by reticulating gypsum veins. Some of the limestones are beautifully marked on the upper surface by fucoids; others are full of shells of the usual character; they are in places lenticularly bedded with the gypsum, which veins, or is intimately mixed with them, while in other cases the two rocks are sharply separated. The veins are fibrous and contain small fragments of limestone. On the eastern side of the island red shales with lenticular beds of bluish-grey argillaceous shale and sandstone again come from beneath the grey and rusty sandstone and shale full of coal pipes, which belong to the coal measures.

Southwest Mabou Springs

The limestones of Southwest Mabou and Glencoe are often black and graphitic, oolitic, brecciated and vesicular; and they give rise, like the plaster, to strong springs. In this district none of the altered rocks of Graham River and Judique occur; on the contrary the sandstones are nearly always soft, crumbling, ripple-marked and micaceous; the shales and conglomerates not less so and more reddish and calcareous than those met with at the Strait of Canso.

Fossils.

Near the upper bridge on Southwest Mabou River, thin-bedded, reddish-grey fine sandstone occurs, hematitic and occasionally false-bedded, full of small concretions like coprolites; succeeded lower down by argillaceous shales spotted with calcspar, and by a bed of impure bituminous, fossiliferous limestone about one foot thick. In the cliffs a downthrow fault of twenty feet is exposed. Concretionary, hematitic limestone, seamed with clay, occurs among the sandstones, containing fossils, among the most abundant of which are the polygonal plates of an encrinite. Lower down, conglomerate, concretionary sandstone and marls of various bright colors, are associated with pink, orange, white, and grey gypsum, passing in places into limestone which in its turn encloses masses of gypsum and has been quarried to some extent. At one point an impure, vesicular, nodular limestone is overlaid by eighteen feet of alternations of grey shale, mottled marl and sandstone, dipping N. 23° W. $<$ 39° in cliffs. Near the middle bridge, blackish shales contain a great number of curious bean-shaped concretions which weather rusty-brown. The associated shales are beautifully rippled and some of the red varieties have the indentations of the ripples filled with green. The strata are much contorted, exhibiting small anticlines and synclines. At the head of tidewater this river displays reddish and greenish shale and sandstone, often rippled, as well as dirty brownish-grey, oolitic, bituminous limestone, veined with calcspar.

Intermixture of limestone and gypsum.

Mabou Harbor Plants.

Half a-mile south of Mabou Harbor, at the end of the sand beach, light sea-green and red, spotted and banded, soft marl and sandstone, with markings of plants, are followed by outcrops of bituminous limestone, vesicular and concretionary or argillaceous and carbonaceous, veined with white and rosy calcspar; succeeded by banded, dark-grey, coaly limestone, by gypsum containing crystals of selenite, and marls containing bands of fibrous gypsum sometimes six inches thick. In one of these bands is a compact lenticular mass three and a-half feet long by eight or ten inches wide, of rusty-brown, coarse, soft, arenaceous rock. Sandstone and conglomerate occur further along the shore, thin and thick-bedded, grey and rusty, with beds of underclay. In places these beds are thrown on end and strike about S. 24° W.: they are much contorted, as always happens when plaster is mixed with softer rocks. Mottled marl, calcareous sandstone, limestone, rusty-grey sandstone, grit, and conglomeritic, argillaceous rock with bands of glistening, hard, coaly matter, and upright and prostrate trees then occupy the shore. But the succeeding rocks will be described in treating of the Port Hood coal measures of which they form a part.

Mabou.

On the south side of Mabou River, immediately above the bridge at Mabou village, light greenish-brown, vesicular, and nodular, conglomeritic limestone, about fifteen feet thick is seamed with red calcite. The vesicles are due to the decomposition of sandy, ochreous material or to contraction of the substance of the rock, and are lined with minute crystals. Limestone, gypsum, and red and green marl are found at various points higher up. In the first large brook, about a mile above the bridge, limestone and gypsum are succeeded by grey, bluish-grey, greenish and reddish argillaceous shale and sandstone, with rusty limestone bands; and similar rocks are found in the beautiful cultivated valleys and hills of the neighborhood. Near Elgin mills, greenish-grey fine sandstone and argillaceous shale are associated with wrinkled, shaly limestone, and higher up red and green shale and marl are met with. Above the gypsum in Glendyer Brook greenish, argillaceous shale and sandstone are seen, and near the head of Mull River, conglomerate, grit and friable, fine, micaceous, rippled sandstone, generally indian-red, but also greenish-grey and seamed with calcite. The different branches of Mabou River present little worthy of notice or that has not been already described in reference to similar rocks in previous reports. The large brooks cut valleys of considerable depth and beauty, the hills on either side rising gently.

Elgin Mills.

Glendyer Brook

Mull River.

In Skye River also typical lower Carboniferous rocks prevail, generally red and crumbling. About two miles and a-half above the bridge on the Skye Glen road, on the north bank of the river, reddish-brown, fine, flaggy, calcareous sandstone and grit are associated with blackish shales indistinctly seen. In the shingle-mill branch the following rocks occur above the Skye Glen road:

Skye Glen.

1. Reddish-grey fine sandstone with a variable dip.
2. Purple and reddish sandstone and conglomerate.
3. Grey, bluish-grey and reddish argillaceous shale, sometimes flinty and calcareous, covered with fucoids.
4. Bluish-grey, concretionary, oolitic limestone, barrel-shaped in the bedding and spotted with iron pyrites, rusty-weathering, the upper surfaces slickensided and covered with whitish calcspar. No fossils observed. About 15 inches thick.
6. Conglomerate.
7. Bluish-grey argillaceous shale and light greenish-grey, flinty sandstone, dipping N. 50° E. $<$ 45°. Here the valleys are cut very deep.

On the east side of Indian Island, Whycocomagh, gypsum, concretionary limestone and conglomerate are exposed.

Whycocomagh.

Grey and red gypsum and marl crop out on the east side of Little Narrows and on the shore towards Portage. From Portage to the head of Whycocomagh Bay no rocks are in place on the low gravelly shore, but blocks of red, brown and grey fine sandstone are in the banks; and further back, gypsum and limestone abound as well as on all the roads

Salt springs. about Nineveh, Washaback and McKinnon Intervale,* the gypsum being as usual accompanied by salt springs.

Middle River. From the bridge, near the mouth, to the upper settlement, Middle River displays frequent outcrops of shelly limestone, gypsum, sandstone, grit, conglomerate, marl and argillaceous shale, ripple-marked and covered with fucoids, which on the east side extend, in plains broken by plaster pits, to the foot of the hills, where they are underlaid by Pre-Cambrian rocks, while on the west side conglomerate intervenes. The Carboniferous rocks leave it at the First Gold Brook to occupy Lake Law, to Northeast Margaree. To a stranger coming from Middle River, Lake Law appears to be the continuation of that river, just as one would suppose McInnes Glen to indicate the course of the Northeast Margaree above Big Intervale, from the greater size of the valley consequent on the presence of Carboniferous rocks. The difference of level between Lake Law and the bed of Middle River is only a few feet.

Lake Law.

Baddeck and St. Ann's Rivers. The singular manner in which the Carboniferous limestone runs up the glens of the St. Ann's and Baddeck Rivers, proving the existence of the same valleys and hills in Carboniferous time, has been frequently pointed out.

Baddeck gypsum quarries. On Baddeck Bay there are large quarries of gypsum, and in Peter's and Buckwheat Brooks outcrops of both limestone and gypsum. Above Andrew Anderson's road, Peter's Brook cuts through reddish and grey marl, sandstone and conglomerate, with a westerly dip, associated in slightly contorted beds with calcareous shale and limestone, full of shells and stems of plants, veins of calcspar and films of hematite. Foyle's Brook exposes shelly limestone and, higher up, calcareous sandstone and conglomerate; and similar rocks, veined with calcspar, are found in Morgan Brook.

Fossils.

Lake Ainslie. The distribution of this formation about Lake Ainslie and Southwest Mabou will be readily understood from the map, upon which the more important outcrops have been marked. On the point east of Dunbar's mill brook is a grey and rusty surf-eaten limestone. At the head of Doherty Cove, mottled shale and sandstone are in the bank, accompanied, on the next point west, by dark bluish-grey and black, papery, argillaceous shale, apparently without fossils; underlaid by grey and whitish shaly and massive limestone, veined with calcspar. For some distance the shore follows nearly on the strike of these rocks which dip at a variable angle inland.

Black shales.

Mount Pleasant The high cliffs immediately above the road in Mount Pleasant Brook display red marl with greenish, concretionary layers of fine mica-

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* Report for 1876-77, page 442.

ceous sandstone bands of dark calcareous shale and grey and bluish-grey streaks of impure limestone. The dip is somewhat changeable, perhaps indicating a fault. With these are associated impure gypsum and gypseous marl, while higher up in the Big Brook, and also in its branches, are the metamorphic, Carboniferours rocks elsewhere referred to. In the small brooks north of Mount Pleasant, red, grey and greenish, micaceous, calcareous sandstone and argillaceous shale are found with limestone.

Patrick Munro's Brook flows through a mound of gypsum seventy feet high into the Northeast Margaree River in which also many other outcrops occur. Associated with limestone and gypsum to form the Hogsback is a bluish-grey shale, full of *Stigmaria*. The distribution of the Carboniferous rocks around the Sugar-loaf and in Forest Glen will be seen on the map. At the head of McInnes Glen, gypsum and grey, impure, shelly limestone run in a narrow belt bounded on both sides by hills of Pre-cambrian rock; and sandstone, shale, marl, limestone, and gypsum exposed in all the roads and streams about Margaree Plains or half-barren pastureland characterize large tracts of country underlaid by these rocks at the Garry, Middle River, Big Brook, Northeast Margaree and elsewhere.

Northeast Margaree.

Plants.

Plains.

On the sea shore north of Broad Cove River, coarse, yellowish-brown sandstone is first seen, giving rise to a sandy soil, in color like that about Strathlorne, succeeded by red, yellow and white marl. Indian-red sandstone and shale then occur at intervals for a considerable distance, associated with a coarse, red, silicious sandstone, with harder concretions, white patches and coaly streaks. Gypsum then appears in cliffs with red marl and limestone as far as the mouth of the Chapel Brook which is occupied by red marl and sandstone, as far as the road. In the cliffs to the northward, red and grey marl, shale and fine, ripple-marked, calcareous, micaceous sandstone, with a few rusty beds showing carbonized plants, dip generally inland and extend to a large brook in which are reddish-grey, crumbling, argillaceous shale and fine, micaceous, wavy sandstone, underlaid up-stream by fine, grey, rusty-weathering sandstone. Similar rocks, often bright-red, occupy the shore from this brook to Marsh Point and include a bed of dark bituminous shale, full of *Cythere*, *Spirorbis* and *Naiadites*, the dip being still inland and the rocks overlie those just described. Beyond Marsh Point these strata continue for about a quarter of a-mile, beyond which comes grey and rusty sandstone full of carbonized plants and probably belonging to the coal measures.

Broad Cove.

Contact of the coal measures.

Plants.

Shells.

In the brook south of Donald McLeod's fishing station, bluish and reddish-grey shale and fine, waved, micaceous sandstone dip north. In the Marsh Brook above Widow Angus Gillis', the fine, grey,

Broad Cove Marsh.

sandstone, shale, grit and conglomerate probably belong to the Carboniferous, conglomerate series, but gypsum is also in the vicinity.

Cheticamp. The outcrops of this formation on the sea coast south of Cheticamp will be noticed in describing the coal measures with which they are in contact. In the little brooks between Grand Etang and Margaree Harbor, bluish and light-grey argillaceous shale and micaceous sandstone occur with limestone traversed by veins of calcspar.

Au Coin Brook, where it runs parallel with the road, cuts large masses of gypsum. In the Factory Brook, at Cheticamp and Cape Rouge, crumbling marl and micaceous sandstone overlie the felsites.

Pleasant Bay. Near the Grandanse and Mackenzie Rivers of Pleasant Bay, gypsum and limestone are in place. North of Grandanse River, indian-red, calcareous sandstone, marl, shale and conglomerate are found near the road with crystalline and semi-crystalline, compact, coherent limestone, white and light-grey, arenaceous, and containing grains of white and vitreous quartz as large as peas. In the same neighborhood the land is broken by plaster pits. On the shore, for some distance west of Mackenzie River, there is a low belt of cultivated land occupied by grey limestone of varying degrees of purity, brecciated, veined with calcspar and fossiliferous, with a seaward dip at a moderate angle.

Fossils.

Black Shales. The rocks of the shore north of Pleasant Bay consist principally of reddish and greenish sandstone, grit and conglomerate, with occasional bands of impure, shaly limestone, veined and blotched with calcspar; and of black calcareo-bituminous shales.

Bay St. Lawrence. Reddish, micaceous, fine sandstone and bluish-grey argillaceous shale occur on the roads about Bay St. Lawrence; and near the beach are blocks of black concretionary limestone. In some of the fields near the shore the broken nature of the ground indicates plaster.

Aspy Bay. Immense deposits of gypsum and limestone appear everywhere around the ponds and rivers of Aspy Bay, but require no special notice. On the road east of Effie's Brook limestone appears in patches among the granite and syenite.

Ingonish. Gypsum, limestone and other Carboniferous rocks occur in the bays of Ingonish. In Rocky Bay they consist of greenish and bluish shale, conglomerate, impure gypsum, limestone and limestone-breccia which come against syenitic rock. The western point of Ingonish Island also displays an outlier of limestone.

North Shore. The rocks of the North Shore of St. Ann's Bay from Smoky Cape to St. Ann's Harbor are in every respect similar to those just described. In French River grey massive limestone is below the road, while reddish conglomerate occurs in some of the neighboring brooks. On the shore north of Indian Brook are limestone and gypsum, red and grey grit, sandstone and marl, some of which contain carbonized plants and have been explored in search of coal. Red conglomerate is in place on Island Point near the mouth of the Barasois River, but the shore in this vicinity is generally sandy and low. Search for coal.

MILLSTONE GRIT.

This formation may be represented in the great thickness of strata underlying the coal measures of the Port Hood district and other points on the western coast, but as no want of conformity is anywhere exhibited till the top of the Carboniferous limestone is reached and as the whole area of the overlying measures is small, no attempt has been made to subdivide them and they will therefore be included in the sections which follow and which were measured along the coast.

COAL MEASURES.

The lowest beds of the most southerly outcrop of the Inverness coal field at Little Judique have already been described.* North of Judique they appear at intervals as portions of the rim of a basin which has been nearly destroyed by the sea. Seams of coal of considerable thickness have been worked at Port Hood, Mabou, Broad Cove and Chimney Corner, concerning which details will be given hereafter. In the meantime the strata will be described as they are seen on the shore, beginning at Port Hood. The undulations of the lower Carboniferous and Pre-Cambrian rocks by which the troughs are separated will be readily understood from the following sections and the map. Inverness coal-field.

Section of Coal Measures from Port Hood Lighthouse Southward, in Descending Order.

	Feet	Inches
1. Grey and greenish argillaceous shale. At least	6	0
2. Grey, brownish and rusty sandstone, often coarse, false-bedded, crumbly; with small patches of concretionary limestone; full of pot-holes formed by the waves. A prostrate tree, two feet in diameter, converted into crystalline and oolitic limestone and ironstone, with traces of galena and blende. Hard, concretionary masses and many plants. The sandstone strikes along the shore, for nearly a mile. Thickness probably at least	40	0
3. Greenish-grey, soft argillaceous shale	1	0
4. Coal, hard, with streaks of pyrites	0	2
5. Greenish and grey soft argillaceous shale and underclay.	3	0
6. Rusty, shaly sandstone	1	10

Fossil trees.

Traces of galena and blende.

* Report for 1879-80, p. 110 F.

		FEET.	INCHES.
	7. Greenish and bluish argillaceous shale with coal streaks.	2	2
	8. Rusty sandstone, full of plants and *Stigmaria*	5	4
	9. Bluish argillaceous shale	1	3
	10. Coal in two layers	0	2
	11. Dark argillaceous shale with plants	2	8
	12. Black carbonaceous shale, 0′ 1″; Coal, 0′ 2″; Clay, 0′ 7″; Coal, 0′ 7″	1	5
	13. Argillaceous fireclay	3	0
	14. Coal	0	5
	15. Black carbonaceous shale	1	0
	16. Grey and greenish argillaceous shale	1	0
	17. Measures concealed, probably argillaceous shale	10	0
	18. Fine sandstone	5	0
	19. Dark argillaceous shale with harder bands	2	0
	20. Measures concealed	9	0
	21. Alternations of dark argillaceous shale and fine sandstone, broken into small blocks by joints	4	3
	22. Compact, rough sandstone with *Stigmaria* on the upper surface	4	4
	23. Measures concealed, probably including a coal seam	1	9
	24. Arenaceous underclay	2	3
	25. Black calcareo-argillaceous shale, with *Naiadites Cythere, Spirorbis,* plants and fish-remains	3	4
Bituminous shale.	26. Coal; local, 0′ 1′; Black shale 1′ 0″; Coal 0′ 1″; Black shale 1′ 6″; Coal 0′ 4″; Black shale 0′ 10″; Coal 0′ 1′; Black shale 0″ 3; Coal 0″ 2; Black shale indefinite	4	4
Main seam,	27. Measures concealed. Perhaps includes the coal seam worked at Port Hood Mines 6 feet thick	35	0
	28. Fine sandstone	1	6
	29. Measures concealed	53	0
	30. Light-grey flaggy sandstones	2	0
	31. Measures concealed	50	0
	32. Laminated fine sandstone	2	0
	33. Measures concealed	2	6
	34. Fine sandstone	1	0
	35. Measures concealed, but probably greenish argillaceous shale, with streaks of coaly shale	6	0
	36. Grey fine sandstone	0	9
	37. Greenish argillaceous shale	7	0
	38. Greenish fine sandstone	1	3
	39. Greenish and bluish argillaccous shale	8	0
Trees.	40. Grey, greenish and rusty, fine and coarse, micaceous, crumbly sandstone; patches of coarse conglomerate; contains coal-pipes and trees turned into pyrites, or into a mixture of ironstone and calcspar, or of coaly matter and prism-pyramids of quartz. Thickness somewhat indefinite as it strikes along the shore for about half a mile	115	0
	41. Greenish and light-grey argillaceous shale; sometimes arenaceous and blackened with plants	10	6

42. Black shale with masses of limestone, crowded with shells, some of the *Naiadites* being an inch and a half in length	2	6	Bituminous shale,
43. Greenish argillaceous shale	15	0	
44. Measures concealed	4	0	
45. Light-grey and rusty crumbling sandstone	7	0	
46. Greenish argillaceous shale.,	6	6	
47. Grey, flaggy, crumbling sandstone	4	0	
48. Greenish argillaceous shale, with thin bands of greenish fine, calcareous sandstone, containing plants	10	9	
49. Grey and rusty flaggy sandstone	5	8	
50. Dark-bluish argillaceous shale	7	3	
51. Ironstone	0	2	Ironstone.
52. Greenish argillaceous shale	6	0	
53. Measures concealed	6	6	
54. Fine, shaly, argillaceous sandstone, with harder bands, passing into thin bedded sandstone, crumbly and blackened with plants	70	0	
55. Greenish and grey argillaceous shale, with ironstone bands; dark carbonaceous layers at top	34	0	
56. Light-grey, fine, micaceous, shaly sandstone	2	6	
57. Greenish, argillaceous shale; not well seen	7	6	
58. Coal 0′ 2″; Black carbonaceous shale 0′ 6″	0	8	
59. Greenish argillaceous shale; not well seen	14	0	
60. Brown, rusty and grey crumbling sandstone	9	0	
61. Greenish and grey argillaceous shale	6	0	
62. Measures concealed	9	0	Lower Carboniferous rocks brought in by a fault.
63. Light-grey and brown crumbling sandstone	70	0	
Total thickness	710	2	

CARBONIFEROUS LIMESTONE.

	FEET	INCHES.
1. Red crumbling argillaceous shale, with greenish harder masses	25	0
2. Measures concealed; probably red shale	5	0
3. Soft, shaly, crumbling, crystalline gypsum, whitish and reddish in irregular beds	5	0
4. Measures concealed; probably gypseous marl. Mouth of a small brook	20	0
5. Marl of various colours, full of veins and streaks of gypsum, some of which are more than an inch thick	25	0
6. Gypsum, perhaps not continuous	3	0
7. Reddish and greenish marl, with occasional thin layers of gypsum and limestone, and veins running in all directions	100	0
8. Impure, bituminous limestone, passing into calcareous sandstone. Included in 72	..	..
9. Measures concealed	22	0

Gypsum.	10. Whitish, crystalline, crumbling gypsum in a broken bank; bedded like the accompanying strata; crystals of selenite in a base of white gypsum, but the crystals are seldom well-formed; sometimes they are so numerous as to obliterate the white gypsum................	35	0
	11. Reddish and greenish shale, gypseous toward the top, and containing several greenish gypseous streaks in the bedding....................	74	0
	12. Dark, impure, laminated gypsum, containing masses of red marl; veins of white fibrous gypsum throughout, and radiating, crystalline concretions of selenite; sandy spots in places..............................	50	0
Little Judique Harbor.	13. Reddish and greenish gypseous marls, veined, and blotched with gypsum, occur in continuous cliffs, the dip of which is obscure; and among them is a 5-feet band of dark, shining, crystalline gypsum and harder shale and sandstone bands. These marls, with rippled, greenish and reddish bands continue nearly to the beginning of Little Judique Harbor. (Susan Creek of the chart.)...	..	..
	Total thickness......................	364	0

SECTION OF COAL MEASURES FROM PORT HOOD WHARF SOUTHWARD.

		FEET	INCHES.
	1. Measures concealed by a bank of dark clay and a sand beach..	46	0
	2. Reef of light-grey sandstone covered with ironstone balls	2	0
	3. Dark shale, with traces of coal and underclay...........	12	0
	4. Light and rusty-grey, broken, fine sandstone, often nodular and containing comminuted plants	5	0
	5. Bluish-grey argillaceous shale..........................	15	0
	6. Light-grey shaly sandstone..............................	4	0
	7. Dark bluish-grey argillaceous shale.....	6	0
	8. Black shale with *Cythere*, *Naiadites*, coprolites, fish remains and coaly matter	0	3
	9. Argillaceous underclay.................................	12	0
Bituminous shale.	10. Grey sandstone veined with pyrites and calcspar........	1	9
	11. Argillaceous shale, full of coaly matter.................	0	6
	12. Rusty sandy underclay, full of *Stigmaria*. Local, and passes into sandstone.............................	1	2
	13. Sandstone....	0	6
	14. Alternations of sandstone and shale....................	1	0
	15. Measures concealed. Argillaceous shale sometimes obscurely seen..	46	0
	16. Greenish-grey argillaceous sandstone and shale.........	40	0
	17. Bluish and greenish-grey shaly sandstone. Dip S. 63° W. <17°..............	10	0
	18. Grey, and bluish-grey sandstone, false-bedded, shaly or in bands 4 feet thick, irregular layers of shale; coaly streaks made by carbonized plants.................	19	0
	Total thickness...................	222	2

The top of this section probably lies about 150 feet below the main seam and is repeated on the shore to the southward of the outcrop of this coal. The measures south of the wharf may also be the same as those north of Isthmus Point, the difference in the two sections indicating a fault.

Correlation of the rocks north and south of Port Hood.

For a distance of about 600 feet north of Port Hood wharf a sand-beach occupies the shore. Then reefs of grey sandstone dip N. 79° E. < 20°. About 200 feet further north an under-clay, with markings of *Stigmaria*, dips S. 23° W. < 20°; but the reefs45 feet to the westward turn sharply northward. At 1190 feet from the wharf the dip of a sandstone reef is S. 54° W. < 19°, and this seems to prevail as far as the first rocks seen north of the little pond at Isthmus Point, although the land is low and sandy, rendering this doubtfully obscure. Beginning the section from the highest rocks seen on this point, we have the following descending sequence:—

SECTION OF MEASURES NORTH OF ISTHMUS POINT.

	FEET.	INCHES.	
1. Grey sandstone, often more or less argillaceous, full of *Stigmaria*; streaks of coaly matter; fucoids; occasional patches of grey and bluish-grey argillaceous shale....	25	0	Plants.
2. Grey sandstone and argillaceous shale, with streaks of coaly matter; trunks of trees........	22	0	
3. Alternations of red and green argillaceous shale, with bands of grey sandstone........	90	0	
4. Detritus of coal and coaly shale seen in the bank in large quantity. Included in 7........	..	..	
5. Grey argillaceous shale or underclay........	..	..	
6. Sandstone and argillaceous shale........	..	..	
7. Measures concealed........	236	0	
8. Grey sandstone forming cliffs and a high shore........	94	0	
9. Measures concealed at the mouth of a brook and pond..	19	0	
10. Grey and rusty, fine, crumbling sandstone, in cliffs. Dip S. 10° W. < 15°........	77	0	
11. Reddish and greenish argillaceous shale, with a black layer near the top and probably more coaly matter near the bottom........	6	0	
12. Rusty concretionary sandstone........	3	0	
13. Coal streak and rusty underclay........	3	0	
14. Dark-bluish argillaceous shale........	1	0	
15. Red and green shale, not well seen........	20	0	
16. Grey sandstone and argillaceous shale in layers, with thin seams of coal or black shale. The order of occurrence generally is: Coal, underlaid by argillaceous shale and overlaid by sandstone........	45	0	
17. Red and green rocks, with sandstone bands and, perhaps, coaly matter; not well seen........	33	0	Ironstone.

		Ft.	In.
	18. Grey sandstone and argillaceous shale; much ironstone.	17	0
	19. Black shale and underclay. A streak..................	0	0
	20. Grey sandstone and argillaceous shale................	34	0
Bituminous shale.	21. Black shale, passing in places into coal, with alternations of calcareo-bituminous shale and underclay..........	21	0
	22. Greenish shaly underclay, passing downward into red and grey shale..................................	33	0
	23. Greenish-grey shaly sandstone......................	30	0
	24. Grey and greenish-grey shale and sandstone. The shale is more or less arenaceons, passes into sandstone, and forms high cliffs..............................	120	0
	25. Dark grey argillaceous shale, full of ironstone nodules. Dip S. 28° W. < 17°...........................	20	0
	26. Grey rusty sandstone................................	20	0
	27. Grey shale, with dark layers and sandstone bands......	18	0
	28. Grey and rusty arenaceous underclay, passing into sandstone..	4	0
	29. Dark-grey shale......................................	36	0
Cape Linzee.	30. Gray and rusty massive sandstone, of the bold headland of Cape Linzee, worn by the waves, and a resort of birds..	51	0
	31. Greenish and dark-bluish shale, with a coal streak......	12	0
Bituminous shale.	32. Mixed argillaceous and calcareo-bituminous shales, with *Cythere*, *Spirorbis* and *Naiadites*....................	3	0
	33. Underclay	3	0
	34. Alternations of grey and greenish argillaceous shale....	55	0
	35. Calcareo-bituminous shale, mixed with coaly shale, passing upward into grey shale.........................	4	0
	36. Grey, fine, calcareous sandstone.......................	19	0
	37. Dark bluish and greenish shale, with black and coaly bands..	45	0
	38. Sandstone band, with underclay and dark argillaceous and arenaceous shale................................	..	..
	39. Alternations of sandstone and shale, which can be measured in detail, but present few points of interest. Dip S. 9° W. < 17°	124	0
	40. Coal, with a band of bituminous shale................	0	3
	41. Alternations as in 39..................................	28	0
	42. Coal...	0	10
	43. Alternations as in 39..................................	44	0
	44. Coal...	0	4
Bituminous shale.	45. Calcareo-bituminous shale............................	10	0
	46. Argillaceous shale and sandstone......................	15	0
	47. Calcareo-bituminous shale....	3	0
	48. Alternations as in 39	14	0
	49. Red argillaceous shale, containing calcareous concretions. Dip S. 23° W. < 10° to 20°..........................	45	0
	50. Red shale mixed with black, succeeded again by red argillaceous shale..	45	0
	51. Coal worked. Thickness undetermined................	..	..

52. Reddish, greenish and grey shale, with coaly streaks...	18	0	
53. Grey sandstone, forming a reef........................	10	0	
54. Red rocks, with dark streaks as before..................	53	0	
55. Reddish and grey fine sandstone, forming a point.......	20	0	
56. Alternations of grey and rusty sandstone and reddish argillaceous shale..................................	50	0	
57. Reddish-grey fine sandstone, with reddish darker markings; passes downward into gray fine sandstone, forming a rough point..............................	106	0	
58. Bright-brown or indian-red shale, with harder bands and a green layer about the middle. Begins at a large brook in a bay..................................	65	0	
59. Sandstone marked with broken plants. Dip S. 6° W. < 10°..	48	0	
60. Reddish shale and sandstone............................	51	0	
61. Thick sandstone, forming a rocky point. Dip S. 5° W. < 17° to 22°..	43	0	Bituminous shale.
62. Black calcareo-bituminous shale........................	2	0	
63. Underclay	3	0	
64. Red argillaceous shale and sandstone, with several thin dark bands..	100	0	
65. Rocks only obscurely seen in the bank. Dip S. 13° W. < 12°..	29	0	
66. Reddish sandstone and argillaceous shale, with patches of conglomerate and grit............................	14	0	
67. Measures concealed......................................	86	0	
68. Grey sandstone, forming reefs...........................	55	0	
69. Measures concealed; apparently red, greenish and grey shales, with thin bands of sandstone. Dip S. 3° W. < 14°...	20	0	
70. Shaly sandstone...	..	..	
71. Measures concealed. Here occurs the beach of Little Mabou pond, past which the first rocks dip S. 60° W. < 21°, making it impossible accurately to estimate the thickness of the concealed interval, even if there is no break. It is perhaps................................	250	0	Little Mabou.
72. Sandstone, occasionally seen on the reefs...............	55	0	
73. Reddish, waving, shaly sandstone, passing into greenish argillaceous shale......................................	28	0	
74. Grey, fine sandstone	17	0	
75. Reddish shale and sandstone	57	0	
76. Bluish-grey, grey and greenish fine sandstone, greatly jointed, spotted and streaked with red, marked with plants, thick-bedded, spots of calcspar. Dip S. 54° W. < 16°..	44	0	
77. Measures concealed......................................	38	0	
78. Grey and rusty, fine, sandstone	11	0	
79. Greenish and reddish sandstone and argillaceous shale seen occasionally on the reefs........................	45	0	
80. Red rocks..	6	0	

		FEET.	INCHES.
	81. Bluish-grey bituminous limestone, containing *Spirorbis;* traces of iron pyrites and hematite..................	1	6
Bituminous limestone.	82. Red argillaceous shale with a few sandstone bands of no great thickness..........	131	0
	83. Greenish, reddish and grey sandstone, forming a point..	137	0
	84. Indian-red shale..	70	0
	85. Beautiful greenish-grey sandstone, streaked with hematite-red concretions, like agates; sometimes reddish, with green spots..................................	54	0
	86. Red shale. Dip W. < 24°...........................	60	0
	87. Reddish and greenish sandstone, passing into conglomeritic grit or underclay at bottom	25	0
	88. Red and purple argillaceous shale, containing layers of greenish sandstone. Of doubtful thickness..........	20	0
Mabou River.	89. Limestone, gypsum, shales, marls and sandstones that skirt the shore, with very changeable dip, to the beach at the mouth of Mabou River..........................	..	..
	Total thickness.................................	3370	11

Smith Island.

The structure of Smith Island is very simple. It displays a segment of a basin of the coal measures, unconformably capping the Carboniferous limestone, the contact of the two formations being well seen in the cliffs on both sides of the island. The eastern shore for half a mile north of Portsmouth Point, and the western as far as Susannah Point, show grey rusty sandstone, with plants and prostrate trees and a few bands of grey and bluish-grey argillaceous shale; while for a great distance further, this sandstone overlies on top of the cliffs, the limestones at the sea level. The east shore from Portsmouth Point is on the strike of the rocks which dip westward; but at Susannah Point the dip is southeasterly. This attitude would bring the rocks of Smith Island beneath those of Henry Island, provided no undulation exists between the islands, and consequently the latter ought to form a higher portion of the coal measures. Perhaps very little higher, however, because the strike of the rocks at Susannah Point would carry them, if continued, to Henry Point.

Coal measures and lower Carboniferous.

Relation to rocks of Henry Island.

The rocks of Henry Island strengthen this view, being similar to the coal measures of the mainland opposite, although they contain no beds of coal. On the shore east of Justaucorps Point, are cliffs of grey, nearly horizontal sandstone and red shale. These rocks extend northward from Fishery Point in alternating layers, forming a segment of a basin similar to that of Smith Island, and of which the lowest rocks occur at Henry Point. The whole thickness seen on the island is probably about 1,200 feet. The presence or absence of coal in the gap between the two islands could be tested by a boring at the north side on or near Henry Point; and the question is one of some importance.

Coal between the two islands.

The extension of the coal measures inland at Port Hood is very obscure. Mr. Rutherford states* that the strata underlying the worked coal seam "have been examined over a distance of nearly three-fourths of a mile from the shore; and although several seams were found, none of them exceeded twenty inches in thickness. 360 feet above the seam worked, there is another bed, the thickness of which has not been correctly ascertained, as it is entirely under water; but the crop is occasionally seen when the tide is low, and it is supposed to be not less than six feet thick." One of the seams referred to here, twenty inches thick, is said to have been found in the millbrook, eighteen chains above the shore road, and two smaller seams about twelve chains higher. The country east and northeast of Port Hood is underlaid by grey and rusty sandstone and shale, containing carbonized plants. In the Hogsback Brook, flaggy, red, fine-grained sandstone, with plants, is underlaid by four feet of dark-grey, dirty, concretionary limestone, in part calcareous, vesicular conglomerate, containing pebbles of syenite and felsite. Grey sandstones also occur in Little Mabou Brook, near its source, where it crosses the old road to southwest Mabou, and are found in the neighbourhood of Southwest Mabou. But no coal has been found among them, and it seems probable that they are older than the coal measures, or represents the barren series of the base of section north of Isthmus Point.

Rutherford's description of strata beneath the main seam.

Limestone.

Mabou Coal Basin.—No difficulty is encountered in defining the limits of the coal-bearing strata at Mabou coal mines, the next in order to the northward, the two limited patches at Coal Mines and Finlay Points being sharply interrupted by the gypsum, at a distance in no case more than a quarter of a-mile from the shore. The composition and relations of the beds of this series will best be understood by the following sections.

Faults.

SECTION OF COAL MEASURES FROM COAL MINE POINT SOUTHWARD, IN DESCENDING ORDER.

	FEET.	INCHES.
1. Light-grey, rusty-weathering, crumbling sandstone, dipping N. 25° E. <46° for about two chains on the shore, then becoming nearly horizontal. It contains coal streaks; a few fine specks of silvery mica; and large, hard concretions, around which the sandstone is arranged in concentric layers. In part blackened by comminuted, carbonized plants and trunks of trees. Patches of greenish calcareous conglomerate and argillaceous shale, extend along the shore for about 28		

Coal Mine Point.

* Coalfields of Nova Scotia, p. 27.

		Feet.	Inches.
	chains, forming Coal Mine Point. Dip greatly obscured by false-bedding, but changing to S. 58° W. < 28°, and lower. Thickness consequently hard to estimate, but probably	125	0
2.	Rusty underclay of variable thickness	0	3
3.	Bluish and greenish-grey argillaceous shale	22	0
4.	Light-grey rusty sandstone	14	0
5.	Light-greenish argillaceous shale	10	0
6.	Measures concealed at the mouth of a brook; but apparently greenish argillaceous shale and sandstone, principally the former	22	0
7.	(Bituminous shale.) Light and dark bluish-grey argillaceous shale, with ironstone nodules and bands. In places full of *Cythere* and coprolites. Dip N. 25° E. <56°	33	0
8.	Layers of coal and coaly shale	7	6
9.	Dark coaly *Cordaite* shale, full of shells	1	0
10.	Greenish-grey argillaceous shale, with ironstone nodules. Passes at top into dark shale	2	0
11.	Dark bluish-grey argillaceous shale, coaly at top; full of shells and plants	4	0
12.	Greenish argillaceous shale, full of nodules and bands of ironstone. Passes into dark shale at top	24	0
13.	Coal and coaly shale. Dip N. 40° E. < 53°	2	0
14.	Underclay	2	0
15.	Measures concealed	3	0
16.	Clay	0	6
17.	Coaly shale and coal	4	0
18.	Coal of fair quality	2	0
19.	Coaly shale, full of *Cordaitè* and lenticular layers of ironstone. Passes in places into coal	10	0
20.	Measures concealed, including a coal seam which has been worked	21	0
21.	Crumbling argillaceous shale, full of ironstone nodules	32	0
22.	Calcareous sandstone	4	0
23.	Greenish argillaceous shale	43	0
24.	Grey, massive, crumbling, false-bedded, micaceous sandstone, with harder concretionary masses. The thickness is indefinite, the dip changing from N. 8° W. to N. 40° E., < 49°–55°	325	0
25.	Greenish-grey, crumbling, argillaceous shale, with ironstone nodules and layers	40	0
26.	Coal and coaly shale	2	0
27.	Measures concealed, including a coal seam that has been worked	7	6
28.	Underclay	2	0
29.	Coal and coaly shale	3	0
30.	Light greenish-grey argillaceous shale, full of rootlets at top	24	0
31.	Coal and coaly shale	1	6
32.	Underclay	2	0

	Feet.	Inches.	
33. Dark bluish-grey bituminous, papery shale, with *Cordaites* and shells	2	3	Bituminous shale.
34. Light-bluish shale, with nodules of ironstone	4	6	
35. Coaly *Cordaite*-shale, with hard partings	11	6	
36. Underclay	1	6	
37. Light-grey sandstone, finely marked with fucoids. More shaly above, and containing a band of argillaceous shale full of ironstone nodules	27	6	Fucoids.
38. Argillaceous shale and underclay, with ironstone nodules	1	11	
39. Black bituminous shale, with coaly bands	0	9	
40. Underclay	1	10	
41. Light-grey sandstone, with streaks of argillaceous shale and ironstone nodules	6	3	
42. Greenish-grey argillaceous shale, with several layers and many nodules of ironstone	30	6	
43. Ironstone, argillaceous shale and underclay in bands	1	8	
44. Light-grey, shaly, waved sandstone, with thin layers of argillaceous shale and bands of ironstone. Crystals of gypsum occur in all the rocks of the vicinity	14	0	Crystals of gypsum.
45. Ironstone	0	1	
46. Dark, papery, argillaceous, bituminous shale, with *Naiadites*, *Cythere*, *Spirorbis* and *Cordaites*	3	5	Bituminous shale.
47. Ironstone	0	2	
48. Black shale, like 46	0	5	
49. Black, wrinkled, calcareo-bituminous shale, a mass of *Naiadites*, with a few other shells. Coherent and passed into coaly shale	1	0	
50. Black, papery, bituminous shale, full of shells and *Cordaites*	0	8	
51. Underclay	0	11	
52. Dark-grey arenaceous shale	1	1	
53. Underclay with ironstone nodules	1	1	
54. Light bluish-grey argillaceous shale, with shells	2	4	
55. Alternations of sandstone and argillaceous shale. The sandstone is very micaceous, covered on the surface with fucoids, and in places matted with *Calamites*	11	4	
56. Greenish-grey argillaceous shale, passing into arenaceous shale at top	6	4	
57. Light bluish-grey flaggy sandstone and arenaceous shale	1	4	
58. Dark argillaceous shale, with streaks of ironstone	4	0	
59. Light-grey argillaceous shale, with a few ironstone streaks and shells	2	6	
60. Ironstone underlaid by and passing into arenaceous underclay	0	6	
61. Coal	2	4	
62. Black *Cordaite*-shale, passing in places into coal	3	0	
63. Underclay	0	8	
64. Dirty coal	0	6	

		FEET.	INCHES.
	65. Underclay with thin coaly streaks; nodules of black and coaly ironstone; clay in pockets	6	0
	66. Ironstone in nodules	0	6
	67. Grey crumbling underclay, with a few ironstone nodules	11	0
	68. Coal	0	3
	69. Underclay	0	4
	70. Light bluish-grey argillaceous shale	2	4
Ironstone.	71. Ironstone	0	1
	72. Black and bluish-grey papery shale, with shells	1	6
	73. Ironstone in nodular layers	0	5
	74. Light-grey areno-argillaceous shale	2	0
	75. Ironstone	0	3
	76. Light-grey areno-argillaceous shale	2	10
	77. Ironstone	0	1
	78. Light bluish-grey arenaceous shales and flags	4	0
	79. Light-grey, fine, areno-argillaceous, papery shales	1	5
	80. Ironstone, passing into arenaceous shale	0	2
	81. Light bluish-grey argillaceous shale, with three bands of ironstone ½–1½-inch thick	4	0
	82. Ironstone, 01. Bluish shale, 04. Ironstone, 01	0	6
Bituminous shale.	83. Dark bluish-grey and black, papery, argillaceous shale, full of *Naiadites* and *Cythere*	1	4
	84. Light-grey argillaceous shale, with a few shells and two streaks of clay	1	1
	85. Ironstone	0	2
	86. Dark shale, with layers of grey bituminous limestone	0	10
	87. Gray ironstone	0	3
	88. Greenish-grey, finely laminated, argillaceous shale	1	0
	89. Dark, fine, bituminous shale, with shells	0	9
	90. Greenish argillaceous shale	1	3
	91. Ironstone	1	0
	92. Argillaceous shale, with ironstone nodules	5	0
	93. Arenaceous shale and sandstone, with layers of argillaceous shale	4	6
	94. Layers of dark and light argillaceous shale	2	3
	95. Ironstone of variable thickness	0	9
	96. Greenish and bluish-grey argillaceous shale and sandstone in alternate layers, with a few ironstone nodules	27	9
	97. Coal and coaly shale	1	3
	98. Finely laminated, coaly shale, with lenticular patches of the root-bed, No. 99	1	3
	99. Light-grey coherent underclay, meshed with rootlets	1	0
	100. Bluish-grey argillaceous shale, with a dark streak at the bottom	1	6
	101. Light-grey coherent underclay, with a few ironstone nodules	2	8
	102. Alternations of light-grey rusty-weathering sandstone and argillaceous shale, with ironstone nodules	35	9
	103. Greenish argillaceous shale, with a coal streak	1	0

		FEET.	INCHES.	
104.	Greenish-grey sandstone, sometimes mixed with shale..	9	0	
105.	Greenish-grey argillaceous shale, full of rootlets........	2	3	Lenticular seam of coal.
106.	Light-grey sandstone. At one place a seam of coal is lenticularly formed at the expense of this bed, and the section is:— Argillaceous shale, with ironstone balls ..1 3.. Coaly shale ....0 9.. Coal ....3 0..	5	0	
107.	Alternations of dark shales and underclay, with large *Stigmaria* converted into ironstone	7	0	
108.	Dark shale	1	6	
109.	Coal...	2	0	
110.	Measures concealed. Probably black shale and underclay..	3	6	
111.	Carbonaceous shale, 0 6. Coal, 0 6..................	1	0	
112.	Rusty, indefinite mixture of coal and gypsum..........	1	0	Coal and gypsum mixed.
113.	Coal and *Cordaite* shale	2	6	
114.	Greenish and bluish argillaceous shale, with impure coaly layers and nodules of ironstone; passes upward into underclay..................................	6	0	
115.	Impure coal or black *Cordaite* shale...................	0	8	
116.	Dark bluish-grey coaly shale; *Cordaites.* Passes in places into coal	1	3	
117.	Underclay, very rusty, particularly on top.............	3	0	
118.	Light-grey and rusty sandstone and arenaceous shale, veined with calcspar and containing a few ferruginous nodules	9	6	
119.	Dark shale, full of ironstone nodules and with streaks of coal..	7	9	
120.	Concealed. Grey clay-rock with streaks of coal........	18	0	Irregular mixture of rocks at the fault.
	Below this is an irregular mixture of Lower Carboniferous and Coal Measures, as follows:—			
121.	Gypsum; irregular.................................	3	0	
122.	Dark-grey clay....................................	1	0	
123.	Coal, veined with fibrous, crystalline gypsum between the bedding and cleavage planes	2	0	
124.	Gypsum	0	1	
125.	Underclay with trunks of trees mineralized with coal and gypsum in concentric layers.....................	3	3	
126.	Gypsum, full of crystals of selenite and gypseous marl ..	6	0	
	Exactly how the foregoing beds at this fault are related it is difficult to determine, owing to the steep and broken nature of the cliff in which they occur, which is situated half a mile north of Beaton Point.			
127.	Intrusive rock, generally compact and felspathic; green, black and purplish; also finely brecciated. Breaks into minute splinters or dice-shaped fragments.......	4	0	Dykes.

		Feet.	Inches.
Basal conglomerate.	128. Conglomerate, probably of great thickness, extends in cliffs to the mouth of Mabou Harbor, overlaid in places by patches of gypsum and marl. Sometimes it is cut by dykes of dark greenish, rusty-weathering, crumbling diorite, varying in thickness from ten feet to a few inches, and some of the pebbles are traversed by veins of calcite. The alteration of the conglomerate by these dykes seldom extends more than a few inches, or at most a couple of feet. Dip generally eastward	..	..
	Total thickness	1173	4

Section of the Measures from Coal Mine Point northward.

		Feet.	Inches.
	1. Light-grey sandstone, No. 1 of foregoing section	125	0
	2. Underclay, with a thin layer of coal	2	0
	3. Coaly shale	0	5
	4. Underclay	0	6
	5. Alternations of black shale and clay, with ironstone nodules	3	8
	6. Light-grey sandstone, with plants	1	0
	7. Greenish, argillaceous shale and clay, with black streaks and ironstone nodules	6	0
	8. Coal and coaly shale	1	4
	In the bank some of the foregoing beds are replaced by sandstone, and seem to run into the thick sandstone. Or, in other words, the sandstone (No. 1) appears to rest upon the upturned edges of the shales.		
	9. Argillaceous shale with black streaks	7	0
	10. Dark coaly shale	1	6
	11. Underclay and argillaceous shale, with coaly bands and ironstone nodules. Becomes sandy at bottom	8	0
Small fault.	12. Measures concealed. Probably red and greenish gypseous marl. A throw of six feet seen high in the bank.	18	0
	13. Sandstone	4	0
	14. Measures concealed	16	0
	15. Argillaceous rocks in thin and thick beds; ironstone nodules. Passes into fine arenaceous shale	18	0
	16. Grey fine sandstone in several layers	7	0
	17. Argillaceous shale with bands and nodules of ironstone	8	0
	18. Coal and coaly shale	1	6
	19. Underclay, with nodules and layers of ironstone	4	6
	20. Light-grey rusty-weathering sandstone	3	6
	21. Underclay and argillaceous shale, with ironstone nodules and coal streaks	8	6
Plants.	22. Grey flaggy sandstone, with a thin bed of argillaceous shale, with ironstone nodules. *Cordaites* and *Calamites*	5	3

	Feet.	Inches.	
23. Grey and blackish shale; ironstone nodules	8	0	
24. Coaly band	1	6	
25. Dark shale	3	6	
26. Flaggy rusty sandstone	4	0	
27. Measures concealed	13	0	
28. Grey, rusty-weathering, fine sandstone, full of broken plants and concretions	13	0	
29. Dark bluish-grey argillaceous shale, with ironstone nodules and variable bands of coaly shale and underclay	8	0	
30. Whitish-grey, very fine, argillaceous sandstone, full of broken plants	3	0	
31. Sandstone like the foregoing, with a lenticular band of argillaceous shale containing ironstone nodules	1	0	
32. Argillaceous shale with ironstone layers and nodules, contorted	20	0	
33. Coaly shale and cannel coal. Greatly contorted and slickensided	5	6	Cannel coal.
34. Greenish argillaceous shale, with ironstone nodules	7	0	
A fault intervenes, running about S. 27° E. Then, on top of the bank, is a coal seam.			Fault.
35. Coal and coaly shale	9	0	
36. Underclay and argillaceous shale; ironstone nodules and irregular masses of coaly shale	10	0	
37. Coaly shale, passing into coal	4	0	
38. Underclay	8	0	
39. Shaly sandstone	2	0	
40. Wrinkled calcareo-bituminous shale, full of *Naiadites*, *Cythere*, etc	3	6	Bituminous shale.
41. Underclay	4	0	
42. Bluish-grey argillaceous shale, with plants	6	0	
43. Argillaceous shale, crumbling into clay	1	0	
44. Measures concealed	1	6	
45. Light-grey, rusty-weathering, massive, fine sandstone. Dip apparently N. 48° W. < 57°	26	0	
46. Greenish argillaceous shale, with a 6-inch band of coaly shale halfway. Perhaps a fault intervenes between the sandstone and shale, or between the shale or gypsum, or both. The dip is assumed to be the same as in 45, but is very doubtful	47	0	Faults.
Carboniferous Limestone.			
47. Gypsum, dipping about S. 42° W. at a low angle. Of considerable but undetermined thickness	..	..	
48. Grey marl with great masses of limestone; cream-colored marl with limestone bands, and conglomerate irregularly mixed with limestone and marl, occupy the shore from Coal Mine Point to Finlay Point, where the thick gypsum is again overlaid by coal measures	..	..	
Total thickness	460	2	

The coal measures of the basin at Finlay Point (The Island) present no great thickness, being cut off on the west by the sea and on the east by the gypsum mentioned above. The following descending section will serve to show the character of the strata:—

SECTION OF MEASURES ON THE SOUTH SIDE OF FINLAY POINT.

		Feet.	Inches.
	1. Grey, rusty-weathering, massive sandstone, containing plants, films of coal and cannel. The dip is variable, turning round about 90° in a distanceof five chains. On the south side of the head, however, it is less irregular, varying only from N. 4° to 22° W. < 45°–19°. Thickness probably	340	0
Cannel coal.	2. Cannel coal, 0 2. Light-grey sandstone, 0 3. Coal, 2 1. Carbonaceous shale, 0 2	2	8
	3. Underclay	3	6
	4. Light-grey sandstone, in thin and thick beds; rusty streaks and irregular masses of light bluish-grey argillaceous shale, calcareous shale and patches of greenish-grey fine conglomerate. Dip N. 22° W. < 28°. Streaks of carbonaceous shale and coal	47	0
	5. Measures in part concealed, but probably rusty sandstone	34	0
	6. Dirty, shaly coal	2	0
	7. Measures concealed	21	0
	8. Rusty sandstone; *Calamites;* five streaks of cannel	6	0
	9. Coaly shale and coal	9	0
	10. Underclay	2	3
	11. Light-grey shaly sandstone	4	0
	12. Light bluish-grey argillaceous shale, with ironstone nodules	3	0
	13. Light greenish-grey shale and sandstone	3	3
	14. Coal and carbonaceous shale	2	1
	15. Yellowish uuderclay	2	3
	16. Coherent, rusty sandstone	6	0
Limestone.	17. Nodular limestone, 0 6 to 1 6. Dip N. 25° W. < 40°	1	0
	18. Argillaceous shale	0	3
	19. Carbonaceous shale	0	2
	20. Bluish-grey nodular limestone in thick and thin beds	6	0
	21. Light bluish-grey argillaceous shale	1	3
	22. Light-grey sandstone	1	2
	23. Light bluish-grey argillaceous and arenaceous shales and flags	14	6
	24. Dark-grey, friable, argillaceous shale, with ironstone nodules	7	0
	25. Reddish and rusty concretionary shale, with irregular bands of nodular limestone	9	0
	26. Light greenish-grey arenaceous and argillaceous shale	6	0
Fault.	Here occurs a fault.		

Carboniferous Limestone.

	Feet.	Inches.
27. Measures concealed	8	0
28. Indian-red marl and greenish-grey fine conglomerate in alternate patches	15	0
29. Similar to 28, but not all well seen	61	0
30. White and mottled, pink and green gypsum with crystals of selenite. The thickness generally assumes that the dip remains the same	154	0
31. Measures concealed at the mouth of the millbrook	..	..
Total thickness	772	4

On the north side of Finlay Point a similar section shows coal measures brought by a fault against gypsum and associated rocks, which are, in turn, underlaid by the quartzite already mentioned; while at the extreme northeast end of the basin, they come against Pre-Cambrian felsites. On the beach, none of the thick gypsum is met with, although in McPhee's fields above, it is well developed, The felsite cliffs are first capped with grey marl and conglomerate. then limestone and limestone-breccia appear, dipping nearly vertically N. 42° W. Further south, calcareous, greenish shales and concretionary limestone come against the felsite, dipping S. 68° E. at a high angle as above. Along the line of contact is a large quantity of heavy-spar. Near this contact also is a limestone-breccia like that on the beach, but it is high up in the cliff, and is probably overlaid by the greenish shales. This is followed by an interval, obscurely seen, in which greenish-grey shale, dipping to the northeastward, appears to overlie a thick grey sandstone, which forms a long point. At the southeast side of this point the sandstone dips N. 35° E. $<$ 43°; but turns immediately to N. 3° W. $<$ 22°, and on the opposite or west side dips N. 15° W. $<$ 23°. It contains carbonized trunks of trees, patches of coal and coaly shale, occupies a breadth of 14 chains and has a probable thickness of 350 feet, perhaps representing No. 1 of the above sections. It is underlaid by greenish argillaceous shale 14 feet, coal 2 inches, underclay passing into rusty sandstone 14 feet.

Faults. Barytes. Coal.

These rocks occur just below the house of Mr. Archibald McDonald (miller). There is then a fault along which the sandstone is turned on end in a direction N. 63° E. The succeeding rocks are greatly jumbled and may be either above or below the thick sandstone, and the order of their occurrence is somewhat obscure. They comprise;—

Faults.

	Feet.	Inches.
1. Indian-red marl	..	..
2. Indian-red friable conglomerate	1	0
3. Measures concealed	15	7

		Feet.	Inches.
	4. Yellowish-grey, coarse, friable, shaly sandstone	3	0
	5. Loose sand	0	3
	6. Indian-red, friable marl	21	0
	7. Indian-red conglomerate. Pebbles of felsite, syenite, jasper, etc	2	6
	8. Red marl	1	0
	9. Measures concealed—55 feet along the shore	..	..
	10. Mottled, grey, red and yellow marl	3	0
	11. Measures concealed for a distance of 15 feet along the shore	..	..
	12. Dark bluish-grey, thin-bedded, calcareo-bituminous shale; fish-scales, teeth, coprolites and spines, *Cythere, Naiadites, Spirorbis*	2	0
Black shales.	13. Dark bluish-grey, flaggy, concretionary, calcareous rock, with the same fossils	2	6
	14. Light bluish-grey, papery, friable, argillaceous shale, slightly bituminous and fossiliferous	1	10
	15. Dark bluish-grey and black, bituminous, thin and thick-bedded shales; in places almost wholly composed of scales, teeth and shells. Sharp folds occurs in these beds	7	0
	16. Dark calcareo-bituminous, fossiliferous shale. Very much contorted	3	10
	17. Dark calcareous, fossiliferous flags, seamed with calcite	5	2
	18. Argillaceous and arenaceous calcareous shales, papery, fossiliferous and very much contorted	2	6
	19. Calcareous, contorted, fossiliferous, bituminous shales and flags; lenticular masses of soft, black, friable, argillaceous shale	10	0
	20. Dark, soft, friable argillaceous shale	0	6
	21. Like 19	9	0
	22. Like 20	1	3
	23. Dark bluish-grey, shaly, bituminous limestone	0	9
	24. Like 20	0	8
	25. Calcareo-arenaceous shale	0	6
	26. Like 20	2	0
	27. Calcareo-arenaceous, fossiliferous flags	0	7
	28. Light bluish-grey, friable argillaceous shale	3	6
	29. Light bluish-grey, arenaceous and argillaceous shales and flags, calcareous and fossiliferous. Dip N. 7° E. $< 36°$	3	6
Limestone.	30. Light bluish-grey, flaggy, arenaceous, bituminous limestone; fossils	5	0
	31. Dark, soft, carbonaceous shale	0	3
	32. Rusty-yellow and light bluish-grey crumbling underclay	4	0
	33. Rusty decomposed conglomerate	1	6
	34. Yellowish clay, containing, as do also the shales, numerous simple and twin crystals of selenite	2	3
	35. Light indian-red or chocolate-brown, soft, conglomeritic marl	1	0

	FEET.	INCHES.
36. Light bluish-grey and rusty-yellow, gypseous marl.....	1	6
37. Like 35. The following section is plain and in descending order..	1	0
38. Light bluish-grey, friable, argillaceous shale...........	4	0
39. Measures concealed. Probably argillaceous shale.......	8	0
40. Indian-red and grey, fine-grained, broken, jointed sandstone passing into 41..............................	7	0
41. Indian-red coarse sandstone, grit and conglomerate. Dip obscure......................................	31	6
42. Measures concealed..................................	32	0
43. Light bluish-grey, flaggy, bituminous limestone........	0	6
44. Measures concealed. Probably bluish-grey marl.......	21	0
45. Gypsum, white with spots of orange, pink and green; crystals and veins of selenite. If the dip is N. < 45°, like the conglomerate, the thickness is...............	21	0
46. Measures concealed..................................	58	0
47. White gypsum..	5	6
48. Measures concealed..................................	116	0
49. Light bluish-grey, shaly, arenaceous, bituminous, fossiliferous limestone, veined with calcspar..............	4	6
50. Indian-red hematitic conglomerate....................	6	0
51. Measures concealed..................................	28	0
52. Indian-red conglomerate, darker than the last..........	12	0
53. Quartzite forming a cliff 20 feet high (described p. 374)..	..	..

It must be remembered that the above section is not supposed to be continuous, but is intended merely to represent the beds as they appear on the shore. From 1 to 11 the beds are probably Carboniferous limestone; and again at 45 this formation appears, while the whole section may be beneath the coal measures. The black shales are those from which an interesting collection of fossils was made by Mr. Foord, of the Geological Survey, in the summer of 1881. In this collection the following forms have been determined by Mr. Whiteaves:

Fossils collected by Mr. Foord

Naiadites (*Anthracoptera*) *carbonaria*, Dawson.
" (*Anthracomya*) *elongata*, Dawson.
Entomostraca.
Rhizodus lancifer, Newberry (scales).
Cœlacanthus (jugular plates).
Scales of two genera of ganoid fishes.
Also jaws and teeth of fishes undetermined.

Broad Cove Coal Measures.—A narrow fringe of grey sandstone skirts the coast from Port Ban to Cheticamp, forming a shallow syncline, the western side of which is only occasionally present. It is underlaid by the limestone formation, and at several points contains workable seams of coal. Considerable ambiguity exists concerning the limits of these rocks, so that the boundary lines on the map are only approximate. No section has yet been made owing to the imperfect exposure of the measures; but the strata will be described as they occur in different places.

Port Ban. At Port Ban, grey fine sandstone caps cliffs of banded Pre-Cambrian felsite and extends as far as the road. From this point the shore for a great distance is approximately on the strike and is occupied by coarse and fine, grey sandstone, with bands of argillaceous shale. The dip, which is seaward, seldom exceeds 10° and the thickness probably is not less than 450 feet. About half a mile west of McIsaac Pond the sandstone is overlaid by a coal seam or group of seams. The seam varies in thickness where seen in the cliffs from 2 feet to 2 feet 6 inches, but in the workings is said by Mr. Robb to be 3 feet 2 inches of bright cubical coal, with a parting 6 inches from the top. Above the coal come 10 feet of dark-greenish argillaceous shale, overlaid by sandstone 12 feet, till the measures are concealed by the sandbeach at McIsaac Pond.

McIsaac Pond.

Broad Cove River. In Broad Cove River, below the bridge at the sandstone quarry grey, nearly horizontal sandstone is found in thick beds, with argillaceous shale and coal seams. One of these seams occurs on the top of a cliff on the left bank, about 100 feet above the sea, where the following descending section was measured in 1873 by Mr. Robb:

	FEET.	INCHES.
1. Greenish fine sandstone	3	0
2. Red and green marl	17	0
3. Massive sandstone, reddish on the outside, but streaked-yellow and green within	20	0
4. Bluish-grey argillaceous shale	7	0
5. Coal, with a thin clay parting in the middle, said to be good gas coal	3	0
6. Underclay, containing *Stigmaria*, silicified with black and grey rock, covered with minute crystals of quartz	..	..

This coal has been worked by pits near the water level, lower down on the right bank. Here the section is said by Mr. Robb to be:

	FEET.	INCHES.
1. Coal	0	11
2. Clay	1	0
3. Coal	3	9
4. Underclay	4	0
5. Greenish-grey fine sandstone, with hard close-grained whitish sandstone in cliffs which extend some distance down the river	..	..

Other details concerning the field are given by Mr. Robb in the Report for 1873–74, p. 182.

A quarter of a mile north of the mine, at a tunnel near the tramway, is a coal seam, of which $4\frac{1}{2}$ or 5 feet has been worked, this being underlaid by clay and more coal. It is supposed to be the 14 feet seam.

In the brook north of Broad Cove River another opening has been made in a seam of coal, associated with argillaceous shale and sandstone, dipping steeply S. 70° W. down stream. In a drift on the seam the strike is N. 18° E. The section is:

14-feet seam.

	FEET.	INCHES.
1. Underclay	..	..
2. Coal	1	6
3. Coal worked	4	8
4. Coal and coaly shale	3	0
5. Clay	0	9
6. Coal and coaly shale	1	9
	11	8

But as this is known as the 14-feet seam; the under-clay (1) is probably overlaid by more coal. Above the bridge at which the seam is worked, another, said to be 5 feet thick, has been opened; above which the brook displays greenish-grey, coarse and fine sandstone.

Faults.

The pits are too far apart for any satisfactory attempt to correlate them, a task which must be left till further development of the area has taken place. To the north and east the coal measures are interrupted by the Carboniferous limestone, but in some places at least the overlap is complicated by faults, the exact position and amount of which is obscure.

Succession of seams as given by Professor Hind and Mr. Brown.

In Brown's Coalfields of Cape Breton, p. 39, and in the report made by Professor Hind in 1873, the sequence of the seams is given as follows:

LOWER GROUP.

	FEET.	INCHES.
Coal	2	6
Strata underlying	60	0
Coal—thickness unknown	..	..

UPPER GROUP.

	FEET.	INCHES.
Coal, the highest bed	3	0
Strata	340	0
Coal	5	0
Strata	100	0
Coal, main seam	7	0
Strata	240	0
Coal	3	6
Total thickness of upper group	698	6

About Strathlorne no rocks are seen, but the country is covered by sand similar to that derived from the sandstone on the shore, so that it is not impossible that a tongue of the coal measures may extend in this direction. In confirmation of this supposition Mr. Isaac McLeod states that in digging into the bank at the post office, coal wash was found.

Broad Cove Marsh.

Chimney Corner Coal Measures.—North of Marsh Point is a still more indefinite basin, containing the lowest beds of the coal measures and some seams of coal.

The Marsh Brook, below the post road, passes over reddish fine sandstone which has been quarried. Lower down are reefs of grey, fine, ripple-marked sandstone and dark argillaceous shale, followed by bright-red marl; and at the mouth, grey and rusty sandstone contains plants. On the shore, between this brook and the next, and for a considerable distance north-eastward, black, argillaceous, shelly, calcareo-bituminous shale, occasionally passing into coal, is accompanied by bands of red and greenish shale, with ironstone nodules; and grey, fine, broken, micaceous, argillaceous sandstone, rusty on the surface, passing into fine grit and containing broken, carbonized plants ; but the absence of grey shale and fern beds here as well as in other parts of the Inverness coalfield is remarkable.

Black bituminous shale.

Coal wrought at McLeod Brook.

There is an interval of a mile and a-half, which extends quarter of a-mile past the mouth of McLeod Brook, concealed by a sandy beach and low banks of red drift; but a short distance inland, on the farm of Alexander McLeod, a seam of coal, said to be three feet thick, has been worked. In a brook about a mile to the eastward is a seam, also said to be three feet. In some of the brooks of this neighborhood, above the road, grey and rusty sandstone is met with, and, in that just mentioned, forms stony, strawberry-barrens. To the northward, an anticlinal brings the lower Carboniferous rocks on the shore. At the contact, a thick grey and rusty sandstone is on top of the cliff, while beneath it are grey flaggy sandstone and bituminous shales full of shells, which with gypsum and purple, red and greenish marl containing calcareous nodules, come with a different dip from beneath the sandstone at several points before the coal measures take the shore at the mouth of the School Brook, and occupy it as far as Chimney Corner. At the mines the thickness of the coal measures is considerably greater or the basin deeper, several seams of coal and a great thickness of associated strata being exposed, and it is also probable that the unconformity is complicated by faults. Professor Hind gives the section at the coal mines as follows in descending order, the dip being north-westerly at an angle of 40° :—

Anticlinal fold.

Professor Hind's section.

		Feet.	Inches.
1.	Thin seams	1	6
2.	Strata, about	300	0
3.	Coal	3	0
4.	Strata	88	0
5.	Coal—main seam	5	0
6.	Strata	200	0
7.	Coal	3	6
	Total thickness	601	0

The strata immediately above No. 3 at Chimney Corner Point are as follows :—

		Feet.	Inches.
1.	Heavy-bedded, grey and rusty sandstone	..	..
2.	Grey and bluish-grey argillaceous shale	10	0
3.	Black shale	10	0
4.	Greenish argillaceous shale	6	0
5.	Grey sandstone	6	0
6.	Coal, No. 3, said to be a good steam coal, worked by Wilson	3	0
		35	0

Strata between Chimney Corner and Margaree Harbor.

North of the cove at the mine, grey sandstone, dipping about N. 80° W. <53°, is underlaid by greenish and reddish marl with bands of whitish sandstone, which is in turn underlaid by grey sandstone and bluish-grey crumbling argillaceous shale, containing a few shells. and passing into a wrinkled, calcareo-bituminous shale full of shells. The strata concealed in the cove would appear to be about 685 feet; the underlying sandstone, etc., 395 feet; underlaid by dark shale with basins of underclay, and two 18-inch bands of sandstone at the bottom underlaid again by a small seam of coal of undetermined thickness and by an underclay. Below these rocks dark shales again appear in and near the small cove at the mouth of the next brook, showing a thickness of about 580 feet, below which is a grey sandstone with a few bands of bluish argillaceous shale. The sandstone contains trunks of trees carbonized and silicified, runs along the shore for about two miles, is probably 300 feet thick, and is underlaid at Whale Cove by three feet of coaly shale with an underclay, succeeded again by grey sandstone 100 feet underlaid by a small seam of coal, one foot of which is visible. The strata are then concealed by Whale Cove for about 425 feet, beyond which a great thickness of grey sandstone, with a few bands of greenish and bluish-grey shale occupies the coast to the mouth of Margaree Harbor. On Grey Point, and at the breakwater, are cliffs and reefs of grey, rusty and fine crumbly sandstone. In the brook east of the limekiln at Whale Cove, and in other brooks of the

Whale Cove.

vicinity, this sandstone occurs to the top of the hill, associated in both branches of the large millbrook, with thin beds of argillaceous shale.

Margaree Island.

The strata of Margaree or Sea Wolf Island consist of grey and rusty sandstone with a little shale dipping nortwestward at a low angle. The soil is very sandy, and supports no vegetation for some distance from the cliffs.

Rocks between Margaree and Cheticamp.

On the shore opposite the school house, two miles north of Margaree Harbor, is a sandstone, like that of Margaree Island, covered with broken, carbonized plants, and enclosing bands of argillaceous shale. Between the road and the shore the land is wet and barren, being probably underlaid by this sandstone, which runs in reefs parallel to the coast line, dipping steeply seaward. Above the road is a belt of low land perhaps underlaid by Carboniferous limestone, beyond which are the waving outlines of the steep hills of conglomerate. At the mouth of the brook near Anthony D. White's, and immediately south of it, red argillaceous shale, probably belonging to the Carboniferous limestone, is in place, and at the head of the next cove, red shale and gypsum are present. About a mile north of the school mentioned above, at the mouth of a large brook, red rocks dip seaward at an angle of 65°, but are succeeded further north by the light-grey, coarse sandstone of Friar Point, associated with reddish-grey argillaceous sandstone and shale. Near the lobster-factory bluish-grey sandstone, with broken, carbonized plants, is associated with drab marl and sandstone.

Cheticamp.

Near the lighthouse on Cheticamp Point, these rocks dip S. 25° E. $<$ 15°. On the outer shore they are well exposed, but the shores of Eastern Harbor are low, and display few outcrops. Such exposures as occur, however, seem to prove that the island forms the axis of a narrow synclinal fold of these measures, which run nearly to Caveau Point.

SURFACE GEOLOGY.

Superficial deposits, properly so called, are as scarce in the region to which this report refers as in that described in the report for 1879-80, being confined principally to the seashore and to the intervales of those large rivers which flow through Carboniferous districts, the soil and surface in most cases being derived from the waste of the underlying rocks. Banks of sand and gravel do indeed appear even in brooks flowing in Pre-Cambrian areas, but their occurrence is unusual, the river beds being generally too narrow to admit of the lodgment of detritus. Dauphiney Brook, a branch of Clyburn Brook, is remarkable for the size of the valley cut by so small a stream and the large quantity of gravel. It probably empties the lake lying to the north-westward, the head of which was crossed by a traverse from Dundas Brook. Power Brook also exhibits the phenomenon of a wide valley filled with drift. The lower part of Clyburn Brook is enclosed on both sides by steep, bald hills of syenite.

Glacial striæ.

Ice grooves are seen in several parts of the region. Around Lake Law they run parallel with the valley, which has a northerly trend.

Distribution of the hills.

The most marked feature in the landscape is the hills, the general arrangement and character of which have been already sketched. They for the most part occur in ridges or groups, but also in isolated mountains, such as the highlands of Cape Mabou, Wilkie's Sugarloaf and the Sugarloaf of Northeast Margaree. On top, these hills are comparatively level for a variable width. When narrow, as on the Skye Mountain, the land is dry and cultivable; but wherever it is so broad that the water has a chance to accumulate in marshes and there is no timber, "barrens" are found. These barrens are everywhere alike, but some of the principal ones may be enumerated. At the head of the McLeod branch of Middle River, mossy fern and spruceland borders the marshes in the brook, which flows here in a bed of sand composed of syenite and quartz. A considerable distance between this and the Fourth Gold Brook is occupied by a barren, covered with a layer of white moss, lichens, equiseta, indian-tea and other plants at least one foot in thickness, but no trees except scraggy red spruce, seldom more than ten feet high, although some dead poles attain a height of twenty feet. On the summit between the two brooks even these trees disappear, leaving bushes and a bare surface of grey and white and brownish moss, lichens and grass, dotted with the bright colors of the golden-rod and a small purple star-flower, followed by dry land underlaid by syenite and covered with blueberries. Except for the small mounds of syenite here and there and a few cradle-hills and clumps of spruce and alders, the surface for a great distance northeast and southwest is uniform and bare. Scraggy spruce again indicates another descent into better timber with little pools of water and bake-apples (*Rubus Chamæmorus*), and birch and spruce, the steep slope of a branch of the Fourth Gold Brook.

Barrens.

Middle River.

Plants of the barrens.

Barrens of Mt. Pleasant and Pine Brooks.

At the head of Mount Pleasant Brook, scrubby, white spruce occurs on a barren intersected by cariboo runs and interspersed with grass and moss-marshes. Near Pine Brook is a large barren with a few hazel bushes, ferns, mountain ash, spruce and blueberries, covered with blocks of syenite and in part dry, mossy and stony.

Northeast Margaree.

The watershed at the source of the Northeast Margaree and adjoining rivers, is occupied by large barrens mossy and treeless, with berries. Masses of the usual crumbling syenite crop out in small knolls over the surface and in certain spots the vegetation has been removed by cariboo in spring in search of food. Droppings and tracks of the cariboo, bear, rabbit and moose are found everywhere; on the wet barrens are a few snipe and plover, and loons visit the small ponds. There is no great depth of soil on these barrens. Sluggish streams flow through them in shallow alder-valleys and marshes, bordered with spruce, ferns and mountain ash, the bark of the latter being used by the moose for food: they are for the most part straight in their course, but sometimes very tortuous, and without feeders from either side; now winding through small marshy tracts, now through scrubby, wiry spruceland, and again through taller spruce and scattered birches. The east branch of the Northeast Margaree ends in two small brooks, the most northerly emptying a pond ten by twenty feet, the other coming down a glade two hundred and fifty yards long with a string of small trout ponds at the top. All the land between the head of the Ingonish waters and the Margaree main camp is absolutely worthless except for bakeapples, blueberries and peat.

Cariboo, moose, etc.

Birds.

Trout.

Peat.

At the head of one of the branches of the North River of St. Ann's is a large hay-marsh which passes into a barren covered with yellow moss and a short bright yellow grass, containing only a few clumps of wiry, twisted spruce bushes, three feet high. A belt of alders indicates where the brooks follow the edge of the barren which is also surrounded by spruce of the ordinary character.

St. Ann's barrens.

Between Green Cove and the road, the country is barren, having been swept, some years ago, by a forest fire which also destroyed the fishing station. In this barren the rounded knolls of red granite and syenite rise conspicuously. Unlike other parts of the shore this is comparatively level and in most parts accessible. The road to Green Cove is a mere footpath but not hard to follow.

Burnt barrens.

Fine blueberry and huckleberry barrens occupy a great part of the road from Ingonish to Aspy Bay, the road being dry and hard although stony. On the barrens near the head of Cheticamp River, *Myrica cerifera* abounds with white, red and black spruce, but no birch.

Ingonish and Cheticamp.

Barrens are found in the Carboniferous district north of Baddeck and elsewhere, but, in such cases, owe their existence to fires. At the Garry, large plains like those of the Big Brook and Northeast Egypt are underlaid by gypsum, and the road to Warren Lake also passes through similar barrens. Patches of barren or half-barren clayland occur among the Carboniferous rocks about Port Hood and Southwest Mabou, much of which can be reclaimed. At the head of Skye and Brook Village Rivers, which rise in the same valley, similar barrens are accompanied by fine hay-marshes.

Southwest Mabou.

The number and diversity of the rivers and brooks * of the region is remarkable, and some of the more important points concerning them may be mentioned. In the southern and well settled portions of the country they resemble those described in the Report for 1879–80, the shorter ones being steep and rapid, the longer more sluggish and often in intervales. In Galant River intervales alternate with narrow ravines formed by bands of grit, the latter being wooded with small spruce, the former with birch and maple. The ascent is remarkably even, and it is consequently a good timber brook. At its head are small stretches of marshy hay-land, but the country, although level, is not productive.

Character of the rivers and brooks.

Galant River.

At the head of Glendyer Brook, Mabou, a large, dry brook-bed occurs in broken limestone land. It is paved with limestone blocks covered with a thin white deposit of chalk, passes through a fine hardwood valley, and is evidently used whenever there is too much water to pass down the subterranean passage, the water continuing thus for about a mile, it then emerges as a strong brook.

Glendyer Brook.

Intervales occur along the banks of the Black Brook north of Ingonish, and in some parts large pines and hardwood are met with. The river throughout its entire length has an even course, with no falls worthy of the name; and at the bridge there are no high hills in sight, the country having fallen gradually with the river. The land, as far as seen on either side, with the exception of the small patches of intervale, is as valueless as that near the bridge, supporting only raspberries, huckleberries, blueberries and foxberries. The river can be followed up to its source, and affords an easy entrance into the heart of the country, running back, as it does, for a distance of thirteen miles to the source of Cheticamp River. The moose hunters seem, from the fact of there being old camps on the headwaters, to be tolerably familiar with its upper stretches which are particularly easy to travel. All the water the river contains comes from marshes, ponds and barrens which well accounts for its dark appearance. The absence of large branches in the lower reaches, and the rapidity of rise in a rainstorm are features in the river.

Black Brook.

Pine.

Moose hunters' Camps.

In the North Aspy River as far as the fork of the Big Southwest, belts of intervale land occur, with pines; and thus far timber has been cut. The bed, with one or two short exceptions, is remarkably even, the rise gradual and steady, walking over the long pebbly stretches easy, the rocks interesting in the extreme, the scenery very fine with the bluff walls heavily timbered with splendid hardwood—

North Aspy River.

* Local usage has been followed in applying the terms "brook" and "river" to the large streams; this varies in different places, and has, therefore, as will be readily understood from the map, no definite relation to the comparative size.

Trees. birch, maple, ash and beech—and soft wood—small pine, large hemlock, white and black spruce. There is land enough on the right bank of the river as far as it flows among Carboniferous conglomerate, to make farms, and from the large timber, supported by the felsite, the same might be said of it, although the slopes are too steep for cultivation. So remarkably straight is this river that one can obtain a lovely view down the valley to the sea from near its source, and a continuation of this straight line skirts the high hills of the promontory of Cape North. Above the Big Southwest Brook the bed is in places rough, but not steep. Near the source it rises in a succession of cascades, spruce and birch fringe the banks even where the small marshes occur. The water is from springs and very cold. The stones of some of the springs are covered with feathery moss, slimy weeds and delicate little trailing plants somewhat resembling chickweed (*Stellaria*), or *Linnœa borealis.*

Straight course of this river.

Mackenzie River. Pine. The Mackenzie River is a very hard one to follow, the narrow bed being rough and without intervale, and the walls precipitous. Lumbering has been carried on for a short a distance up, a few pines, seldom exceeding two feet in the butt, growing at the foot of the hills, the tops of which are clothed with small spruce. On August 17th, 1881, the following berries were ripe in its bed :—Straw, rasp, huckle, blue, fox (*Vitis Idœa*), pigeon, cran and serviceberries, red and black currants, but this lateness is no doubt in consequence of the depth of the valley and absence of the sun, because strawberries were ripe in the settlement of Northeast Margaree the same year about the middle of July.

Berries.

Indian Brook of St. Ann's. The Indian Brook of St. Ann's is rocky and inaccessible below the upper settlement, but the upper part is comparatively level spruce-land and mossy fern-land with a few birches, and in the McMillan branch hay and alder-marshes occur. Above the outlet of Gisborne Lake there is very little rise in the East Branch, which is bordered by hay-marshes; at its head alder-marshes, 150 yards wide, are succeeded by spruce-land. A wonderful profusion of Indian pears was found in this brook on Sept. 23rd, 1881, in the western branch, and two days later cherries were equally abundant, with high-bush cranberries, blueberries and pigeonberries, although on the barrens at the head of the river, these fruits were spoiled by frost on Sept. 16th, a week earlier.

Season of wild fruits.

At the head of Cheticamp River barrens and marshes follow for several miles, as on the Indian and Ingonish Rivers, before it cuts into gorges. On all the gentle slopes tall spruce-poles occur. Where the Northeast Margaree River comes near the Cheticamp, the former is only a few feet below the level of the surrounding country, whereas the latter is in one of its wildest ravines. A short distance further down, however, the Northeast Margaree also cuts deeply into the land, but is nowhere so dangerous as the Cheticamp, although like all these rivers subject to floods which overflow the intervales and destroy the bridges. Mr. Campbell states* that the water rises in the lower part of the Cheticamp River, where the channel is 150 feet wide, to as much as fifteen feet above its ordinary level, and the rise in the Indian Brook at times must be quite as great. Freshet in the Cheticamp River.

In the neighborhood of the Baddeck camp, the river flows in narrow alder and hay-marshes, and the hills are timbered with hard-wood and spruce. At the head of John McDonald's Brook similar marshes are found with small ponds. Most of the timber on all the hills about St. Ann's and Baddeck has been blow down by gales, the eastern slopes having suffered most. Northeast from this camp there is little variety in the character of the country, which is covered with spruce, birch and mountain ash, and has a few not very steep slopes, often strewn with windfalls. Then comes an area of mossy marshes with scraggy spruce and alders, extending to the North River. The brook from the small lake in the neighborhood leads in a winding course through hay-marshes, to John McDonald's Brook. Southeast of the camp, for more than a mile, the country is comparatively level, with several small, marshy depressions; then a little brook begins from a narrow marsh, runs into lagoons and to the Baddeck lakes. These lakes are famous for trout-fishing, and the shores are easily accessible, being laid with small flat pebbles or boulders, and none of the lagoons being difficult to get round. Baddeck River. Baddeck lakes.

The branch of the North River of St. Ann's, southeast of Peter's barren, flows in its upper part through level land and marshes. On a traverse southwest from the confluence of this with the main river the line for some distance ascends through spruce woods, blown down on top of the hill, and strikes the west branch among alder and grass-marshes. Below this point, the river runs comparatively level, nearly to the great falls, showing pretty sand beaches, alders and grass, the banks being always wooded. In the upper part of this branch and near Ranald's Brook, the country is covered with light timber, scraggy spruce, ferns, sarsaparilla, pigeon-berries, moss, white maple-bushes and alders. The land is of fair quality, not much elevated above the brooks which come from springs. In Ranald's Brook the banks are sometimes precipitous, at other times sloping, and wooded with birch, mountain ash, spruce and small white maple, some of the birches yielding large sheets of canoe-bark. North River of St. Ann's.

In all the rivers that pass through Carboniferous rocks, intervales occur, of which the principal have been already mentioned. They are Intervales.

* Goldfields of Nova Scotia, p. 10.

all remarkably productive. In some cases, however, as in the South-west Margaree, the valley is narrow, and the cultivable meadow land consequently scarce. But although the river is here in a deep valley, the upland is good, and above the road is a line of sloping, well cultivated land, behind which lie steeper, often rugged, wooded hills.

Sea shore.

The sea shore is always high and rocky when occupied by Pre-Cambrian rocks, and even when formed by Carboniferous strata if these latter be sufficiently coherent to resist abrasion. On the Bras d'Or Lake the shores are as a rule low.

Sand beaches.

Long sand-beaches occur in many places, the principal of which are at Aspy Bay, St. Ann's, Broad Cove and Mabou. That at North Aspy Pond is three miles long, and is covered with small conical mounds of sand, a little coarse grass and a few other plants. A long sand beach occurs at the head of Cheticamp Harbor, and the country thereabout is sandy from the disintegration of the grey sandstone which forms the coast.

Want of harbors.

There are no good ship-harbors on the coast from the Strait of Canso round by Cape North to St. Ann's, the best being the open roadstead of Port Hood, Mabou Harbor, and the Eastern Harbor of Cheticamp. Attempts have been made to improve those of Mabou, Margaree and Ingonish with tolerable success considering the difficulty of the undertaking and the small sums of money granted by the Dominion Government for that purpose. It has also been proposed to cut through the beaches at McIsaac Pond and Aspy Bay. "McIsaac Pond* covers an area of eighty-four acres, has a depth of water varying from ten to twenty-five feet, and is separated from the Gulf by a beach of coarse shingle, two and a-half feet above high water, resting upon a bed of mud and sandy subsoil. The water to within a few fathoms of the shore is deep, with excellent holding ground and the absence of rocks and shoals renders the approach easy and safe; so that it is only necessary to construct a breakwater-channel to render the pond a safe harbor of refuge in the vicinity of the most prolific fisheries of the Gulf of St. Lawrence, and afford facilities for shipping coal. A survey of the locality was made in 1878 by Walter M. Buck, C. E., who estimated the cost of opening the beach at $19,347."

McIsaac Pond.

Aspy Harbor.

Inside the beach of the north pond of Aspy Bay, for a distance of two miles, there is a harbor with two and a-half to three fathoms of water, but at present the entrance is not permanent, the water breaking through in different places, Aspy Bay is said to be easily accessible for vessels, and not closed by ice in winter. The sand is not more

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* Report of the Inverness Coal, Iron and Railway Co.

than two feet deep, being underlaid by clay, and outside the beach the water deepens rapidly. The distance between the points of three fathoms deep outside and inside the bar will not much exceed 300 yards; and the holding ground is good, for there seems to be a deep substratum of stiff boulder clay into which piles can be driven to any depth that may be deemed necessary.*

TIMBER, CLIMATE, ETC.

The trees, plants and animals mentioned in my last report are also to be found in the region further north; and incidental mention has already been made in the foregoing pages of the timber characterizing particular districts. The trees of the intervales are large and good. Fine elms and oaks occur in the valleys of Cape North and Pleasant Bay. The slopes of the hills are also heavily wooded as well as the summits with lighter timber, except on the barrens already described. A few pines of considerable size occur in the brooks at Neil's Harbor and in Little River further south; but they are of no economic value. Here we should like to pay tribute to the exquisite beauty and great variety of the woodland flowers and to the flavor and abundance of the small wild fruits. Trees. Wild flowers and fruits.

Oysters are found on the low gravelly flats about Portage Creek, St. Patrick's Channel, Whycocomagh Bay, and other parts of the Bras d'Or Lake; and heaps of clam shells on the shores of the lakes and creeks where some mink or muskrat has been feeding. Lobsters abound on the coast. Herring, cod, mackerel, halibut and other fish, are taken everywhere, and wherever there is a boat harbor it is thronged with huts. Trout are found in all the streams. In Lake Law trout and eels abound, and gaspereaux also are said to have ascended to the lakes before the construction of mill dams on the brook. In the first branch of the Indian Brook of St. Ann's, above the shore road, among the falls, numerous small eels four inches in length were seen. A wonderful trout-pool in which salmon are also occasionally taken, is that on the Lake Ainslie Trout Brook just below the bridge on the shore road. But for salmon fishing the Margaree River below the Forks and the Northeast Branch have the widest fame. The latter is fished for many miles above the settlement, there being no great falls; and trout are found in abundance at the very head. Among other excellent salmon streams are the Barasois River, the middle branch of the North River, the Indian Brook as far as the falls, and the Cheticamp River to the foot of the gorge. Oysters. Fishes. Trout. Salmon.

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* Campbell's Gold Fields of Nova Scotia, page 11.

Cariboo and moose.

Herds of cariboo roam over the barrens, on one of which, not far from Big Intervale, about a hundred and fifty were counted one day about the end of October, 1881. Moose, once numerous, are now seldom seen.

Scenery.

The scenery around Whycocomagh, Little Narrows, Baddeck and Great Bras d'Or is not less charmingly picturesque and varied in feature than in other parts of the Bras d'Or Lake, but is surpassed in grandeur by St. Ann's, Ingonish and Cape North. The country inland about Brigend, Whycocomagh, Lake Ainslie and the head of Southeast Mabou is like other conglomerate districts. Cape Mabou resembles the highlands elsewhere, and the glens are very beautiful besides being easy of access. The brook near McDonald's shop, Middle River, has a valley of singular beauty. The best known, however, is that of Lake Law, with its chain of deep, dark lakes, overshadowed by hills which are finely sculptured and, as it were, isolated by the brooks which form gulches between them. The black shadows thrown upon the surface of the lowest lake by these hills are particularly fine by moonlight, and many a study of lights and shadows is afforded in this vicinity, Another good view of these lakes is obtained from the upper end when first the traveller from Middle River comes in sight of them.

Lake Law.

From the top of the barren between McRae and Pine Brooks there is a fine view of the valleys of Middle River and Margaree, the Bras d'Or Lake, Boisdale Hills and all the region towards the Gulf of St. Lawrence, the hill descending most precipitously on the Margaree side. A good view of the settlement of Northeast Margaree and the Sugarloaf can be obtained with much less fatigue from the road between John Miller's and John Coady's on the opposite side of the Big Brook. And in every part of the Margaree River the scenery is romantic, abounding in that variety of feature of mountains and glens and valleys in which the beauty of Cape Breton inland or river scenery consists, aided greatly by the sculpture of the hills, the alternation of patches of spruce and hardwood, of farms and woodland, gentle slopes and rugged precipices, and by the silvery threads of the brooks winding down from the hills in fine curves or falling over the cliffs after emerging, as it were, from the solid rocks on a steep face—an appearance due to a sharp turn in the brook which conceals the upper part from view. The haze which often hangs over these hills contributes greatly to their beauty by softening the outline, and through it the dull red sun makes rosy the few clouds floating through the prevailing blue. The dark blue or indigo of the distant hills, the cloudy green of those a little nearer and the bright green and sharply defined outline of those close at hand produce an effect of color that cannot be

Margaree River.

described, but is well seen from the pass at the head of the pretty glen of Coolavee at the narrow belt of marsh-land from which brooks flow northeast and southwest. The scenery of the Big Intervale, and the two valleys separated by the Sugarloaf, is justly admired by everybody who has visited them. Big Intervale.

The shores display bold striking views wherever the Pre-Cambrian rocks are in place. The hill behind the Lake settlement of Cheticamp is rounded on top and appears like a huge dome, being separated from the adjoining hills by a pass and two glens, one running to the Farm Brook and the other to the Factory Brook. At the lake the country is cut into mounds and hollows by gypsum. In the Farm Brook is a very beautiful fall with a pool at the bottom and magnificent cliffs, and there are others in various parts of the country. The land along the shore from Cheticamp to Cape Rouge is very hilly, and great difficulties lie in the way of building a road to Pleasant Bay. A road could probably be made through the interior from Big Intervale across the head of the Rocky and Campbell's Brooks to Cape North settlement, crossing the Cheticamp River above Artemise Brook. A magnificent view of Pleasant Bay is obtained from the hills between that bay and Fishing Cove. Cheticamp.

About Cape North the scenery is very striking. The cliffs are massive, the glens pretty, and the sea shore wild. The short brooks are steep and rough, full of rapids and cascades and with small scraggy barrens at the head; the longer ones, like the rivers elsewhere. At Sparling's Brook, Mr. Zwicker some years ago erected buildings for curing salmon, at a cost of $400 or $500, all of which were swept away by the sea. Wilkie Brook runs for many miles in a level, wooded valley which the cattle follow. Cape North.

The Big Glen of Baddeck is very beautiful, and in the tributary of the Northeast Branch, which crosses the road a quarter of a mile south of this branch the hill on the north is a huge dome beside which the brook runs in a beautiful hardwood valley. The water is bright and cold, the stones covered with greenish-yellow moss, grass, etc. Diorite floors the brook, which is overarched with maple bushes. Baddeck glens.

St. Ann's is also noted for its bold and imposing scenery, which has been compared* to that of Mount Desert in Maine. A curious feature of the syenitic hills of the east side of St. Ann's Glen is the ridged and furrowed character of the surface, the hill being so narrow and high that the water instead of forming definite brooks comes down the slopes in hundreds of tiny brooklets. But grand as are the combinations of sea, land and sky—the high massive hills, gullied brooks, St. Ann's.

* Warner's Baddeck and That Sort of Thing.

stretches of sand, fields and wood, the ever moving sea and quiet ponds—which enter into the magnificent scenery of St. Ann's and the North Shore, they are well nigh forgotten within sight of the mountains of Ingonish. Two deep bays, separated by a narrow, picturesque, rocky promontory, opening upon the sea and nestling, as it were, among the mountains; these mountains, the highest in Nova Scotia, an imposing feature in the precipitous rise of their sculptured sides from the rivers which flow into the bays; outside the open sea, which gives evidence of its power by the huge boulders piled far above high tide upon the breakwater; large brooks coming down, deep, gloomy and solitary valleys—"the mysterious entrance into far valleys in the unseen mountains behind"; life in the foreground, the huts of the fishermen on the shore, the vessels in the harbor, the white sails of the American fishing fleet here and there along the shore, gulls and ducks on the water, and beyond a lighthouse on an island. Although the road over Smoky Cape is steep, it is good, and on approaching the South Bay we obtain from the hill top a view of the sea and the bay below which fills us with delight. The sea, over-shadowed by the hills, the waves rolling on the beach and booming along the cliffs produce a pleasure not unmingled with terror.

Ingonish

Farm produce.

The crops raised in northern Cape Breton are the same as those of the south. Apples, plums, cherries and other fruits are largely grown at Mabou, Lake Ainslie, Margaree and elsewhere. Oats, wheat, barley, buckwheat, hay and potatoes are the principal crops, and seldom fail to ripen.

Seasons.

The season differs in the valleys and on the hills. Spring is sometimes very late owing to the quantity of drift ice on the shores. On June 7th, 1881, patches of snow were seen in some of the sheltered glens about Northeast Margaree, while at the same time there were banks of violets in the neighborhood. Two days later, mayflowers (*Epigœa repens*) were found on the hill between Cape Rouge and Fishing Cove. On the top of the hill between Pleasant Bay and Cape North on June 13th, there were three feet of snow, and two days later three feet and a-half on the road between Wilkie's Sugarloaf and Bay St. Lawrence. Bake-apples were in great abundance on Peter's barren on August 3rd. Wild cherries were ripe at Ingonish on September 11th, and blueberries and huckleberries about the same time. In many parts of Cape Breton there are said to have been eight feet of snow on the level in the winter of 1881-2, and twenty to thirty feet in the gulches. On June 6th, 1882, there was ice in Sydney Harbor and the steamer could not go round from the Bras d'Or Lake to Sydney. On the mountains, in the woods bordering the barrens of Margaree, snow was seen on June 23. But both of these seasons were remarkably backward, and, notwithstanding their lateness, harvest does not seem to have been later than usual or less abundant.

In 1883, on the other hand, when the shores were free from drift ice all spring, root crops and a considerable quantity of grain had been put in the ground before April 20th.*

ECONOMIC MINERALS.

Coal.—The want of suitable harbors has hitherto retarded the development of the valuable seams of coal found on the Gulf shore at Port Hood, Mabou, Broad Cove and Chimney Corner; so that although several attempts have been made to establish collieries at these places, none of them have been successful, the cost and uncertainty of shipping having deterred vessels from coming here to load, when the harbors of the Sydney and Pictou coalfields were so much more safe and accessible; and the hope of all the collieries on this side of the island lies in the construction of a line of railway from the Strait of Canso northward. The following particulars respecting the work done at these mines are mostly derived from the reports of the inspectors of mines for Nova Scotia.

Port Hood Mines.—At Port Hood, in 1865, a slope was driven 300 feet northwest at an angle of 27°, by the Cape Breton Company, on the six feet seam, and in this and the two following years 8,503 tons of coal were sold from the mine. At distances of 50 yards on the slope, levels were turned on each side and working places won out. The bords were driven ten feet wide and pillars left six to eight feet thick and the full length between each level. The upper levels were driven from 500 to 300 feet, and the lower 150 feet in each direction. The seam varies a little in section as seen on different sides of the slope, and about 200 feet in each direction from it.

Cape Breton Co.'s mine.

South Level.			*North Level.*		
Coal with bands	1	5	Coal, coarse	0	8
Slaty band	0	9	Coal, with partings	0	10
Coal	4	2	Coal, good	4	4½
	6	4		5	10½

No pillars have been worked. A short distance south of the slope, a shaft was sunk to the upper level. An adit from the shore was also connected with this level on the north side, and drained the mine to the extent of about 180 yards from the crop. A steam engine of 14 horse power was erected to pump and haul. The expenditure for 1866-68 was $35,081.

* In the Report for 1879-80, page 116 F., 16 lines from bottom, "29th of April, 1879," should read "29th of October, 1879."

Tremaine's mine.

North of the Cape Breton Company's slope 2,220 feet, and about 600 feet north of the lighthouse, a slope was driven in 1875 to win the coal on a sea area held by E. D. Tremaine and others, which reached the area at a distance of 478 feet on the pitch of the seam, where it had a minimum cover of 150 feet. Beyond 600 feet there was a sufficient cover of solid measures to permit a portion of the coal to be removed. The slope dips at an angle of 23° 30′ S. 85° W., is 10 feet 9 inches wide and 6 feet high, accompanied by a return slope. At a depth of 660 feet two levels were driven to test the seam, which obtained a good reputation as a house and steam coal. A hoisting engine of 26 horse power was erected, with a single 12-inch cylinder and 2 feet stroke, and a drum 6 feet in diameter, to which steam was supplied by two plain cylindrical boilers 30 feet long and 30 inches in diameter. In 1877 a few hundred tons of coal were taken from the pit, which was, however, closed in 1878 owing to an explosion of one of the boilers, and has not since been re-opened.

"The destruction of the bar which connected the mainland with Smith Island, exposing the harbor to the north winds, is a great drawback to the opening of any colliery at Port Hood. As the public wharf, 500 feet long, is fast silting up with the drift from the north, it is thought that sunken blocks, well ballasted, would with comparative quickness collect the drift, and that in this way the bar might be restored. The Cape Breton Company shipped outside the light, but the ice was very destructive to the wharf." *

Mabou Coal Mines.—Owing to the absence of a shipping place, and to the limited extent and faulted condition of the basin, no coal for other than local use has been extracted from the Mabou area, although the quantity in workable seams underlying one square mile is estimated by Mr. Brown at 27,000,000 tons.

Mr. Robb's description.

Broad Cove Mines.—The extent of this coalfield is somewhat obscure, as well as the relation of the different seams to one another, but the quantity of coal underlying it is without doubt very large. The condition of this district in 1873 was described by Mr. Robb in the Report for 1873-74, page 182. In 1877 a level was driven westerly 100 yards, from the bank of the river below the bridge, at John McIsaac's, 2,500 feet from high water, above which the land rises and gives a lift of nearly 100 yards on the seam, the lower portion of which for 40 yards was opened by a second level used as a return air course. Between the levels headings were put up every chain. A small portable engine of 10-horse power is used at the mine. In 1879 an incline was started which cut the levels obliquely. The coal shipped

* Mr. Poole's Report for 1875.

was conveyed on a wooden tramway to the mouth of the river, where it was dumped into lighters, and from them transferred on board small vessels at anchor in the roadstead. The quality of the coal is fully equal to that from most of the Cape Breton mines; but in the absence of shipping facilities the owners of this mine can only hope for the construction of the railway to the Strait, or of an artificial harbor at McIsaac Pond.

Chimney Corner Mines.—Operations on a large scale were carried on at these mines between 1866 and 1873, at a cost of $44,538. These were principally confined to the lowest seam, but in 1868 a drift was put in on one of the out-lying seams three feet six inches thick, and a few working places turned out of it. In the following year a slope was driven from the surface on the main seam, an engine erected for pumping and hauling, and other arrangements made to place the mine in a condition for shipping coal. This seam was proved by a series of pits for a distance of half a-mile, and on the same course pits were sunk at intervals for a distance of three miles from Chimney Corner Cove, and seams of coal exposed, which are the supposed continuation of the upper group.

The workings lie nearly altogether beneath the sea, but the roof being comparatively impermeable to sea water no inconvenience was felt. "If, however, the main slope were situated about half a-mile from the harbor, the thickness of the strata between each seam would admit of two or three seams being worked together, and the increased thickness of the roof would guarantee the security of submarine workings."*

In 1872 the main slope was 400 feet down, levels had been driven to the southeast 300 to 800 feet and working places formed. Another slope had also been connected with the workings for ventilation, and a tramway constructed along the face of the cliff to a shipping place. One of Cameron's special steam pumps, No. 6, kept the mine free from water. The shipments of coal were not large, and the destruction of the engine house and miners' dwellings by fire on March 3rd, 1873, brought the mine to a standstill, and it was not re-opened till Mr. Evans' return in July, 1882. The works are now again in partial operation, and it is hoped that coal will be shipped in the summer of 1883. Prior to the fire about 10,000 tons of coal are said to have been shipped to Nova Scotia, Prince Edward Island, and various places in the United States and Canada.

Professor Hind estimates the land area underlaid by the three upper seams at three-quarters of a square mile and the water area at

Professor Hinds estimate of the quantity of coal.

* Professor Hind.

half a mile, assuming that the latter is thus limited by the syncline seen on the coast further south, and which is supposed to lie half a mile to the westward of the mine. The quantity of coal in these areas combined he estimates at 15,000,000 tons, or deducting half for pillars, waste, etc., 7,500,000 tons of available coal; and if the lower seams should prove as valuable as is supposed, this estimate must be greatly increased.

Coal of Bay St. Lawrence.

The "coal" of Bay St. Lawrence, on the shore at Burton's, near Salmon River, is a black bituminous shale, full of patches of limestone and silica, and containing traces of bright coal in seams. Associated with this are grey and bluish-grey shale and sandstone, which probably underlie the gypsum. The coal is of no economic value.

Peat-bogs of considerable extent, "capable of yielding an unlimited supply of that description of fuel of the finest quality,"* occur on all the barrens of the district, but particularly, as pointed out by Mr. Campbell, on those of the northern wilderness.

About a mile south of Mabou Harbor is a three-feet bed of peat with trees in it.

Lake Ainslie.

Petroleum.—From the circumstance that drops of oil ooze from the dark shale and sandstone on the shores of Lake Ainslie and spread themselves over the surface of the water it has long been believed by many that large reservoirs of petroleum, like those of Ontario and Pennsylvania, might exist in this neighborhood and be discovered by boring. Within the last twenty years, consequently, several companies have been organized for the purpose of testing this question, but have met with bitter disappointment.

In 1874 two boreholes were put down, the first of which it is said gave indications of oil, but was lost at a depth of 650 feet by the breaking of the rods. The second hole was put down to a depth of over 900 feet. Altogether some $20,000 were expended.

Baddeck River.

Result of borings.

Several years later numerous holes were sunk both on the eastern and western sides of the lake, to a depth, it is said, of 1.100 feet, and also at McRae's bridge near Baddeck. Engines and derricks were erected and upwards of $100,000 expended in the two years 1880 to 1881 † with no other result than to prove the probable groundlessness of the belief in the existence in paying quantity of the petroleum, which is contained apparently only, in small quantity, in the highly bituminous rocks of the neighborhood, as at Gaspe and Memramcook, New Brunswick, where similar trials have been made.

Iron Ore.—Further explorations have been made in Cape Breton

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* Campbell's Goldfields of Nova Scotia, page 8.

† Report of Commissioner of Mines.

county and elsewhere by persons interested in the contact deposits of red hematite; but no mining has yet been done. A specimen of hematite from the head of Loch Lomond, analyzed by Mr. Adams * yielded 64.494 per cent. of metallic iron, .034 of phosphorus and .078 sulphur. On Philip McDonald's farm, boulders of iron ore weighing 1,000 lbs. are said to have been found. At Archibald McVicar's, an opening has been made in a bed of red hematite near an outcrop of grey granular felsite. *Loch Lomond.*

Mr. Moseley has still further developed the deposit between East Bay and Boisdale, † and the bed in the eastern opening is now 13 feet thick. ‡ *Red hematite at Curry's.*

Between the head of Forks Lake and East Bay, in Smith Brook, red hematite was exposed in some trenches cut across beds of purple and dark felsite and bands of clay. It is apparently in lenticular veins following the stratification in a general way, seldom exceeding three or four inches in thickness and said to contain a large percentage of phosphoric acid and manganese dioxide. Between Smith Brook and Macbeth's there is a vein of micaceous iron ore varying in size from a foot downward, in a dark soft belt in the felsites on the side of the mountain. *Smith Brook. Hematite in veins in Pre-Cambrian rocks.*

Very fine specimens of specular iron ore and red and brown hematite are found on Donald Campbell's land, Lewis Mountain, but apparently only in small veins. Hematite also occurs in vugs in felsite a few hundred yards below the grist mill on Lewis Mountain road. *Lewis Mountain.*

The Gairloch Mountain iron ore is described on page 5. An analysis § shows it to contain 69.295 per cent. of metallic iron. Mr. Evans mentions the occurrence of specular iron ore at Lake Law. Mr. John McLeod of Big Intervale, Margaree, showed us specimens of red hematite said to have been found in the vicinity. Many of the rocks in other localities contain these ores in traces. The red syenite of the Middle Aspy River contains hematite in the joints, often associated with talc so as to become soft and soapy. Hematite is stated to occur between Cape Rouge and Pleasant Bay. *Gairloch Mountain.*

No further test has been made of the extent and quality of the iron ores of Whycocomagh, described in the reports for 1873–74, page 180, and 1875–76, page 415. *Whycocomagh.*

A deposit of specular iron ore has been worked to some extent near the shore of Robinson Creek, at the western line of the Indian Reserve in Richmond county, by Messrs. Joseph Matheson, of L'Ardoise, and

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* Report for 1880–81, page 7 H.
† Report for 1877-78, page 28 F.
‡ Mr. Gilpin. Report of Commissioner of Mines for Nova Scotia, for 1881, page 15.
§ Report for 1879–80, page 14 H.

Salmon River Indian Reserve.

John Morrison, of St. Peters. The ore has been extracted from pits, several hundred feet apart, near the limestone of that vicinity, which also contains calcspar veins holding traces of copper pyrites. But the relation of the ore to the surrounding rocks is obscure, and its occurrence is perhaps, like that of Guysboro county, dependent on the intrusive rocks of the neighborhood. Specimens were presented to the Geological Museum by Mr. Paint, M. P. The result of a partial examination of this ore will be found in Mr. Hoffmann's report (p. 17 M M).

Magnetic Iron Ore is found in the sand of nearly all the beaches, but more especially on those of Aspy Bay, Ingonish and St. Ann's, and is said by Mr. Campbell to be abundant at some points between Pleasant Bay and Cape St. Lawrence. Near McKinnon Intervale a large block of labradorite, 12 by 10 by 8 feet, which is to all appearance a boulder, contains blotches and streaks of magnetic iron ore. In a pit near it the parent rock is said to have been found by Mr. James McKenzie of Sydney, but to the south and north plaster occurs. Blocks of similar felsite were also seen in the roads and fields of the vicinity.

Titaniferous Iron Sand was found in the washings in the Middle River goldfield.

Manganese Ore.—Large deposits of pyrolusite, which promise to be of great importance, have recently been discovered and developed by the Hon. E. T. Moseley of Sydney on the south side and near the head of Loch Lomond in Cape Breton county. The ore is associated with lower Carboniferous rocks and has been worked in two places about three-quarters of a mile apart. At the most easterly of these, in a brook on the farm of Norman Morrison, a tunnel has been driven about 30 feet on a vein about 7 inches thick, dipping N. 87° W. < 25° in red fine sandstone overlying reddish and greenish grit, with grains of quartz about the size of wheat, and red marly sandstone. The ore is irregularly mixed with red and grey bituminous limestone, red and greenish shale, conglomerate and other rocks, blotched with calcspar. It is in lenticular layers and also intimately mixed with the limestone, being probably of the same nature and origin as the hematite and forming at times a cement for the pebbles of the conglomerate.

Loch Lomond.

Morrison mine.

McCuish mine.

At the western or McCuish mine the ore shows in streaks in a red marl or sandstone dipping S. 89° W. < 32°. A number of bands of ore in a belt here occupy the bedding-planes of a bright-red argillaceous shale. The main seam is generally overlaid by red, calcareous, argillaceous shale and limestone, while conglomerate lies below and is also found in thick beds in the adjoining brook. At one point a lenticular band of dark conglomerate comes between the shale and the ore.

Yield.

These mines were first worked in 1880. In 1881 about 70 tons and in the following year 59 tons of excellent ore were shipped to the

United States where it is applied to the preparation of chlorine used in the manufacture of bleaching powder, to decolorising glass and other purposes. It is very free from iron and remarkably pure. An analysis of a sample from the Morrison mine afforded Mr. Adams* 91.84 per cent. of manganese dioxide, only 12 per cent. of ferric oxide and 2.91 per cent. of insoluble residue. Other analyses are given by Mr. Adams, but without mentioning from which mine the samples come, in the Report for 1879-80, page 17 H. Owing to the recent great rise in the price of manganese, these mines will, it is hoped, prove exceedingly remunerative; and it is not improbable that, associated with similar strata in other places, deposits equally rich will be discovered. Mining is conducted by open quarrying and tunneling, and it is the intention of Mr. Moseley to erect an engine for pumping and other purposes. Composition of ore.

Samples of bog manganese from Big Harbor, Boulardrie Island, have been analyzed by Mr. Adams,† the best of which was found to contain 25.42 per cent. of manganese dioxide and 33.52 per cent. of water. Boulardrie Island.

Galena.—As already remarked, many of the lower Carboniferous limestones hold traces of galena, but the attempts frequently made to develop some of the most promising have resulted only in disappointment. On the hill at D. No man McVarish's, Southwest Margaree, one of these limestone strata is full of minute veins of calcspar and quartz, holding minute traces of galena. At Pleasant Bay, near the mouth of Mackenzie River, grey quartzose grit with patches of greenish and reddish fine sandstone, is associated with a dark-grey and brownish, highly bituminous, limestone, with calcspar veins. The veins hold galena, which is also disseminated in the limestone and grit. These rocks do not extend far inland, but are surrounded by the underlying gneiss. The galena occurs chiefly in two veins $5\frac{1}{2}$ and 3 feet thick respectively, and a shaft 15–20 feet deep has been sunk in each. The galena contains both silver and gold, and is associated with copper pyrites. At the mouth of the river copper pyrites and galena appear in specks with iron pyrites and fluorspar in the strings of white quartz which penetrate the syenite and granite. Professor How mentions bitumen also as found in the calcite of this locality. The "mine" has been known for many years and a large sum of money spent in exploring it. Southwest Margaree. Mackenzie River. Bitumen.

In Cape Breton county, near the head of Loch Lomond, small pits have been sunk in massive grey limestone containing fossils. A minute quantity of galena is disseminated in it as small grains. In a large brook between this point and Mira River is a dark breccia, Salmon River.

* Report for 1881-82, page 12 H.
† Report for 1881-82, page 12 H.

probably one of the basal beds of the millstone grit, containing large fragments of compact felsite, bound together by a rusty calcareous cement containing galena. Some of the layers for a thickness of four feet have been mined and several tons of ore extracted. A specimen analyzed by Mr. Adams* yielded 2.879 ounces of silver to the ton, the galena constituting but a small proportion of the whole.

Port Hood. A small vein containing galena, of no commercial value, was also found in the sandstone of the coal measures at Port Hood, between two seams of coal, and traces of galena also occur in the Pre-Cambrian rocks as in Cheticamp River.

Cheticamp River.

St. Ann's. Some further desultory work has been done at the North River of St. Ann's at the mine.† In the workings the vein now dips N. 83° E. < 30°, and carries calcspar, varying from 1 foot 7 inches downward, but where thickest it is barren and split by bands of the country rock. In one place it is six inches thick and contains three quarters of an inch of galena, but generally the galena is mixed with yellow and purple copper ore, or sometimes nearly replaced by black blende.

Barasois River. Further explorations in the veins in the syenite of the Barasois River‡ have not led to an improvement in their prospects, the largest being less than six inches in thickness. In some places, however, the vein consists almost entirely of pure galena, while in others copper pyrites is present.

Copper Ore.—The wide dissemination of traces of copper ore among the Pre-Cambrian rocks in the Carboniferous conglomerate at its contact with limestone, and also in the associated igneous rocks, lensd strong confirmation to the opinion that notwithstanding the many failures hitherto, to find a workable deposit, such will yet be discovered.

Whycocomagh. In a branch of Brigend Brook, near Whycocomagh, Mr. Duncan McDonald found a vein of quartz containing, it is said, copper pyrites with traces of gold and silver; and some mining was done in it. In Campbell Brook is a vein from four to six inches thick, traceable for several feet. It contains copper pyrites, which is also found in some of the felsites of the neighbourhood.

Great Bras d'Or. In a brook flowing into the Great Bras d'Or, east of Big Harbor (Port Bevis), a pit has been sunk in a diorite containing quartz veins, from which a little copper ore and galena were extracted. On the shore of St. Ann's Harbor, inside the beach and opposite Englishtown, the cliffs of dark purple porphyritic and epidotic felsite contain irregular lenticular veins of calcspar and quartz, seldom exceeding three inches. These hold copper pyrites, galena, hematite, etc., and have been to

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* Report for 1881-2, page 12 H.
† Report for 1876-7, p. 452.
‡ Report for 1876-77, p. 452.

some extent tested by Lieut.-Col. Bingham, Judge Tremaine, and others, whose enterprise deserves to be successful.

For some years prior to 1865 a company was engaged mining for copper ore at Cheticamp, and in 1864 about 12 men were employed. A shaft was sunk to a depth of 106 feet and connected with an adit 410 feet in length. An air shaft, 30 feet in height, was also cut from the adit level to the surface of the ground. But not proving productive the works were discontinued.* They are situated in the vicinity of the trap and sandstones of the base of the Carboniferous. Professor How mentions that green and blue carbonate of copper, grey and yellow copper ore in calcite, and chrysocolla are found at Cheticamp, probably at this mine, or in that at Jerome Brook, as well as perfect crystals eight inches long, of red felspar, in the Pre-Cambrian syenite of the neighbourhood. Cheticamp.

Further north, on the coast near Jerome Brook, pits have been sunk in a dioritic rock showing an irregular vein of calcspar, quartz and baryte, containing yellow copper ore, changed into green carbonate on the surface. In places this vein is more than a foot thick, but in others it thins out entirely and takes up again on the strike of the diorite. Higher in the cliff are blotches and vugs full of crystals of quartz associated with copper ore and magnetite. The deposit resembles that of St. Ann's and gives little promise of persistence. In the traps of this neighbourhood native and vitreous copper, together with the rare zeolite, poonahlite, are reported by Professor How to occur. Jerome Brook.

North of Cheticamp, copper ore is seen at Poulet Cove, near Money Point, and elsewhere, about Cape North. Traces are also found in McLean and Stewart Brooks, in the Big Intervale of Margaree, but none of economic value. Poulet Cove. Margaree.

A shaft was sunk 75 feet on the Eagle Head copper ore in 1880 and a considerable quantity taken out.† Gabarus.

Mining has been vigorously prosecuted at the Coxheath copper mine since 1878, the property having passed into the hands of an American company. The tunnel referred to in the Report for 1879-80, page 123 F., was driven about 35 feet, but not far enough it is thought to cut the bands of rock carrying the ore. Long costeening trenches were then cut and a shaft sunk about 50 yards upstream from the tunnel, which passed through some excellent bands chiefly of purple ore, accompanied by a considerable quantity of iron pyrites. About 1,000 feet above this shaft another was sunk 15 feet in the brook, from which fine specimens of yellow copper ore were taken. About 700 Coxheath copper mine.

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* Report of the Commissioner of Mines for Nova Scotia.
† Reports for 1875-76, page 415, and for 1877-78, p. 29 F.

feet further up the brook in the same belt ore was again found, and in many small pits in the neighbourhood. During the last two years mining operations on a much larger scale have been carried on. Two shafts, 1,000 feet apart, have been sunk to a depth of 156 and 140 feet, and in the autumn of 1882 were furnished with hoisting engine, steam pump and power drills and a Blake crusher. A blacksmith's forge, store, laboratory, engine houses and other buildings have also been erected. In the main shaft, at a depth of 120 feet from the surface, a crosscut was driven and cut the ore three feet from the shaft, but was continued about 80 feet in the hope of cutting a parallel lode. The ore was drifted on and a little stoped out. Twenty feet lower, drifts were pushed east and west, nearly 80 feet in each direction, showing, it is said, a large quantity of paying ore. In the east drift a winze was sunk 30 feet. In addition to copper the Coxheath lode also carries silver. Two assays, by C. T. Lee, of samples of the ore yielded:—

Buildings and machinery.

I.

Silver,	35	oz. per ton: Value	$ 38.50
Gold,	$\frac{1}{5}$	" " "	4.13
Copper,	$20\frac{1}{5}$	per cent. per ton: Value	60.00
Total value			$102.83

Composition of ore.

Lead—a trace. Arsenic—none.

II.

Silver,	73	oz. per ton: Value	$ 80.30
Copper,	21	per cent. per ton: Value	63.00
Total value			$143.30

Prof. R. H. Richards, of the Massachusetts Institute of Technology, assayed a sample of chalchopyrite, galena and quartz, which yielded:

Silver,	56	oz. to the ton: Value	$ 61.60
Copper,	$15\frac{1}{10}$	per cent. to the ton: Value	45.30
Total value			$106.90

The explosive used is principally dynamite, of which two and a-half tons were laid in last fall for the winter's use. The blasts at both shafts are exploded by electric batteries. Mr. H. C. Burchell, C. E., is the manager of the mine, while the company's consulting engineer is Mr. T. W. Revere.* It is to be hoped that the energy and capital thrown into this enterprise will not be wasted.

Great Bras d'Or.

Gold has been supposed to occur in various parts of the Great Bras d'Or and Little Narrows; and fruitless search has been made for it. At Charles McLellan's (tanner), Broad Cove Chapel, a pit was sunk 25 feet in the hope of finding gold associated with the iron pyrites in a

* Cape Breton *Advocate*, March 22nd, 1883.

bluish-grey argillaceous shale. About 20 years ago the existence of gold in the sand of many of the rivers was noticed by Mr. Campbell, who mentions particularly the Middle, Long Point, Northeast Margaree, Baddeck, Fisset, Cheticamp and Cape Rouge Rivers. But in only the first of these has gold been found in sufficient quantity for working, although Mr. Campbell found the sand of the Northeast Margaree nearly as auriferous. Mr. Campbell's explorations.

Middle River has been proclaimed a gold district by the Government, but is unlike the other districts of the mainland in the mode of occurrence of the gold in the veins and surrounding rocks. A farmer named Morrison, living in the neighborhood, was the first to call the attention of the Government to the gold found in the district, for which he received a free grant of an area on one of the brooks, and became one of the most successful in washing out gold. Middle River.

The first attempt, on an extensive scale, to test the gold in this river was made by an American company in 1867. They commenced operations near McLennan's bridge, on the Margaree road, by constructing sluices and other apparatus, with which they washed during the entire summer, and obtained, as I am informed by Mr. Alexander Wright, of Moncton, a considerable quantity of gold and several barrels of black (magnetic) sand.* However, as the expenditure exceeded the receipts, they did not continue their search, although it was shown that at this point, as well as for some miles upstream, every panful of gravel yields particles of gold.

In 1870 Mr. Wright and others tested by cradles, sluices and pans, in the same way, all the brooks above McLennan's bridge, finding gold in all those on the left bank. They also sunk a shaft in the main river with the view of reaching the bed rock, but an influx of water stopped the work. The largest piece of gold found is said to have been worth $12 or $15, but generally the nuggets ranged in value from fifty cents to $2. In several cases the gold was found adhering to quartz, although it was not found in any of the quartz leads of the neighborhood. Notwithstanding all the favorable indications no results proportionate to the outlay seem to have been obtained since the region was proclaimed a gold district, although numerous companies and individuals have at various times, sought for gold in this region. It may be that the proper appliances and an intelligent determination to test thoroughly the value of the district were wanting. Size of nuggets found.

Silver.—Mr. Campbell states that native silver in nuggets, in the surface drift and in strings and nests in sparry veins, occurs in Mackenzie River. Mackenzie River.

* Titaniferous iron sand according to Prof. How, who also mentions nuggets of bismuth up to the size of a pigeon's egg among the washings.

Limestone is found in abundance in all the Carboniferous areas, and is quarried for local use.

Baddeck quarries.

Gypsum.—The only quarries from which gypsum is exported are those at the head of Baddeck Bay and Big Harbour (Port Bevis), already described.† This is owing to their great facilities for shipping and to the excellent quality of the gypsum.

Clays fit for the manufacture of bricks occur in many places. White, red and brown clays are found at the south bay of Ingonish, and a reddish variety in the Skye River, near the schoolhouse, at Indian Rear. Bricks are made at Southwest Margaree and Lake Law. *Fireclay* occurs in connection with the coal seams at Chimney Corner, Broad Cove and elsewhere.

Bricks.

Building Stone.—Sandstones fit for building are confined chiefly to the coal measures and lower Carboniferous. They are quarried for local use at Southwest Margaree, Broad Cove, Cheticamp, Whycocomagh, Southwest Mabou and Pleasant Bay.

Marble.—Limited patches of marble have been frequently stated, in the course of this report, to exist at Whycocomagh, Middle River, St, Ann's, Ingonish, and elsewhere. Between Cape North and Bay St. Lawrence is a white point said to consist of crystalline limestone.

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† Report for 1875-76, p. 417.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., Director.

REPORT

ON

APATITE DEPOSITS,

OTTAWA COUNTY, QUEBEC.

BY

J. FRASER TORRANCE.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.

1884.

Dr. A. R. C. Selwyn, LL.D., F.R.S., &c.,

Director of the Geological and Natural History Survey of Canada.

Sir,

I have the honor to report that in accordance with your instructions received on the 17th May ult., I proceeded to Montreal to obtain any information and maps, procurable from Mr. Vennor or elsewhere, that might be of service to me in the geological explorations of the apatite-bearing region of Ottawa county. While there I engaged Mr. Wm. H. Howard, B.A.Sc. (McGill), and Mr. W. J. Torrance to assist me for the season.

My report of the season's work is herewith submitted.

I have honour to be,

Sir,

Your obedient servant,

J. FRASER TORRANCE.

28th March, 1884.

REPORT

ON

APATITE DEPOSITS,

OTTAWA COUNTY, QUEBEC.

BY

J. FRASER TORRANCE.

We left Buckingham together on the morning of the 7th June, and began our work in the field by a visit to the High Rock mines and the adjacent properties in Portland West, upon the right bank of the Rivière du Lièvre, not far below the High Falls.

High Rock Mine.

The "High Rock" property is owned by the Phosphate of Lime Co. (Limited), London, England. The principal pits have been opened upon Lots 5, 6 and 7, Range VII., and Lots 1 and 2 and part of 7, Range VIII.

The openings are all on one broad belt of pyroxenitic rock, with a general north-west trend. Proceeding in the same direction we come upon the Dugway Pits, and then to the Star Hill mine, belonging to the Union Phosphate Mining and Lands Company of New York and New Jersey. In the reverse (S.E.) direction, this belt exhibits remarkably rich surface indications and pockets of phosphate on Lots 1 and 2 of Range VII., Portland West.

The richest pit on the High Rock property, now abandoned and partially filled with water, was called the Bonanza Pit. It is on the north-east corner of Lot 7 in Range VII. In shape it is very irregular, both in its horizontal and its vertical sections. At the surface it averages about forty feet wide by sixty-three feet in length. At the water level its section is 60 feet × 66 feet, and its sump is said to be seventy feet deep; but this is probably an exaggeration. Its depth could not be ascertained with a line, as the pit was sunk on an incline

Bonanza Pit.

beneath its south-eastern side. Its enlargement in sinking has been caused by undermining the southern and eastern sides in "winning" flat stringers of apatite from two inches to one foot in thickness. In the centre of the pit there rises a kind of island of comparatively barren pyroxenite to a height of some twelve feet above the water level. It also has been much undermined on its western side in following a flat stringer of apatite about six inches thick.

A cutting has been driven from the edge of the hill to drain this pit, but it was not driven at a sufficiently low level to afford any permanent relief It failed to disclose any workable deposit of apatite. But this is not surprising, as the cut does not average over six feet in depth and about thirty feet in length.

The country rock is a crypto-crystalline green pyroxenite with finely disseminated apatite and occasional patches of coarsely crystalline white orthoclase. The walls and floor of the pit are everywhere dotted with crystals or scales of dark muscovite. The massive apatite occurs here in irregular masses of all sizes and attitudes. This pit is said to have yielded 700 tons of choice apatite.

I was much impressed with the admirable position of this pit for testing the question of the depth at which such deposits are likely to be worked to any great advantage. It stands on the brink of a hill, pitching sharply to the south-west, and the flat, locally known as the Beaver Meadow, lies about 400 feet below the pit. If a cutting were driven into the hill at any sufficient depth, at right angles to its general trend, it would in all probability disclose fresh deposits of apatite of sufficient extent to yield a very handsome profit upon the enterprise.

Economy of steam drills.

In such an undertaking it would be advisable to use a *pair* of steam drills to remove this large body of rock as cheaply as possible. It is to be regretted that the few companies at present employing such machinery in our phosphate mines are running single drills. While they thus save the capital required for the purchase of a second drill, and do not require quite so large or expensive a boiler, they employ almost as much labour for one drill as would suffice to work two. A fireman and a skilled mechanic, with an assistant, are requisite to work one drill. By the substitution of a slightly larger boiler and the employment of an additional assistant, two drills could be worked instead of one. The necessary repairs would cost less, and the work would be done twice as fast. When one drill is being run and it needs any repairs, the men are all idle until these are effected. But with two drills there is very little chance of both getting out of adjustment at the same time.

The next opening to the Bonanza is about 25 ft. to the south-east of it, and is on an extension of the same deposit. It is 84 feet long, running S. 60° E. mag., and it averages about 10 feet wide. Its general features do not materially differ from those of the Bonanza pit itself.

"Captain pit," also abandoned and full of water, lies to the north-west of the Bonanza. Its length is 150 feet and strike N. 65° W (mag). Its greatest width is 41 ft. and the least is 6 ft., averaging 18 ft. The country rock here also is pyroxenite, irregularly impregnated with apatite. Immediately on the north-east side of this deposit the country rock is a reddish gneiss, with a vertical dip apparently striking N. 70° W. (mag.) Openings on the High Rock property.

Pit No. 4 is 59 ft. long × 10 ft. wide, × 12 ft. deep. It is now abandoned, but is said to have yielded about 300 tons of prime apatite.

Pit No. 5 is about 32 ft. long × 15 ft. wide, with a smaller pit (21 feet long) at the north end of it, separated from it by 12 feet of comparatively barren rock. It is now abandoned, but is reported to have yielded about 250 tons of choice apatite. At the southern end of the opening, the pit is said to extend forty feet farther underground. But it was too full of water for us to see anything of this subterranean extension. The country rock here is chiefly pyroxenite with some white fine-grained felsite, reticulated with green pyroxene.

Pit No. 6 is about 41 ft. long by 25 ft. wide; now abandoned. The country rock is a massive dark pyroxenite, irregularly veined and impregnated with apatite.

Pit No. 7 is the nearest one to the company's office, on the northern side of the road from the wharf. Its length is 76 ft., on a strike N. 57° E. But its width varies greatly. At the E.N.E. end it is 50 ft. wide, in the middle only 16 ft. and at the other end 23 ft. The average depth in the western half was about 18 ft. (It is probably a good deal deeper now—February, 1884.) But the eastern end was full of water. The cross-cutting at this latter end follows the apparent strike of the country rock, which is here N. 60° W. astron., with a dip apparently S. 30° W. < 45-60°. But this observation was not entirely reliable. More pyrite was noticed in this pit than in those above described. In the northern side of the western end, the apatite was arranged in narrow vertical bands, and had every appearance of being a vertical vein. And there was a very rich show of apatite covering the bottom of that end of the pit, apparently lying almost horizontal. These two masses merge into one another.

This affords a good illustration of the difficulty of classifying these deposits of apatite. During the past season I often noticed in the same pit patches of apatite that might easily be taken for the contents of a fissure vein, if there were any casing rock on either side of it to separate it from the country rock, and patches of flat-lying apatite that Classification of deposits as veins or beds.

might easily be called bedded if they were of any great extent or approximately uniform thickness and if the country rock showed any planes of bedding parallel to the longest axes of such patches. Or else it might easily be assumed that the country rock had been more or less tilted and overturned since the deposit of the apatite, and that the vertical patches were interbedded and the more horizontal ones were veins, if their relations to the country rock were such as veins and beds respectively are wont to maintain. But, unfortunately, I failed to perceive these concurrent conditions.

The season's work has left upon my mind a strong conviction that these deposits in Portland and Buckingham are irregular segregations from the country rock; and are confined to one or more zones of rock that approximately follow the course of the Rivière du Lièvre in a general N.N.W. direction, and are more or less heavily impregnated with apatite. Very possibly there is but one such zone, with the Rivière du Lièvre occupying a synclinal near the summit of the series.

These phosphate-bearing rocks are characterized by the predominance of pyroxene in their composition and the frequent presence of irregular patches of coarsely crystalline lilac or violet-coloured felspar.

Mr. Vennor's opinion.

Mr. H. G. Vennor considered a band of rusty-coloured gneiss to be a guide to the richest deposits. I saw no such band associated with apatite; although such bands very commonly accompany the graphite. On the contrary, there is a singular scarcity of such gneisses in the High Rock belt of pyroxenite and associated rocks, considering that there is always more or less iron pyrite present in these phosphate deposits.

Pit No. 8 is a small shallow opening in pyroxenite. A good show of apatite on the surface pinched out on sinking a few feet. There is a patch of coarsely crystalline felspar at the end of this pit; which is now abandoned.

Pit No. 9 was almost 18 ft. square × 12 ft. deep last June. The country rock is a massive, fine-grained pyroxenite with apatite in irregular flat-lying patches. About 60 tons is said to have been mined here at the above mentioned date.

Pit No. 10 is only 27 feet from No. 9. and the surface has been stripped from one to the other. But the character of the two deposits is very different. In No. 9 the apatite lies flat, or nearly so; whereas in No. 10 it occurs in small vertical veins in the pyroxenite. It is now abandoned and full of water. Supposed to be 24 feet deep. It is said to have yielded about 120 tons of apatite.

Pit No. 11 is said to have yielded from 350 to 400 tons. It is 95 ft. ong × 21 ft. wide, striking due East and West (mag.), with a small lateral pit on its south side.

It is now abandoned, and most of the bottom is under water. But at the west end it is quite shallow, with some show of massive apatite in the bottom and end. The country rock here is pyroxenite, with much felspar and coarsely crystalline mica. Here and elsewhere the mica and apatite are distributed quite independently of one another, occurring sometimes together, but just as often by themselves.

Openings on High Rock property continued.

Pit No. 12 is rectangular and of tolerably uniform section, viz., about 26 ft. × 18 ft. In June it was 44 ft. deep, and had a floor of solid apatite. At about 12 ft. from the surface the apatite is said to have pinched almost completely out, but it soon "came in" again quite as richly as before. The country rock is massive pyroxenite. On the dump we picked up specimens of compact, pale, greenish-yellow apatite. One large specimen, apparently of massive epidote, gave also reactions for phosphoric acid and calcium.

Pit No. 13 is 23 ft. long × 16 ft. wide × 12 ft. deep. The country rock is terribly mixed up. It is principally pyroxenite with patches of white and flesh-coloured felspar. The weathered surfaces about this pit are chiefly pinkish felsite with some white quartzites. The general strike of the beds is N. 50° W. The dip is uncertain, but seems to be N. 40° E. < 82–90°.

Nature of country rock.

The remaining openings examined on this property were more in the nature of open cuts than pits; being long, shallow trenches, rather low down on the slope of the hill, and not far from the Beaver Meadow.

Open cut No. 1 is 29 ft. wide where the line crosses it. It cuts about 50 feet along the west side of the hill, which is partly undermined, and ends in a cavern about 40 ft. long and 15 ft. wide, parallel to the survey line. The country rock is pyroxenite, rather rich in pyrites.

Open cut No. 3 is 181 ft. long on a N. W. and S. E. course, and from 12 to 30 ft. wide. At the S. E. end I observed a horizontal mass of apatite cutting into some vertically-banded pyroxenite and felsite. We obtained specimens of banded apatite and pyroxenite from near the same spot. One of these specimens weighs several hundred pounds, and exhibits a structure rudely resembling the Eozoon Canadense. At this end of the cutting we also found a mass of flesh-coloured felsite reticulated with green pyroxene, and containing more or less quartz: similar to that already described as occurring in pit No. 5. We found here some small, imperfect crystals of zircon, and crystals of ilmenite. Aggregations of the latter have been found weighing two pounds. A good crystal of pale-red zircon, about $1\frac{1}{4}$ inch in length, lying in the company's office, was said to come from this cut. We also saw there a very perfect crystal of scapolite, with small crystals of apatite embedded in it.

Structure like *Eozoon*.

Open cut No. 2 is situated between No. 1 and No. 3, but at a rather lower level. It is 110 feet long, and parallel to No. 3. It varies from 25 ft. to 50 ft. in width, and is of various depths. Some of the apatite here is of reddish colour. A wooden tramway, 149 feet long, runs from this cutting to the roof of a large cobbing-honse.

Wilsonite and scapolite.

Besides the specimens already mentioned, we also found specimens of wilsonite and scapolite on the dumps of the Bonanza and Captain pits.

The Dugway Pits on Lot 7, in Range VIII., belong to this same company (The Phosphate of Lime Co., !imited); although the greater part of the lot belongs to the U. P. M. & L. Co. of New York.

Pit No. 1 is 24 ft. south of its derrick. It is 80 feet long, east and west, and 30 feet wide at the widest part. The country rock is a massive, dark pyroxenite. Some large crystals of very dense, heavy apatite were blasted out of this pit. The manager, Mr. Wm. McIntosh, kindly presented me with some of them for our collections. One is now in the museum. This pit is abandoned and full of water.

Pit No. 2 is 60 ft. long upon the surface by 48 ft. wide at the surface. But the deeper end is only 33 ft. wide on the surface and contracts to 20 feet wide in the bottom. In June this pit was 28 feet deep with a splendid show of apatite in the bottom, carrying much fine pyrite. But work was abandoned here in the autumn. This pit runs E. and W. on line with pit No. 1, and close to it. At its east end there is a small cave, and on the surface there is a large pocket of decomposed apatite mixed with rotten pyrite. This rests upon the solid rock, and is overlaid by fine sand and boulders. The country rock here is chiefly massive dark pyroxenite, which in this pit seems to strike E. and W., with nearly vertical dip to the north.

Pit No. 3 is of very irregular shape. It lies on the opposite side of a shallow ravine from Pits 1 and 2. The pyroxenite here is interrupted by irregular patches and stringers of felsite. Much mica is mixed with the little apatite visible. This pit was never of great importance.

The dividing line between the two properties runs across the west end of pit No. 2. The Union Phosphate Mining and Land Co. employed a party of men for some time stripping and prospecting on their side of the line, but they found nothing worth opening.

Union Phosphate Mining & Land Co. of New York.

We next visited the works of The Union Phosphate Mining and Land Co. of New York and Orange, N.J. The chief workings are open cuttings on the western slope of Star Hill, which lies along the east side of St. Helen's Lake. The line of openings strikes N. 40° W. mag. Very rich croppings of phosphate are found extending for a considerable distance along this strike. These deposits are so rich that single blasts sometimes break out five or six tons of apatite. The country rock is usually a dark massive pyroxenite. The deposits of phosphate are accompanied by an abundance of coarsely crystalline dark phlogopite. Pyrite is scarce.

The general strike of the country rock about there is N. 38° W. This is the trend of the ridge itself.

One of the richest "shows" of apatite here is contained in a crystalline biotite-orthoclase rock cut by a vertical trap dyke about four inches thick on a strike of W.N.W. The beds did not appear to be in any way affected by this intrusion. The apatite in contact with the trap did not differ in any perceptible way from that occurring elsewhere. Trap dyke.

At the north end of St. Helen's Lake we found some yellowish-green garnets associated with ordinary red garnets in a white felsite, carrying spots of dark pyroxene. From a little distance this bed bore a striking resemblance to weather-beaten birch-bark. These pale garnets gave a yellowish-green colour to the borax bead.

This Co.'s "Red Show" pit was 31 ft. long × 10 ft. wide, and quite shallow. It lies mid-way between the Star Hill and Dugway pits. The country rock is a coarsely-crystalline micaceous pyroxenite with some pinkish orthoclase. "Red Show" pit.

Late in the autumn a steam drill was set to work on the breast of Star Hill with the intention of moving a great quantity of rock during the present winter.

The Emerald Mine.

During the season we paid several visits to the Emerald mine, which is one of the three largest apatite mines in Canada: "High Rock" and "Star Hill" being the other two. This mine is situated on Lot 18 of Range XII. in the township of Buckingham, on the left (eastern) bank of the R. du Lièvre and is about seven miles from the village of Buckingham. The chief openings are on the summit of a high hill popularly known as "The Fort." At the time of our first visit (in June 1883) mining operations were confined to one pit, whence a large quantity of choice sea-green phosphate has been extracted during the last three years. (The foreman estimated this quantity at five thousand tons.) There was a considerable admixture of pinkish calcite in this phosphate near the surface; and much of the apatite was obtained in large crystals penetrating in every possible direction these irregular masses of calcite. But there was not much of this mineral visible in the bottom of the pit. The apatite obtained thence contained but little admixture of anything save pyrite, chalcopyrite, and the pyroxenic country rock. "The Fort" hill.

On the rise of the hill above this main pit and between it and the old Grant pit upon the adjacent property, there are several smaller pits; all of them showing similar rich green apatite in this pyroxenitic rock and accompanying felsites.

There are similar exposures on the north western flank of this hill. In fact, the whole hill is in all probability impregnated more or less richly with apatite. The workable deposits are merely segregations of greater or less extent from the surrounding country rock, which here presents no beds of marked and constant character to enable either the attitude or thickness of the formation to be determined.

Segregated deposits from country rock.

This same difficulty was constantly met with throughout the summer. The lithological character of the rocks in this district was not found to be a safe guide for their identification at any distance from the point of original observation.

Near the main pit of the Emerald mine is a dump of several hundred tons of "seconds," containing, probably, from 40 to 50 p.c. of apatite. Upon it we found some interesting specimens of rounded crystals of very dark glossy apatite; rounded lumps of red calcite, closely resembling blobs of sealing wax, in a crypto-crystalline mass; rounded crystals of dark-green apatite associated with chalcopyrite and pyrrhotite. We also found here some specimens of sphalerite, associated with these other minerals. But these latter specimens appeared to have been all extracted from a single small gash vein from one to two inches thick. A diligent search failed to find any in the pit. One specimen contained a single speck of galena, identified by the blowpipe reactions.

Occurrence of galena.

In June the main pit was about 140 ft. long × 40 ft. wide upon the surface, but narrowed and contracted very much in sinking. Its strike was about N. 60° E (true). Its depth was about 40 ft. The only means of draining it at that time was by heavy iron-bound tubs, hoisted by horses and two derricks on opposite sides of the pit. During the summer, however, a boiler was set up and a steam drill started with the intention of cutting through the slope of the hill into the pit, and thus freeing it of this very serious hindrance to mining. But the serious mistake was made of starting this cutting on a level but slightly lower than the bottom of the pit. As soon as this has been sunk a few feet deeper, recourse must be had once more to the former costly method of hoisting the rock and water.

Old Grant pit.

The old Grant pit, on the adjacent lot, has been abandoned for several years, and is full of water. It was worked by a whim. On the dump here we found quite a number of fine specimens of the banded apatite and pyroxenite. The dump was mainly composed of pyroxenite, with a good deal of felsite. We found also crystals of scapolite.

It is perhaps worth while to note that this banded apatite and pyroxenite has never been found at any greater depth than a few feet below the soil. Some of it was found in the eastern end of the main pit of the Emerald Mine, immediately below the soil. The specimens we obtained at High Rock were found close to the surface.

At the Emerald Mine we also obtained a large specimen of pink calcite banded with the pyroxenite in precisely the same way. But it was unfortunately left at Platt's house. Banded calcite and pyroxenite.

The strike of the rock near the Grant pit was found to be N. 46° W (mag).

The Fowler and Bacon Properties.

These are adjacent to each other on the First Range of Portland East—Fowler's lot being the eastern half of Lot No. 3, and Bacon's being the western half of the same lot. Little work has been done here. The openings on both properties are close to the side line separating them, and not far from the south side of the range.

"Fowler's big show" is a stripping on the side of a hill. It shows a breast of massive green apatite about 10 feet long, freely spotted with large but imperfect crystals of black phlogopite. This stripping runs north and south across this bed (?) of apatite. The country rock is pyroxenite and felsite irregularly mixed. There are a number of other smaller openings close to this, all showing some apatite. But I did not hear of any apatite being found elsewhere on this lot than in this one patch, close to the side line. No attempts have been made to mine this deposit. It has simply been stripped on speculation. Now (February, 1884,) I am told that it has been recently sold for a very considerable sum. Country rock

Higher up on the same gentle slope are the Bacon pits on the west half of this lot. The main pit is 19 ft. × 13 ft. × 10 ft. deep, with fair shows of apatite in both ends. The country rock is massive pyroxenite. There is a small vein of pink felspar in the western side of the pit. Another small opening has been made about 60 ft. N. 60° E. of this pit. And a little trenching has been done in the immediate vicinity. About 20 tons are said to have been taken off this property and about 10 tons off Fowler's half. Bacon pits.

On our way back to the Lièvre we observed the strike on two different exposures to be respectively N. 15° E., with dip S. 85° E. $<$ 47°, and N. 38° E. with dip S. 52° E. $<$ 75° (mag.)

La Compagnie Française des Phosphates du Canada.

This Company, organized in France, owns a large number of so-called phosphate lots, but their chief work seems to have been confined to Lots 1 and 2 of Range III. and No. 1 of Range IV., Portland East, and Lot 16 of Range VIII. in the same township.

Compagnie Française des Phosphates du Canada.

Pit No. 1 on Lot 2, Range III., is 30 ft. long × 10 ft. wide and 25 ft. deep. The strike of this opening is N. 56° E. In the S.W. end and bottom there is a 2–3 ft. seam of apatite dipping N.W. The country rock is a massive iron-grey crystalline rock, consisting chiefly of quartz, hornblende and mica. The apatite has a good deal of mica associated with it. There is some brilliant red calcite finely disseminated through portions of the country rock, and also in the apatite itself. This pit was being worked at the time of our visit.

Pit No. 2 was abandoned. Its length was 91 ft. on a strike N. 30° E. The N.E. end and centre were full of water. But at the S.W. end there was a little massive green apatite exposed, with coarse phlogopite imbedded in it. The country rock is similar to that about No. 1. Its strike is obscure, but appears to agree with the direction of the opening, and has a dip of N. 60° W $<$ 65°.

Pit No. 3 is 16 ft. wide by 32 ft. long. The country rock here is a granular massive pyroxenite with some white felsite upon the surface, with a strike N. 30° E. and dip N. 60° W $<$ 77–90°. Very little apatite was visible in the walls of this pit, and almost no mica or pyrite.

Pit No. 4 is 20 ft. long by 13 ft. wide and 6 ft. deep. It differs from No. 3 in having large patches of pink calcite in the country rock, holding crystals of green apatite and some mica. In the country rock there are also patches of pale lilac felsite carrying a little apatite

Pit No. 5 is a stripping on the side of a hill to the N.W. of M. Folcher's house. It is 15 ft. × 6 ft., and shows a little apatite and mica in pyroxenite. There are four or five other strippings on the side of this hill—west of No. 5. But none of them show any quantity of apatite.

Pit No. 6 is noteworthy for the scarcity of apatite in it. Its eastern end is sunk in gneiss, striking N. 30° E. with a vertical dip. But the western part is in pyroxenite showing a little apatite. A few tons are said to have been obtained from this pit.

Pit No. 7 is 45 ft. N.E. of No. 6, and is 34 ft. deep. Its section is about 15 ft. × 10 ft. It runs on the strike of the country rock N. 32° E. and has a very regular foot-wall, dipping N. 58° W. $<$ about 80°. There were no ladders to get into it. We saw very little apatite in the walls. There seemed to be more in the bottom. But it was too dirty for a clear view. The country rock is pyroxenite with a little white felsite and some spots of pink calcite.

I noticed a little titanite in almost every stripping on this hill.

Pit No. 7 is 68 ft. due east of my station L. Its area is 20 ft. × 10 ft. and is 4 ft. deep. Here we found a little green apatite and black mica in pyroxenite.

Pit No. 8 is 9 ft. wide × 10 ft. deep. The country rock is pyroxenite, with a little titanite in white felsite.

Near my station M there are four pits.

Pit No. 9 is 17 ft. N. 20° W. from it and is 23 ft. deep. Its section is 16 ft. by 12 ft. The country rock is massive pyroxenite.

Pit No. 10 is 25 ft. N. 82° W. of No. 9. This is 15 ft. wide and 26 ft. long on the strike N. 08° E. Full of water. The country rock is a massive pyroxenite, containing some tourmaline. A little titanite and some small crystals of chabazite accompany the apatite, and also some black mica and pyrite. Some calcite here is very red.

Pit No. 11 is 16 ft. from M, bearing S. 20° E. from it. It is 10 ft. × 10 ft. × 7 ft. deep. The country rock here is chiefly felsite; mostly lilac, but some red. A fair show of apatite in the bottom. Country rock.

Pit No. 12 is 27 ft. from M, bearing S. 10° W. from it. It is cut into the side of the hill. It is 13 ft. × 16 ft., and on its upper side is 23 ft. deep. The country rock is pyroxenite, with spots of dark red calcite in one corner. Some of the apatite is very deep red. On the dump we found specimens of a dark red micaceous mineral containing much water. Its foliæ had lost all elasticity. Doubtless this is an altered mica. (rubellan ?)

Pit No. 13 is full of water. Apparently deep. It is 25 ft. wide and about the same length. The country rock is pyroxenite.

Pit No. 14 is 25 ft. × 10 ft. Country rock, pyroxenite.

Beside pit No. 15 there was an open cut about 40 ft. long, striking N. 26° E. and showing a deposit of apatite averaging 3 ft. in width, as far as it had been stripped.

East Half of Lot 7, Range I., Portland East.

The main pit upon this lot is 32 ft. × 63 ft., on a strike N. 63° E., and is about 43 ft. deep. As this pit was full of water at the time of our visit, and was scooped into a deep cave at the NE. end, I had to take these dimensions from Mr. Platt, who assures me that over one thousand tons of phosphate were taken from this one pit. In its N.E. end black mica is much more abundant than apatite. This pit is richer in mica than any other yet visited. It occurs here chiefly in large imperfect crystals, whereas it generally occurs mostly in fine scales. We noticed also at this pit an unusual scarcity of sulphides of all kinds. While this pit was being worked, a great deal of the mica extracted here was used for road metal, for which purpose it is about equal in value to sawdust. Abundance of mica.

Pit No. 2 is cribbed up at its mouth for a windlass and is full of water. Platt says that it averages 10 ft. × 6 ft., and is 14 ft. deep.

He reports that 22 tons of apatite were extracted. We found zircon on this dump. The country rock around 1 and 2 is pyroxenite.

Pit No. 3 is a dry hole of irregular shape. It averages about 9 ft. × 7 ft. and is 13 ft. deep. The country rock is pyroxenite, with a good deal of pink felsite.

Pit No. 4 is a tunnel driven into the hill. It is 6 ft. high × 8 ft. wide, and is 16 ft. long. The country rock is chiefly white (with some pink) felsite. Very little apatite is visible in the sides and end of this tunnel. About fifty tons of apatite are said to have been obtained here.

Tamo Lake Mines.

On Lot 14 of Range V. in Portland East there are three pits lying close together. They are small and shallow and offer no features worthy of note. The country rock is pyroxenite, showing but little red and green apatite in patches through it.

Found the strike of country rock near one of these pits to be N. 28° W. with dip S. 62° W. < 83°. Another exposure a little to the east of this gave the dip as N. 60° E. < 67°. It seems likely that these pits are on the summit of an anticlinal.

Major Chapleau's company.

Major Chapleau's Co. own Lots 16, 17 and 18 in Range VI. of Portland East. During last summer they worked almost exclusively on the N.W. corner of Lot 17. The long opening is 66 ft. long on a strike N. 10° E. At the south end it turns off abruptly to S. 40° E. for another 60 feet. The deepest sinking was done in this easterly extension. But it was nowhere over 9 ft. deep at end of September. The country rock is a massive pyroxenite. On the gentle slope just below this pit to the south, is a series of strippings, showing patches of red and green apatite in the pyroxenite. The apatite mined was green and massive, with no crystals. This pit is remarkably free from mica and pyrites.

The strike of rock near the boarding house was noted as N. 9° W.

On Lot 16 we saw a couple of small abandoned openings by the roadside.

The Haycock Mine.

This mine, on Tamo Lake, was worked in the early part of the summer by Messrs. Van Rensselaer, Falding & Co. of New York, under contract with the Dominion Phosphate Company of Montreal. The chief work done was the cutting of a deep, open drift, with a steam drill, from the western slope of the ridge of pyroxenite—along the course of which all the old pits had been sunk—into its heart. The direction of the cut was N. 80° E., and its length was 117 ft. It was carried in 18 ft. wide, and its greatest depth was 37 ft. The beginning of the cut was through red and grey quartzites, striking N. 15°, W., with a dip N. 75° E. < 80°. But almost the entire cut was through greyish pyroxenite.

Very little phosphate was found in this cut until the abandoned "Deep pit" was reached. In it they struck a very good floor of solid apatite, which they were just beginning to exploit at the time of my last visit. Haycock mine openings.

This cut and all the other openings in this property are on Lot 18 of R. VII, Portland East.

Pit No. 1 is 34 ft. × 70 ft. on a strike of N. 15° W. Its greatest depth is 12 ft., but it would not average more than 6 ft. Country rock is pyroxenite. We found here a fine specimen of crystalline tourmaline on pyroxenite.

There are twelve small pits to the north-west of the steam cut. They all occur in one bed of vertical, massive pyroxenite, striking N. 15° W. The greatest width of these pits apart, in an E. and W. direction, is 110 ft. The country rock in all of them is massive pyroxenite, with stringers of calcite. We found here crystals of white and yellow chabazite.

La Compagnie Française des Phosphates du Canada is working also on Lot 17 of Range VIII, in Portland East.

Pit No. 1 is 13 ft. × 45 ft. on a strike of N. 11° W. It was full of water and reported to be 25 ft. deep. From the north end of this pit the surface has been stripped on same strike for 115 ft., and shows patches of apatite with much mica and a little pink calcite, scattered through the pyroxenite.

Pit No. 2 is 9 ft. deep by 7 ft. in diameter.

Pit No. 3 is quite shallow. It shows very little apatite in the country rock, which is chiefly white felsite, enclosing patches of massive green pyroxenite.

Pit No. 4 is the only one now worked. It is of very irregular shape. It is 20 ft. long × 10 ft. wide, at its deepest end. The strike of this opening is N. 65° W., with a dip of S. 35° W. < about 75°. Its greatest depth was about 20 ft. Both pyrite and pyrrhotite occur in this pit—the former being in the larger quantity.

The Watt Mine.

This mine is situated on Lot 6 of Range I., Portland East.

Pit No. 1 is filled with water. It is sunk on an incline, and said to be 160 ft. deep. The section at surface is 15 ft. × 14 ft. At a depth of 15 ft. it decreases to 14 ft. × 8 ft. It was worked by a horse whim. The country rock is chiefly pyroxenite with disseminated spots of apatite. It contains very little mica. The rock in the vicinity of this pit strikes N. 50° E. with a vertical dip. Other exposures on this property, gave strikes of N. 45° E., N. 50° E., N. 55° E., N. 45° and N. 50° E.

Watt mine openings.

Pit No. 2 is said to be connected with No. 1 by a tunnel. The dimensions of this pit are 13 ft. × $11\frac{1}{2}$. ft. Platt says that it is 50 ft. deep. It has a log building over it. The country rock is similar to that of No. 1.

Pit No. 3 is $16\frac{1}{2}$ ft. × $7\frac{1}{2}$ ft., and has a windlass over it. It was 16 ft. deep to surface of water—5 ft. deep. The country rock is pyroxenite, with a good deal of apatite disseminated in patches through it. There was a good deal of felsitic rock upon the dump, essentially composed of white felspar—with embedded particles of crystals of pyroxene. At a distance of 40 ft. from this pit, N. 15° W., there is a pit sunk in granite (?) showing also some quartzites. Very little mica in these rocks.

Pit No. 4 is 15 ft. × 23 ft. Filled with water to within 11 ft. of the surface. Total depth about 18 ft. The country rock here is pyroxenite with a good deal of disseminated apatite, and also patches of it, and an abundance of mica. Specimens of crystalline titanite and calcite, crystals of hornblende and tourmaline, and lumps of white and grey felsitic rocks were collected here.

In the autumn Mr. William Allen of Ottawa took possession of this property, and has since been working steadily upon it.

Cameron's Property.

This name is often applied to Lot 27 in Range VIII. of Portland East.

Pit No. 1 is 62 ft. × 24 ft., with strike N. 45° E. Its depth was 58 ft. to the floor of the pit, with an 8 ft. sump. This pit is a large, irregular cavern about 18 ft. high at the bottom of an inclined shaft 22 ft. × 24 ft. in section. The apatite was chiefly red. The foreman reported that about 1,800 tons of apatite had been extracted from it.

Steam hoisting engine.

This shaft is the only one in the valley of the Lièvre with a steam-hoisting engine. The country rock is pyroxenite with some apatite and much calcite of great variety of colour. Some patches of lilac felspathic rock. Very fine specimen of pink, green and white wilsonite and scapolite were obtained here. Strike of the rock near here is N. 20° W.

Pit No. 2 is 10 ft. × 24 ft., and is 42 ft. deep. The apatite here was green. About 25 tons were extracted. The country rock is pyroxenite and a white and lilac felspathic rock with pyrite, a little mica, some wilsonite, pyrrhotite, a little chalcopyrite and some calcite.

This property is owned by the Philadelphia & Canada Phosphate Mining Company.

McLaren's Mine.

This is the popular name of Lot 27 of Range VIII. in Portland East.

Pits 1, 2, 3 and 4 are all on a belt of rock running N. 50° E. The country rock of 1, 2 and 3 is pyroxenite with much disseminated apatite, a little mica and some felspathic rock.

Pit No. 3 has a good show of phosphate, mixed red and green. It yielded over 30 tons.

Pit No. 4 is 20 ft. × 6 ft. and about 20 ft. deep. It shows a vertical wall of mica (?) running N. 50° E.

Pit No. 5 is 16 ft. × 10 ft., with a depth of 25 ft. It has yielded 20 tons. The country rock is a dark, fine-grained pyroxenite with some felspathic rock. Other minerals are very scarce in this pit.

A number of fine specimens of stilbite were collected on this property, and also some very interesting specimens of apatite, in which the red and green colours were so mingled as to imitate woody fibre. Stilbite.

Croft's Mine.

This is on Lot 24 of Range VII. in Portland East. The Big pit is 60 ft. × 30 ft., and is 20 ft. deep to the surface of the water, which is about 15 ft. deep. The apatite here is both red and green. The country rock is pyroxenite with a little red calcite in patches through it. Crystals of pyroxene, hornblende and tourmaline are abundant. The two latter occur with the calcite. Apatite occurs in the walls of the pit in irregular veins and patches. A small piece of steatite was found upon the dump.

The other (small) pits showed some red and green apatite. The country rock is pyroxenite with very little calcite.

The Ross Property.

Lot 2 in Range VII. of Portland West has been already referred to in this report. The country rock is pyroxenite and a greyish felsitic rock. There are very good surface shows of green apatite with very little mica and pyrite. The general strike of these shows is N. 55° W. It is a pity that so little work has yet been done to test this property. It is situated on the same great belt of rock as the High Rock and Star Hill mines. I consider it to be decidedly one of the most promising lots for permanent work to great depth.

Kendall's Mine.

Is situated on Lot 26 in Range XI. of Buckingham. The apatite obtained there was extracted chiefly from a cut in the side of a hill. About 100 tons of hard compact apatite was mined from a vein about

18 ft. wide in massive pyroxenite. This phosphate is much coloured by ferric oxide, resulting from the decomposition of pyrite.

Plates of mica occur in the country rock, associated with the apatite.

Vennor's Lot.

This is the popular name of Lot 26 in Range XII. of Buckingham.

Pit A. is about 10 ft. × 12 ft. and 22 ft. deep. The country rock is composed essentially of pyroxene and scales of mica. The apatite is whitish-green. The general colour of the rock is the same. Some specimens of apatite were almost white. But the paleness of the colour was largely due to the finely granular texture of the rock.

Pit B. is 9 ft. × 6 ft. and 14 ft. deep. The rock is similar to A.

On Lot 24 in Range XII. of Buckingham, we obtained very fine specimens of pyrophyllite associated with noble serpentine in a white rock of unknown composition.

There are also two small shows of apatite on Lot 27 of Range XI. of Buckingham.

Statistics of the Trade.

From Mr. John Lewis of the Montreal customs I obtained the following figures, for which I desire to express my thanks.

Shipments of phosphate from Montreal in the two years ending on 31st December, 1882, and 31st December, 1883, respectively—

	1882.	1883.
2nd Quarter	8,946 tons=$177,741	6,619 tons=$146,038
3rd "	5,657 " 112,275	9,729 " 210,582
4th "	1,982 " 42,003	3,118 " 65,342
Total....	16,585 tons=$332,019	19,466 tons=$421,962

The collector of customs at Quebec kindly informs me that during the year 1883 there were exported from that port 200½ tons of phosphate.

The collectors of customs at Kingston and Brockville kindly inform me that no phosphate was shipped during the past year from their respective ports.

From Mr. Joseph Nimmo, jun., of the Bureau of Statistics at Washington, I received the following very interesting and valuable table of the imports of "Crude Phosphates, Kainit, Superphosphates, and Fertilizers," into the United States in the year ending 30th June, 1883.

STATEMENT showing the Imports of Phosphates, crude; Kainit; Superphosphates and Fertilizers, not elsewhere specified, into the United States, by Countries, during the Year ended June 30th, 1883.

COUNTRIES.	IMPORTS OF							
	Phosphates, crude.		Kainit.		Superphosphates.		Fertilizers not elsewhere Specified.	
	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.	Tons.	Dollars.
Danish West Indies	275	825	....	....	....	....	....	....
France	102	682	....	....	....	....	....	....
French Guiana	250	2,050	....	....	....	....	....	....
Germany	44,033	367,970	39,119	246,231	....	....	50	1,866
England	1,262	24,081	....	....	7,666	120,576	....	....
British North American Provinces	254	4,420	....	....	....	....	98	2,341
British West Indies	2,547	25,088	....	....	....	....	....	....
Hayti	235	1,767	....	....	....	....	....	....
Dutch West Indies	2	26	....	....	....	....	....	....
Cuba	190	857	....	....	....	....	....	....
Porto Rico	231	1,625	....	....	....	....	....	....
Brazil	....	....	....	....	....	....	2	70
Total	49,381	429,391	39,119	246,231	7,666	120,576	150	4,277

Treasury Department,
Bureau of Statistics,
February 12, 1884.

JOSEPH NIMMO, Jr.,
Chief of Bureau.

Small imports to United States from Canada.

From this statement I learn the extraordinary fact that only 254 tons of crude phosphate were imported from Canada in that year, although a very large amount of American capital is invested in our phosphate mines. One of the most productive mines for years past has been owned by an American company, viz., The Union Phosphate Mining and Lands Company, and another—viz., the Emerald Mine—has been recently purchased by American capitalists.

As far as I can learn the total output of these mines has always gone to Britain.

As 1,262 tons of crude phosphate and 7,666 tons of superphosphate were imported into the United States from Britain in that year, it is highly probable that a very considerable quantity of our Canadian apatite has been used in enriching American lands after a voyage across the Atlantic and back.

In regard to the destination of the 19,666 tons of phosphate exported from Canada in A.D. 1883, I obtained no figures. But Dr. T. Sterry Hunt, F.R.S., &c., in his admirable paper on the "Apatite Deposits of Canada," presented to the Am. Inst. of Mining Engineers, states that 1,576 tons were delivered in Hamburg and 650 tons in Stockholm, the rest going to British ports.

Prices.

Prices fluctuated very considerably during the year. Mr. Lomer, of Montreal, tells me that in the spring of 1883 he obtained 1s 6d per unit for the phosphate that he shipped to Hamburg and Stockholm. But in Oct., 1883, he was offered only 1s 2d per unit for 80 per cent. phosphate.

Messrs. Gillespie, Moffatt & Co., of Montreal, obtained 1s 1½d per unit for a consignment to Avonmouth of 75 per cent. phosphate, when similar apatite was worth only 1s 0d in London. This shows the difference in prices at different centres of consumption.

If the government had a mining bureau receiving quotations of prices from these various points at regular intervals, their prompt publication in our papers as an official bulletin or otherwise, would greatly benefit the trade.

Such an office might also materially help to develop a *direct* trade with the sea-board of the United States by direct shipments in barges from Buckingham to New York *via* the Champlain canal, instead of this indirect trade *via* England, with its numerous transhipments and many brokers.

Inspectors and analysts.

The question of appointing official inspectors and analysts to certify to the quantity and grade of every shipment from Montreal has been often agitated. As far as I can learn, the shippers are at present compelled to accept the certificates of the analysts employed by the purchasers as the basis of settlement.

I hesitate to recommend any official action by the government in this matter.

The only suggestion that I could make is this, and it is of a very local character. The apatite mined in the valley of the Lièvre might be crushed in a suitable mill at the falls immediately below the steamboat landing at a fixed tariff and put up in barrels for shipment. Such a mill could have a mechanical ore-sampler attached to it in such a way that a certain definite percentage of the crushed product would be mechanically separated and delivered as a sample of the lot. This could be analysed by a chemist attached to the mill and his certificate delivered along with the consignment, or else the sample could be sealed and delivered to the owner for analysis by any other chemist. Sampling.

Such a mill should be able to crush this apatite more cheaply than any English mill, because the apatite would require no extra handling. All of it has to be landed from the barges near that particular point and loaded on wagons to haul it to the railway station. It would not be difficult to arrange machinery to unload the barges and transport the apatite to the mill very cheaply with the aid of this water power.

The freight to Britain on this phosphate might be rather higher than when in bulk. But there would be no loss or deterioration in transhipment. Ballast could not get mixed with it on the Montreal wharves or in the vessel's hold, and the charges for loading and unloading, &c., would be lower. The greatest advantage, however, would be in the certainty of obtaining a fair and accurate sample of the entire shipment.

As long as phosphate is shipped in bulk no two samples can be taken from the same lot of *precisely* the same composition. If they are selected by some proper rule they should always approximate to one another more or less closely, but they can never agree.

This lack of correspondence has very frequently caused serious trouble between the Canadian shippers and English buyers. But the shippers have always been forced to give way and comfort themselves with some sorry theory about deteriorations and loss of weight in process of transhipment or discharging at the British port.

GENERAL REMARKS ON APATITE INDUSTRY.

I fail to agree entirely with Dr. Hunt's views upon the nature of these deposits. He divides them into only two classes,—viz.: bed and fissure veins. This is correct if we use the term bed in a sufficiently broad sense. But the vast majority of the deposits that I have yet seen are very irregular segregations from the phosphate-bearing country rock, which is generally a massive pyroxenite. As these deposits are found in a certain bed, which is more or less richly impregnated with phosphate and may sometimes be traced for a consider- Dr. Hunt's views on origin of Canadian apatite deposits.

able distance, such deposits may be said to be merely a bed of phosphate of irregular richness. But I take exception to this kind of classification as being misleading. And it seems to imply the submarine origin of these deposits. Whereas the origin of these pyroxenic rocks may possibly be due to contemporaneous intrusion.

There has always been phosphoric acid in the earth's crust—long before any form of life existed upon our globe. Why should we conclude, without absolute and undeniable evidence, that this massive crystalline apatite was necessarily accumulated by organic action? In my opinion this is an open question.

But every scientific man, at all familiar with the past history and present aspects of our Canadian phosphate industries, must endorse his condemnation of the present methods of development, which he describes as follows:—

Condemnation of existing methods of apatite mining.

"The larger part of the productive workings are upon the bedded deposits. These, however, are for the most part opened only by shallow pits; a condition of things which is explained by the peculiar character and the frequency of the deposits, and also by the economic value of the apatite. This mineral, unlike most ordinary ores, is, in its crude state, a merchantable article of considerable value, and finds a ready sale at all times, even in small lots of five or ten tons. Like wheat, it can be converted into ready money, at a price which generally gives a large return for the labour expended in its extraction. Hence it is that farmers and other persons, often with little or no knowledge of mining, have, in a great number of places, opened pits and trenches for the purpose of extracting apatite, and at first with very satisfactory results. So soon, however, as the openings are carried to depths at which the process becomes somewhat difficult from the want of appliances for hoisting the materials mined, or from the inflow of surface waters, which in wet seasons fill the open cuts, the workings are abandoned for fresh outcrops, never far off. In this way a lot of 100 acres will sometimes show five, ten, or more pits, often on as many beds, from twelve to twenty feet deep; each of which may have yielded one or more hundred tons of apatite, and has been abandoned in turn, not from any failure in the supply, but because the mineral could be got with less trouble and cost at a new opening on the surface near by."

"These conditions are scarcely changed when miners, without capital and unprovided with machinery for hoisting or for pumping, are engaged, as has often been the case, to extract the mineral at a fixed price per ton. These, having no interest in the future of the mine, will work where they can get the material with the least expenditure of time and labour, and often will quit one opening for another which is more advantageous. The very abundance and the value of the mineral mined has thus led to its careless, wasteful and unskilful exploitation. It is the working of these causes, in the way just explained, which has thrown undeserved discredit on this mining industry, and, more even than the injudicious schemes of speculators and stock-jobbers, has retarded its legitimate growth."

"It is evident that the proper development of these deposits will require regular and scientific mining in place of the crude plan of open pits and trenches, which, from causes already explained, has hitherto, with few exceptions been followed. As a basis for calculation in mining, it becomes necessary to establish some data as to the production and the value of the apatite-layers which we have described. The specific gravity of the mineral, as deduced from many specimens of massive Canadian apatite is from 3.14 to 3.24. If we assume 3.20, this will give for the weight of a cubic foot of apatite almost exactly 200 pounds. A fathom of ground, carrying a bed or vein of apatite one foot in thickness, will thus contain thirty-six cubic feet, or 7,200 pounds of apatite ; equal to a little over three and one-fifth tons of 2,240 pounds each. Allowing the fractional portion, equal to nearly seven per cent., for loss in mining (it will be noted that coarse and finely-broken apatite are equally merchantable), we shall have as the net product of a layer of apatite for a fathom of ground mined, three gross tons for each foot in thickness."

Dr. T. Sterry Hunt, in the same article, gives the following interesting facts about the cost of extraction and market value:—

Cost of extraction and market value.

"The market value of apatite, which, as is well known, is chiefly consumed for the production of soluble phosphate by the manufacturers of artificial fertilizers, varies greatly, other things being equal, with its purity. Thus, while at present the price in England is 1s 2d, the unit for apatite giving by analysis 75 per cent. of tricalcic phosphate, there is paid an addition of one-fifth of a penny for each unit of phosphate above that percentage, so that a sample, yielding by analysis 80 per cent. is worth 1s. 3d. the unit. The price in the English market is subject to considerable fluctuations, having within the last four years been as high as 1s. 5½d., and as low as 11d. the unit for 80 per cent. phosphate. The present may be considered as an average price.

"The Canadian apatite shipped to England has yielded for various lots from 75 to 85 per cent., 80 per cent. being the average from the best conducted mines, though lots from mines where care has been used in the dressing and selection of the mineral for shipment have yielded 84 and 85 per cent. Many of the smaller miners to which we have alluded, selling their product to local buyers, take little pains in dressing, and hence their product is apt to be lower in grade. It will be seen, from the rule adopted by foreign purchasers, that there is great profit in a careful selection and dressing of the mineral for market. The basis being 1s 2d the unit for 75 per cent., with a rise of one-fifth of a penny for each unit, it follows that while a ton of 75 per cent. apatite will bring only 87s 6d, a ton of 80 per cent. will command 100s, and one of 85 per cent. 113s. 4d."

"In the present state of the industry it is not easy to say what would be the cost of production. At the outcrop of the large masses of apatite, and in the open cuts and quarries already described, the cost of extraction and dressing is, of course, very variable, estimates in different deposits giving from $2 to $8 the ton. In Ottawa county, where within the last four years, deposits have been opened and mined on a better system than heretofore, the figures of production and cost are instructive. According to the report of the manager in July, 1882, the High-Rock mine, in Buckingham (*sic*) yielded, in 1880, 2,400 tons, and in 1881, 2,000 tons of apatite. An adjoining portion of land having been then acquired, the production of this company's mines in 1882 and 1883, is stated at 5,000 tons annually; from eighty to ninety men being employed. The cost of the mineral is here given at $4 the ton, dressed, at the mine; in addition to which $3 is paid for carriage to the railroad or the river, and about $1 additional to Montreal, the port of shipment. The mines in the Ontario district are, for the most part, in or near to the waters of the Rideau canal, or some of the many lakes connected therewith, from which the freight to Montreal is $1.50 the ton. I am informed by a merchant, who is a purchaser and shipper of apatite, and is always engaged in mining it both in Ontario and Quebec, that the average cost for freight from Montreal to England, with selling charges, is 20s. the ton; which, for apatite of 80 per cent., now worth 100s. the ton, would leave 80s. or $19.36."

"Deducting from this the cost of production and of transportation to Montreal, there remains a large profit."

Statistics of shipment.

Dr. Hunt follows this with a paragraph upon the statistics of shipments. When he speaks of 1883 and 1884, he evidently means the fiscal year ending upon the 30th June. He says:—"The amount of apatite shipped from Montreal has gradually increased, and, according to the published figures, attained in 1883, 17,840 tons, of which, it is to be remarked, that 1,576 tons were delivered in Hamburg, and 650 in Stockholm, the remainder going to Liverpool, London and other British ports. Of this about 15,000 tons were from Quebec, and the remainder from Ontario, &c."

Dr. Hunt's concluding remarks should obtain as wide a circulation as possible:—"The methods of mining hitherto generally pursued in the apatite deposits of Canada, allow of many improvements which would materially reduce the average cost of production and give a permanency to the industry which the present modes of working can never attain. The regularity and persistence of the bedded deposits, and of some of the veins, warrants the introduction of systematic mining by sinking, driving, and stoping, with the aid of proper machinery for drilling, as well as for hoisting and pumping. The careful dressing and selection of the apatite for the market is also an element of much importance in the exploitation of these deposits. The cost of labour in the apatite-producing districts is comparatively low, and there are great numbers of beds now superficially opened, upon which regular mining operations, conducted with skill and a judicious expenditure of capital, should prove remunerative. It must be added, that the areas in question have as yet been very partially explored, and that much remains to be discovered within them, and also, there is reason to believe, in outlying districts; so that in the near future the mining of apatite in Canada will, it is believed, become a very important industry."

With most of these remarks of Dr. Hunt's, I fully agree. But some of them are open to discussion. In his statement of the cost of extraction of apatite from the High Rock mines, he evidently omits the very important factor of interest upon the Phosphate of Lime Co.'s capital. I cannot state the amount of this capital positively, but believe that it is £100,000 stg. As it is an English corporation I suppose that five per cent. would be a fair rate of interest for this calculation. For an annual output of 5,000 tons of phosphate this would be a charge of exactly £1 per ton. Thus, the phosphate shipped from High Rock costs about $12 at the railroad depot in Buckingham, instead of $7. Freight by rail to Montreal is $1.25 per ton. Cartage in Montreal from cars is 25c. to 75c. per ton. Harbour and port warden's dues are 11 cents per ton.

If shipped by barge down the Ottawa from the mouth of the Lièvre River to Montreal the cost is $1 to $1.50, according to despatch. The barges can be laid alongside of the ship. Thus the charges for cartage are saved. But this is probably counterbalanced to some extent by the possibility of claiming for demurrage on the part of the ship or else of the barges, if they are kept waiting.

The margin for profit for companies of large capital in this phosphate business is thus shown to be altogether too small to permit of reckless or ignorant management. Great skill is required to conduct mining operations in such a way as to guarantee the stability of the enterprise while providing punctual dividends. Any fool can extract phosphate from the surface of a phosphate-bearing belt of pyroxenite. But it requires a very skilful engineer to do it in such a manner as to afford some reasonable hopes of the work being continued profitably

Margin of profit.

Capital invested.

for the next fifty years. It is hardly necessary to add that unless the mines are likely to maintain their dividends for that length of time, they should be now paying very large dividends to cover the ultimate extinction of the large capital invested.

I have already pointed out the folly of running a single drill on these mines. One boiler should not only run two steam drills, but the necessary pumps and hoisting engine also.

The heaviest tax on these phosphate mines is the cost of baling out the wide-mouthed pits with tubs hoisted by horses. As the work consists almost exclusively of sinking, with no attempts at drifting or stoping, a very small infiltration of water in the night prevents the men from commencing work next morning until an hour or two has been wasted in slowly baling it out with a horse. It is by no means uncommon for a whole morning to be wasted in this way. In any continuous spell of wet weather all the profits of mining may easily vanish. With small shafts and proper pumps the weather would have very slight influence upon the amount and cost of output.

Competition in European markets.

Our Canadian phosphates have always been exposed in the English markets to the keen competition of phosphates from Norway, Spain, Carolina and Germany in all their various grades of purity. The West Indian phosphates enter that market more largely every year. And now, I am assured, Russian phosphates are being offered freely upon that market.

Phosphate deposits of South Carolina.

In the recently published volume upon the Mineral Resources of the United States, by Mr. Albert Williams, jun., of the Geological Survey of the U.S., there is a very valuable article upon "The Phosphate Deposits of South Carolina," from the pen of Mr. Otto A. Moses. In this article he mentions that "although there are at least 500,000 acres of the lowlands and streams of South Carolina underlaid by the phosphate beds, there are not more than 20,000 acres which it will pay to mine at present prices." He says, "The price of phosphate rock changes but little, the demand being comparatively constant, as is the supply of labour. With the exception of a sudden rise to $9 a ton a couple of years ago, there has been a uniform price of about $6 for clean-washed phosphates. This, of course, varies with freights, most of the rock being exported. As the prices abroad fluctuate but little, there is a comparative regularity in the output, which gives great stability to the trade. There is a growing demand in all directions, caused by the impoverishment of land and the increase of knowledge; so that there is no present probability of an interruption to the further development of this industry."

Conditions of sales.

"The rock is generally sold on a simple guarantee that it shall contain not less than 55 per cent. of the bone phosphate of lime

(3 Ca. O., P.O.$_5$), and irrespective of carbonate of lime or moisture. This rather loose method causes a uniformity of product, but does not encourage the miner to select his rock with a view to obtaining the highest yield of soluble phosphates of lime with given quantities of solvents—an object to be considered in the manufacture of fertilizers." He farther reports that—"Since the discovery of the value of the phosphate rock bed of South Carolina, in 1867, to the present time, about 2,250,000 tons have been mined by land and river companies in about equal proportions."

Mr. Moses gives a list of companies and individuals engaged in mining, and states that their aggregate capital is over $2,000,000.

Manufacture of phosphates.

In regard to manufacturing, he says that the manufacture of phosphates in South Carolina has been developed on an enormous scale, over $3,500,000 of capital being invested by twenty-one companies, which have a capacity of 250,000 tons per annum. Ashley and Cooper Rivers, in the neighbourhood of Charleston, are lined with the finest and most extensive collection of fertilizer factories in the world. Others of equal importance are being erected in the Beaufort district. Most economically arranged, and located in the heart of the phosphate region, on deep water and on railroads, they have such natural advantages of position as will give them control of the phosphate trade of the South and Southwest, and perhaps, in time, of the whole country.

A total capital of $3,350,000 is invested in this business. The shipments have steadily increased from 22,589 tons in 1872 to 130,000 in 1883 (up to 1st June).

This volume contains valuable reports upon Apatite, Marls and Gypsum, etc. From the article upon Apatite, written by Mr. F. A. Wilber, I must extract one brief paragraph—the concluding one :—

"Apatite is used in the arts as a source of phosphoric acid and phosphorus, and its value to the manufacturers of fertilizers depends upon the amount of phosphate of lime which it contains. Since the discovery of the deposits of phosphatic marls in South Carolina the demand for it has decreased, and these latter deposits now furnish the supply of phosphates in the market."

Norwegian phosphate.

The output of the Norwegian mines affords a striking contrast to our frightfully improvident superficial Canadian methods (or, rather, lack of method) of exploitation. The comparison is all the more profitable from the fact that these Scandinavian deposits occur in rocks of very similar age and character to our own. That district extends about 50 kilometres along the coast, with a depth of about 5 kilometres. Mr. Frank Adams informs me that Gjögren (a Swedish geologist) reports that a single section of about one square mile in extent, viz., Oedegarden, in Bamla, yielded in 1882 about 15,000,000 kilogrammes (about 16,500 tons), valued at 1,750,000 marks—about $437,500. This is only 85 tons short of the total output of all Canada for the same period.

I am at a loss to understand why no shipments of our Canadian apatite is made direct to New York via Lake Champlain by the American companies engaged in mining it here. My brother, Mr. Wm. F. Torrance, who is largely engaged in forwarding between Montreal and New York, writes me that a transportation company would contract to carry phosphate from the Buckingham wharf to New York City for $3.50 per 2,000 lbs. during the summer months and $4.00 during October. He adds that if no contracts were made in advance some might *possibly* be shipped as low as $3.40 per 2,000 lbs., but that most of it would have to pay from $4.00 to $4.25.

Home markets for superphosphates.

It seems to me that a greater effort should be made to develop a home market for these phosphates in the shape of superphosphates. The Ontario Agricultural College at Guelph has been doing good work in this direction. I believe that, in consequence, the demand for fertilizers in Ontario is steadily increasing. The only extensive factory in Canada is that owned by the Brockville Chemical & Superphosphate Co., Limited. Unfortunately, I have failed to obtain any statistics as to their annual output of superphosphate and other fertilizers and acids.

There is another superphosphate factory in Halifax, as I learn from the advertising columns of a local newspaper. But it is probably of small capacity and no national importance. It advertises itself as the Chemical Fertilizer Co., and sells its wares as "Ceres" superphosphates.

The report of Mr. Gordon Broome in 1870 contained some very startling figures as to the amount of phosphoric acid exported from Canada in 1869 in the shape of grain and flour. The figures for the past year would be still more striking.

Plumbago.

I cannot close this report without calling attention to the remarkable fact, that while the United States, in the years ending 30th June, 1882 and 1883, imported the following quantities and values of manufactured graphite, our Canadian mines were all idle:—

In 1882, 159,421 cwt., valued at $363,835: and in 1883, 154,893 cwt., valued at $361,949, being an average value of about $2.30 per cwt.

Mr. Joseph Nimmo, Jr., the Chief of the Bureau of Statistics at Washington, sends me these figures and writes as follows:—

"No plumbago was imported from Canada during the year mentioned (viz., year ending 30th June, 1883), nor during the six months ended December 31st last. The imports of that article came mainly from Germany and the British East Indies."

One chief reason of the utter collapse of our very promising trade in that mineral was the *uncertain* quality of the article shipped. I am assured by an American expert who used a good deal of plumbago from the Buckingham mines, that his company "tried a great deal of the graphite some years ago, but were obliged to give it up *because it did not run uniform.* Some of the crucibles made from it were as good as any, but others would crack. They gave it a thorough test, and used a great many barrels of it." He thinks that "it contained sulphur and other impurities." Collapse of plumbago trade in Canada.

There is no excuse for dressed graphite containing sulphur, when the difference in the sp. gravity of plumbago (about 2.25 to 2.27), and pyrite (4.83 to 5.20) is taken into consideration.

In the very valuable report on Graphite, by Mr. Hoffman (Geological Survey Reports 1876.1878), a very simple and cheap method of destroying all other noxious impurities was pointed out and illustrated; viz: the digestion of the dressed graphites in a bath of hydrochloric acid. By this agent the carbonate of lime and oxide of iron are removed, besides alumina, magnesia, a little silica, and traces of manganese.

Until acid-chambers are erected in Ottawa county or at Montreal, the best plan of working our plumbago deposits would be to dress the plumbago as completely at the mines as mechanical skill can accomplish, and then ship it to Brockville in barrels for the further treatment with acid before its export.

As long as the price of dressed plumbago does not fall below $40 per ton, many of our Canadian deposits could be profitably worked, always provided that they are managed by competent mining engineers. No mining company need hope to succeed in Canada or any other part of the world, unless its manager has had a careful technical training, or the ore is of phenomenal richness.

In the volume upon Mineral Resources, already so often quoted, there is an instructive article upon Graphite by Mr. John A. Walker. He says that:—"The only place in the United States where graphite is now mined sucessfully is at Ticonderoga, New York. The Dixon Company now mine a graphite schist 15 feet thick, carrying from 8 to 15 per cent. of graphite, practically an inexhaustible supply." In regard to ore dressing, he says:—"Several methods (both wet and dry) have been attempted. The process used by the Dixon Company at Ticonderoga owes its success to careful supervision. It is a wet process, in which the ordinary process is reversed, the 'tails' being the useful product, while the 'heads' are thrown away. All attempts at dry concentration have failed." Ticonderoga mines.

In 1882 the output of the Ticonderoga mine was 400,000 pounds. For 1883, the Dixon Company have arranged to produce 500,000 pounds. The average spot value may be stated at eight cents per pound."

In regard to the different kinds of plumbago he gives some valuable information:—

German black lead.

"German black lead is a product of Bavaria. It is of the amorphous variety, and is dressed chiefly by washing. Its price depends on its percentage of graphite, and the nature of its impurities, varying from $1 to $10 per hundred weight in cargo lots. It is used in the manufacture of pencils, stove polish and foundry facings. Ceylon plumbago is mined at Travancore, Ceylon, and is shipped from Colombo to all parts of the world. It occurs in immense veins of great purity. Cobbing and sizing are the only preliminary operations it undergoes. It appears in the market graded according to size, as large lump, small lump, chip and dust. Its price varies from $2 for dust to $10 per hundred weight for prime lump, in cargo lots. It is used for all the purposes of the trade, except the manufacture of pencil leads."

Price of American phosphates.

"American graphite, from the nature of its occurrence, appears in the market only in the dressed condition. Its price ranges from $2 to $10 per hundredweight wholesale, according to purity and fineness. Fineness exercises considerable influence on the price of graphite, on account of the difficulty of pulverizing it. American graphite is used for all purposes of the trade, and *excels all kinds as a lubricant.* It is the same geologically, &c., as the Canadian."

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., Director.

REPORT

ON THE

GOLD MINES

OF THE

LAKE OF THE WOODS.

BY

EUGÈNE COSTE, M.E.,
Diplomé de "l'Ecole Nationale Supérieure des Mines," Paris.

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1884.

To

Alfred R. C. Selwyn, Esq., LL.D., F.R.S., F.G.S.,

Director of the Geological and Natural History Survey of Canada.

Sir,—I beg to submit to you my report on the gold mines of the Lake of the Woods, which I inspected last summer in accordance with your instructions. Specimens were collected from the various mines: these have been assayed in the laboratory of the Survey by Mr. Hoffmann, with results as given in his report, M. Assays, numbers 23 to 58 inclusive.

I have the honor to be,

Sir,

Your obedient servant,

E. COSTE.

Ottawa, 16th January, 1884.

REPORT

ON THE

GOLD MINES OF THE LAKE OF THE WOODS.

BY

EUGÈNE COSTE, M.E.

So much has been said about these gold mines, I was led to suppose that important developments had been made. On visiting them, however, I soon discovered that very little work had been done in the district, and that the so-called mines are all still in an entirely primitive state. Everywhere, in fact, the shafts and openings are quite shallow; and at the time of my inspection, the Winnipeg Consolidated was the only mining company having two drifts commenced, and these still quite short. This Report is, therefore, of necessity, very incomplete, and for want of information as yet unattainable, it will throw but little light on the future prospects of this district; though it will shew what has already been achieved. I may say that I have paid no attention to the fabulous assays that were furnished me by the proprietors of the different mines I visited. According to them the richness was never less than some hundreds of dollars to the ton, and sometimes over a thousand. At present, however, it is only possible to say that some of the veins are auriferous, notably those of the "Pine Portage," the "Keewatin" and the "Winnipeg Consolidated" mines, and one of the veins of the "George Heenan Location;" but their richness does not appear to be exceptional, and they are not likely to pay, unless owned by stronger companies and worked more efficiently. Serious mistakes have, in fact, been made, resulting in several cases in a suspension of the works. At the Argyle Mine, for instance, the first thing observed is a splendid crushing-house for amalgamation and concentration, provided with ten powerful stamps and two fine concentrators (Frue system); but you look in vain for the shaft, for none of the numerous holes made in the outcrops are deserving of that name. Why not have tested the property and developed the veins a little with the few thousand dollars expended for the stamps, which now have nothing to crush? Had the money been spent in underground work, the company would now know the precise value of its property; there would be a shaft at least 300 feet in depth and several drifts at different levels, in other words, a real mine. Whereas now, after this premature outlay for a crushing-house, the company is, I believe, short of money, and has been forced to suspend its operations. No one will pay a high price for a property which has not been tested, and of which it is, therefore, impossible to know the value.

At "Pine Portage Mine" a similar mistake was made. the erection of the crushing machinery should have been deferred, and it should have been on the lake shore instead of on a creek which dries up every summer.

I shall now proceed to describe these mines. I may incidentally remark that questions of territorial jurisdiction appear to have considerably retarded mining development in this district.

At Big Stone Bay, some ten miles southeast of Rat Portage, and on Clear Water Bay, about twenty miles to the southwest, are to be found the several veins which have so far been slightly worked. They intersect the Huronian rocks which, in Big Stone Bay, are chiefly chlorite and hydromica schists, hornblende schists and amphibolites, and in Clear Water Bay, mica schists and quartzites.

The geology of this country, as well as its geography, is as yet imperfectly known. The labours of the Geological Survey, more especially those of last season, shew, however, that a band of Huronian rocks some twenty miles wide, from north to south, and running in the general direction from northeast to southwest, crosses the northern part of the Lake of the Woods and Shoal Lake. (See Dr. Bell's geological map of the Lake of the Woods.*) North of this band, and in perfect conformity with the Huronian strata, everywhere nearly vertical, runs the Laurentian gneiss; to the southeast is the large peninsula of the middle of the Lake of the Woods, hornblende schists, and others quite similar to the Huronian schists alternate repeatedly with the orthoclase gneiss; we then cross a true Laurentian tract until on Rainy River we again strike Huronian strata, for the most part, however, deeply covered with drift and exposed only in a few places. Do these several bands—which I have called Huronian, because, in America, that word alone will shew what kind of crystalline rocks are alluded to—all occupy synclinal valleys in the Laurentian gneiss? It is probably so with the broad band which crosses the north part of the lake, though, in the railway cuttings near Rat Portage, the dip of the rock is north, that is to say, under the

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* Report of Progress: 80-81-82:

gneiss; but the folds must be isoclinal, and this is probably merely one of those frequent inversions of these ancient strata. But it is very possible that the other narrower bands which cross the middle of the lake may be intercalated with the Laurentian gneiss; in the places where I found these beds, on the southwest shore of the great peninsula of the middle of the lake, the strata are completely vertical. No geological section has as yet been made across this country, and further explorations can alone furnish accurate knowledge of the stratigraphical arrangement of these different beds. Further explorations also can alone shew the exact form and extent of the various granite masses, which have invaded the schistose strata in many places; they are granite, of a medium grain, hornblendic, with pink orthoclase, and their quartz has also a peculiar pinkish tint. In Dr. Bell's map of 1881, appear at the least fourteen of these granite masses, very distinct, one from the other, as observed on the shores of the Lake of the Woods. The work of this season has shown the existence of others; it has demonstrated especially that the two masses crossed by the C. P. Railway immediately to the east of Patton and at Rossland, extend much farther than was thought, to the southwest. In fact the first one reaches the lake, and the Rossland almost touches the head of Pine Portage Bay, and seems to extend under it and to have raised to the surface three miles further on, the lower graphitic gneiss, which, on Quarry island, stands at least eighty feet over the lake, everywhere surrounded by the Huronian rock, and is a true gneiss granite at the centre, where was the C. P. Railway quarry. Adjacent to these granites and towards the southwest, that is to say, in the direction which seems to have been the strike of the upheaval of these two granite masses, are situated all the important veins, large numbers of veins having already been discovered on the shores and islands of Big Stone Bay. If, starting from that bay, we follow the same strike, we find on the other side of the lake, to the southeast of Shoal Lake, seven of the granitic masses above referred to, and between those two points, on an island in the middle of the lake, I myself met with another hornblendic granite cut in places by a subsequent eruption of true Syenite without quartz. Consequently, within a belt some fifteen miles broad, of which the axis would be about a straight line from Monument Bay to Patton, and following the direction indicated, S. W., N. E., movements, due perhaps to lateral compression, seem to have fractured the crust at a very remote period. Through these lines of fracture, the granite rocks forced their way upwards lifting the Huronian schists, and in so lifting them fractured them still more in other directions. All these efforts created a real field of fractures, wherein the metaliferous emanations—which doubtless preceded, accompanied and followed the granitic eruptions—have made a real field of veins. And in fact, if the vein of the Keewatin mine, one vein on Copper Island and the vein, as yet unworked, of the Lake of the Woods Mining Company, run parallel with the axis, S. W., N. E., of the granitic upheavals, all the other veins may, as to their directions, be divided into two series of strikes perpendicular to each other, namely:—

One series, N. S., dipping east,
One series, E. W., dipping south.

I do not mean to assert thereby that all these veins trend precisely N. S. or E. W., but, as will be seen hereinafter, those that vary most from the one or the other of these two directions, do not vary therefrom more than twenty degrees. I will add that the N. S. veins seem to me to be truer fractures, more regular and wider, with better defined walls and that the filling matter is more massive and contains less of the surrounding schists mixed with the quartz. Though these observations are not as yet sufficiently numerous to base a rule on them, I have thought it right, nevertheless, to formulate them, for, with the exception of the three veins above mentioned, all those that I have seen, numbering about twenty, are in conformity therewith.

I now proceed to describe the lodes in the order in which I visited them.

District of Big Stone Bay.

George Heenan Location, Hay Island, Big Stone Bay.—A vein, called "the vein in front of the house," only two feet wide, here cuts the extremity of a little narrow point which juts perpendicularly into the lake. The strike, referred to the true meridian, is exactly 90° * (E.W.); it dips to the south at an angle of 85°. This little vein is badly defined, and the quartz is largely mixed with the surrounding schists running in the same direction; but it is rich in gold and has yielded many fine specimens which I have seen: native gold alone is there with the quartz and very little iron pyrites. On this little narrow point the vein was soon exhausted, the water level having been reached; the miners then proceeded some 300 feet to the west, on the other side of the little bay formed by the point, where they found, about on a line with the vein of the point, small seams of quartz running with the schists over a breadth of about three feet. This quartz is white and friable and mixed with calcite and much mispickel

* The strikes will always be referred to the true meridian, and will in all cases be calculated in degrees, commencing at North, which will be zero, and turning in the direction of the movement of the hands of a watch.

and iron pyrites; it contains no gold visible to the naked eye, unlike the yellow, hard quartz of the point. However, the miners thought they had again struck the rich and promising vein of the point, and at once decided to sink a vertical shaft, some 200 feet from the lake, a little way up the hill. Four miners were working at it at the time of my visit; they were left entirely to themselves and had contracted to sink a pit nine feet by seven, which was then some forty feet deep. The intention was, when the pit had reached a quarter depth, to make a drift towards the south, and thus strike the vein once more. That is to say, if it exists, which is not certain! I advised, therefore, that the horizontal drift should at once be opened.

Big Copper Lead.—A little more than a quarter of a mile farther east, and forming part of the George Heenan Location, another and wider vein (about eighteen feet in average) starts from another bay on Hay Island and runs precisely on the same strike (90°); it forms a slight ridge in the wood and can be traced eastwards for some 2000 feet. A few blasts have been fired in this vein on the shore of the bay, and exposing a very confused vein, not a good fissure, filled with quartz mixed with spathic iron and rich in copper-pyrites, iron-pyrites and mispickel. Neither the gold nor the silver are visible to the naked eye; but I was told assays had been very satisfactory for both metals. To the west, on the other side of this bay, about a quarter of a mile farther, another vein is exposed; it corresponds exactly with the extension of the Big Copper Lead, and it must be simply one and the same vein; the filling is the same, and there is no difference between specimens taken from the two places. This vein if extended still farther to the west, would pass to the south of the vertical pit I have mentioned sunk on the first vein of the George Heenan Location, and probably within a short distance of it. On the day I left Rat Portage, George Heenan told me he had come upon this vein again in the woods, less than 300 feet to the south of the pit, and that it was now the intention to extend to that point the southern drift they are about to make from the pit, in order to work this second vein through the same pit; they must be working at it at the present time. If this is really the case there is here a good vein nearly one mile in length, and 10 feet broad, but the richness of which in gold and in silver is still unknown.

Bay to the East of Pine Portage Bay.—Two veins have been discovered in this bay by G. Heenan. One is on the east shore, 300 or 400 feet back in the woods; its strike is 170°. A few blasts only had been fired and showed a clean fracture, thirteen feet thick, filled with white, glassy quartz, holding a little iron and copper pyrites and mispickel; a small speck of gold was visible in one of the specimens I picked up. The second vein is at the head of the bay, and is also some little way back in the woods. Its strike is 10°, its thickness eleven feet, and it is filled with quartz in which no mineral is visible. These two veins seem to dip towards the east, but they had not been sufficiently opened up, and I was unable to make sure of the fact.

Maiden Island.—East of the above bay.—A vein was discovered on this little island by Mr. Young. A hole only some twelve feet in depth had been made, showing a small vein one foot and a half in thickness, dipping east; direction 10°; the filling is quartz, rich in iron and copper pyrites and covellite.

Copper Island.—An island in Big Stone Bay: half a mile north-east of the Keewatin Mine. A few blasts only had exposed a vein on this island from four to five feet in thickness; direction 40°, and filling matter consisting of white, glassy quartz, rich in iron-pyrites and copper-pyrites mixed with a little calcite.

Keewatin Mine—Hay Island.—This mine is located in a bay of Hay Island, half a mile south-south-east of Hay Island Point; two veins are visible on the shore, at the head of the bay. The strike of the more easterly vein is 10°, and it dips 60° east. A few blasts opened it a little, and at this point its appearance is not favorable. The quartz, which is rich in iron and copper pyrites and in mispickel, runs in small veins between the laminæ of the schists, forming a total width of about six feet of impregnated matter; the quartz is very white, granular and crumbling. The second vein, on the shore, is only some forty or fifty feet farther west; its strike is 40°; and therefore must meet the first a short distance from the shore, under the lake. It forms, on the shore of the lake, a small escarpment of slight elevation. The upper part of this bluff is a mixture of quartz and schist permeated by mineral matter consisting chiefly of mispickel with white and yellow iron-pyrites and copper-pyrites, blende, galena and calcite. But at the base of the bluff, on a level with the ground, the several veins of quartz unite and seem to form a massive vein about fifteen feet wide, and having no schist mixed with it; it was difficult to get a good sight, for the soil hid it in parts. When this vein was discovered and before any blasts had been fired, the summit of this bluff consisted of cavernous quartz honeycombed from the decomposition of the pyrites; the gold alone remained unaltered, and was, it appears, visible in some of the specimens. I did not see any of those specimens, though I sought carefully in a large heap of the ore; but I crushed and washed several specimens of this decomposed quartz, as well as of the unaltered lower quartz, and I obtained each time a fine colour of gold. This vein is, then, undoubtedly auriferous; but to what extent, and what is its average richness, I have no idea. Back of the escarpment

I have just mentioned, the hill rises to a considerable height, and nothing was easier than to follow the vein by a tunnel starting from the shore of the lake, with a slight slope towards the lake. The lode, apparently a rich one, would thus have been tested; afterwards a vertical pit might have been sunk and the work of extracting commenced on a large scale and systematically. In place of that, the miners ascended the hill at once on the strike of the vein; and at a point some 400 feet from the lake, they sank an inclined pit in a small quartz vein, which seems to be merely a branch of the great lode; but it fills a cleanly cut fracture, with a well defined wall, and dips very regularly 62° to S.E. At the surface, the thickness of this little vein was only six inches, but it steadily increased as the pit deepened, and reached one foot and a-half at 65 feet, the bottom of the pit, the distance being measured according to the inclination. The quartz of this little vein is less impregnated with mineral matter than that of the hill, and it has hitherto shewn itself less rich in gold; it is harder, and its crystals are larger. At the time of my visit all work had been for some time suspended; it was considered a hopeless task to continue sinking the shaft in the small vein and to be no farther advanced than the first day, after having expended from $8,000 to $9,000. It has since been reported that a company had acquired the property, and that work was about to be resumed; I learnt this with pleasure, for this vein seems to be wide and rich. I was told that other lodes are known in the immediate vicinity of the Keewatin Mine; they have never been worked, and I was unable to find any person to show them to me.

Winnipeg Consolidated Mine, East Shore of Big Stone Bay.—It may be said that an average of five or six men worked at this mine the whole of last summer; but always very irregularly, work being suspended sometimes for more than a week. The pit is sunk on a narrow lode, consisting of thin streaks of quartz running between the foliation of the surrounding schists, the whole forming a thickness of 1′ 6″ to 3′ 6″. It follows the outlines of this very irregular vein, the strike of which varies from 100° to 110°, with a general dip to the south, but with greatly varying inclination:—

65° at the surface,
57° " 40 feet,
45° " 80 feet,
65° again at the bottom of the pit, which was 95 feet deep, measured on the inclination.

At the depth of eighty feet, two drifts had been commenced; the western drift was thirty-five feet in length and the eastern twenty-five. The true vein of massive quartz, in these drifts as well as in the pit, was found to be narrow (6″ to 2′); it is certainly auriferous, and I think rich; it contains, besides iron and copper pyrites, mispickel, a little calcite and a very little galena and blende; it follows the foot wall. At the roof, the enclosing amphibolite is changed into schist for one or two feet, and these schists are penetrated by small veins of quartz and impregnated with mineral substances; they are taken out and submitted to the stamps in the crushing-house, like the quartz. The crushing-house is located on the shore of the lake, 500 or 600 feet from the pit; it contains five stamps, a long, copper, amalgamated retaining plate, a grinder which receives all that passes over the plate and grinds it more finely; and lastly, a sort of closed pan, the inner surface of which is also amalgamated so as to retain the last particles of the amalgable gold; the refuse runs into the lake, carrying away all the non-free-milling gold.

Since my visit I have learned that two other drifts had been commenced at a depth of ninety-five feet; this seems to me to be a mistake, for I do not imagine it can be the intention to continue the extraction through this frightful shaft, which follows all the gradients I have mentioned. The company must now know the exact average richness of the vein; and if it is worth working, a vertical shaft must be sunk at once and the lode struck through the strata, as well as the other parallel veins of which I shall now speak, and regular operations on a large scale could then be commenced. For this a strong company is required; in fact none but wealthy companies can with any hope of success undertake to work such narrow lodes intersecting this excessively hard ancient formation; this has not hitherto been sufficiently recognised in the region of the Lake of the Woods.

Quite a number of other veins are known in the immediate neighborhood of the Winnipeg Consolidated Mine. Two of them are near the lake: one at 200 or 300 feet north of the stamp mill, and the second at 400 or 500 feet to the south. The first is two feet wide, it dips 75° to 80° south, and strikes 110°. The strike of the second is the same; it dips only 45°, to the south also, and its thickness is three feet. A third vein is visible on the hills, 300 or 400 feet south of the shaft; same strike 110°, thickness four to five feet, dip also south. All these are quartz veins holding iron and copper pyrites; specimens were collected, and the assays of Mr. Hoffmann, chemist to the Geological Survey, will show whether they are auriferous: the veins of this region appear to be nearly all more or less so.

A mile and a-half east of the Winnipeg Consolidated Mine, in the woods, and forming part of the property of that company, is another vein in which a small excavation some ten feet deep had been made. This appears to be a very good fissure, and the vein of quartz filling it is massive; it is quartz mixed with calcite, and is rich in iron and copper pyrites, with a little galena. The thickness of this lode is about five feet; it strikes 165°, and dips east.

Lake of the Woods Mining Company.—About a quarter of a mile farther east, in the woods, another vein, about eleven feet in thickness, has been purchased by an American company; this company, I was told, proposed commencing operations this winter. The strike of this vein is 40°, exactly the same as that of the second vein of the Keewatin Mine, and the dip is also southeast. This is, I think, a very good fissure vein, the quartz is massive, without intercalations of the surrounding schists. The ore is also in many respects similar to the ore of the Keewatin, and is remarkable, like the latter, for the large quantity of mispickle and white iron pyrites contained in the quartz; in addition to that mineral the quartz contains yellow iron pyrites and a little copper pyrites.

Canada Mining Company.—This company is working the same vein as the Winnipeg Consolidated Company; its shaft is 300 or 400 feet further east than the shaft of the latter company; it follows the inclination of the vein, and was only some forty feet in depth; only four men were working at it. The vein at this point does not appear to be so good as at the Winnipeg Consolidated Mine; it is neither wider nor more uniform, and the quartz is more largely mixed with schists. At a point 800 or 900 feet further east, the Canada Mining Company have excavated a small hole in a vein which is in line with the extension of the above mentioned vein, has the same strike, and which consequently seems to be the same. Properly speaking, it is at this point no longer a vein; narrow streaks of quartz running through the schists, and mixed throughout with a little pyrites, are all that can be seen.

Minnesabic Island.—This island is situated in Big Stone Bay, about a mile to the westward of the Winnipeg Consolidated Mine. Two true veins, well formed, with good walls, have been slightly worked on the west point of this little island. An inclined shaft, following the vein, some thirty feet in depth, had been sunk in each of these two veins separately. Their direction is 10°; they dip to the east; the easterly at 60° and the westerly from 75° to 80°. The thickness of each vein varies from six inches to two feet, and the filling is quartz mixed with a little calcite and holding iron and copper pyrites and a little galena; they are auriferous, but I have no idea of their average richness per ton.

Pine Portage Mine.—If this mine were well and fully worked, I think I may safely say that it would now be classed among the mines paying dividends. Instead of this, the money spent upon it has not been well spent, and the mine is still but very slightly developed.

Pine Portage Bay is a long, narrow bay of the north shore of Big Stone Bay; the mine is three-fourths of a mile back in the woods, north-northeast of the head of this bay, and four or five miles south of Rossland Station, the first station east of Rat Portage.

At the time of my visit in August there were but four men at the mine carrying on the sinking of the shaft, a blacksmith and a cook; the crushing-house had been idle for nearly a month for want of water, and several men (five or six) had been dismissed. The great blunder had been made of erecting the stamp mill on the side of a small creek, full of water in the spring, but absolutely dry in summer. Clearly the proper place for the mill was the shore of the Lake of the Woods; a self-inclined plane would have given an easy connection between the mine and the head of Pine Portage Bay. Bèsides, the fitting up of the crushing-house was entirely premature; the mine should have been first developed, and the crushing-mill erected only when the preliminary work was done and the mine in a regular working condition. But how could a lumber merchant and a gentleman farmer undertake to develope a mine without the assistance of a single competent person? Yet this is what has been attempted at Pine Portage Mine, and the parties should not be surprised at their own failure. The shaft sunk in the vein was only forty-three feet in depth, at the time of my first visit; and yet a crushing-house with five stamps and two fine Frue vanners for concentration had been erected two months before on the bank of a creek without water, as though the proprietors had been seized by a mania for spending money on seeing a little gold in the quartz. At the time of my second visit, four weeks later, the shaft had reached a depth of sixty feet; four miners were carrying on the sinking under a contract. They worked as they liked and blindly, not being controlled by any competent person. Such was the method of working adopted on this vein, which is, nevertheless, the most promising of all those I saw on the Lake of the Woods.

Let us then speak of the vein, as there is no mine. The strike is 160 °, and it dips to the east with an inclination varying from 65 ° to 70 °; its thickness is a little over seven feet. The dimensions of the shaft were ten feet by seven, which did not reach the true foot wall of the vein and did not show its full thickness. This vein seems to me to be a very good fissure, clean cut, and one which has remained for a long time open, as is shown by a very regular clay about one inch to one inch and a half in thickness, which separates the vein from an excellent and very regular roof. The quartz of this vein is massive and but little mixed with schist, white, very glassy and tolerably friable; it is certainly very auriferous and is impregnated with iron and copper pyrites, blende, galena, mispickel and a little covellite and variegated copper. Down to a depth of twenty-five feet in the shaft there was a little calcite mixed with the quartz, and the galena, very finely crystallised and most probably argentiferous, was then more abundant. I was told that at that depth several blasts produced much native silver and some native copper; but the parties were never able to show me the smallest specimen of either of these minerals, and I looked in vain for a long time over the heap of ore piled up near the crushing-house. Shortly before reaching the depth of sixty feet, the calcite, which had never quite disappeared, again showed itself in larger quantity; and the quartz, a little calcite and a little iron-pyrites were the only minerals visible at the bottom of the shaft at the time of my second visit; the quartz was still auriferous and contained also a little galena invisible to the naked eye, and very probably argentiferous. The place where the shaft is sunk is at the base of a pretty high bluff which the vein follows for some distance and into which it afterwards enters. At the latter point a horizontal drift under the bluff had been commenced in the lode on the ground level. The vein in this drift is largely mixed with schists, and its appearance is not so good as in the shaft; the clay layer still follows the roof; but the direction of the lode has changed and has become N. S. A lode which thus changes its direction a little at various points, is generally well defined and rich in one only of such directions; the good direction, that of the rich portions, seems then here to be 160°. Other veins, thick and in large numbers, I was told are known in the vicinity of Pine Portage, but some of the "prospectors" are strange men! While many of them complacently exhibit a lot of little quartz streaks and try to pass them off upon you for lodes of great richness, others pretend to know important deposits but they cannot be induced to show them to you. I hit upon one of the latter with reference to the veins known in the vicinity of Pine Portage Mine; perhaps, after all, he had really nothing to show me. But this part of the country is a narrow band of Huronian schists, confined between the two great granitic masses of Patton and Rossland, and must have been extensively fractured at the period of the formation of the granite; hence I should not be surprised had numerous lodes been really discovered there. There is one visible on the hill which forms the bluff above mentioned, its thickness exceeds nine feet and its strike is 70°; the quartz contains iron-pyrites, pyrrhotite, and black needles of hornblende; I do not yet know whether it is auriferous or not, it can be traced for a considerable distance.

Before concluding my remarks on the Pine Portage Mine I shall add a few details and considerations in relation to the stamp-mill.

The speed of the engine was regulated so that the stamps might give ninety strokes a minute, which is a very high speed; the stamps, as I have stated, number five; the head weighs 750 lbs. and the fall is 7, 5. From the amalgamated copper plate, where the crushed ore leaves a portion of its gold, it proceeds to the Frue concentrators These "Frue ore concentrators" were furnished by Fraser and Palmer, of Chicago, at the price of $750 each. They are inclined tables, twelve feet in length and four feet in breadth, formed of endless bands of India-rubber twenty-seven feet in circumference. These bands pass over rollers which stretch them, and the rotary movement of the rollers imparts to the tables an ascending motion of translation which had been fixed at three feet a minute, but may be increased or diminished at will. In like manner, according to the nature of the ore treated, the inclination of the tables may be changed; at Pine Portage it was 4½" in twelve feet. During their upward movement the bands receive a repetition of slight transverse shakes 180 to 200 per minute. The matter to be concentrated, that is to say, the muddy mixture of quartz, pyrites, blende, galena, &c., still containing gold and silver, reaches the base of the band which is furnished with a rim in order to make this matter accumulate to the depth of about half an inch. Streamlets of pure water, on the other hand, fall upon the upper portion of the table, and as they flow down effect the washing, which is facilitated by the lateral shocks by which the matter is constantly shaken. As a consequence the quartz, the calcite and a small portion of the pyrites are washed away by the water and form the "refuse"; whereas the heavier matter (blende, galena, the greater part of the pyrites, the gold and the silver) reach the top of the table, where they fall into a special trough and form the "concentrated slimes." I brought a little of the concentrated slimes with me, and an analysis by Mr. Hoffmann will show whether the system of concentrating, which I have just described, and which was that followed at Pine Portage Mine, is suited to the ore of that mine. These concentrated slimes were set aside and were not treated. Why not continue the treatment of this ore? Why undergo a heavy expenditure and then stop half way and get no return? The parties should either have made arrangements to dispose of the ore as it leaves the mine, or else, if they were sufficiently venturesome and sufficiently rich, make up their minds to treat it thoroughly. With an ore so largely composed of pyrites, in which a large proportion of the gold cannot be directly amalgamated, owing to the presence of sulphur, arsenic, antimony and perhaps tellurium, great loss would ensue if nothing more were done than passing the ore over a plate of amalgamated copper; once the ore is crushed, parties must therefore make up their minds not only to make concentrated slimes, but also to give them further treatment by processes which are somewhat complex and expensive. They must either be roasted at a low temperature with superheated steam, so as to drive off the sulphur, arsenic and tellurium which prevent the mercury from dissolving the gold, or be treated with a mixture of mercury and chloride of lime, the result being a complex reaction which liberates the chlorine, the latter in turn liberating the gold and enabling it to amalgamate. Other processes might also be used, such as the treatment with chloride of mercury in connection with iron or cast-iron, &c.; but, I repeat it, all these processes are very expensive, more especially as regards the outfit. Now, is it wise to launch out into all this expenditure before having a real mine in regular working order of extraction, so as to be sure that this costly establishment for crushing and treating it is needed, and that it will serve a purpose and bring in a return? It is therefore mere folly to set up a crushing-house when you have only a twenty foot shaft and a vein of which you know almost nothing.

Sultana Lead.—On the east shore of Indian Bay (Big Stone Bay), a thick vein of quartz cuts the gneiss and forms a species of dike on the shores of the lake, the quartz having withstood the action of the atmosphere better than the adjoining gneiss. This gneiss forms part of the same outcrop as the gneiss of Quarry Island, an outcrop forming a qua-qua-versal of limited extent, the centre of which is granitic gneiss, and which is surrounded everywhere by the Huronian schists. It is a hornblende gneiss, graphitic in places; at the foot wall and roof of the vein it changes into a species of hornblende schist. This vein, called the Sultana Lead, is about 30′ wide. Its strike is 70°, and its dip south at an angle of 72°; the quartz is yellowish, hard and void of minerals; I do not think it is auriferous. It reappears 500 or 600 feet to the east on another bay of Indian Bay; and also a quarter of a mile to the west, on the island directly west of Quarry Island. In the foot wall of this quartz vein, at 12′ or thereabouts, is another little vein with softer and whiter quartz, which is auriferous and contains mispickel, iron-pyrites and galena—probably argentiferous. The thickness of this little vein varies from 6″ to 1′. The gneiss at the foot wall of this second vein, and between the two veins, is also changed into hornblende schist.

Island South-east of Scottish Island.—On the south-west point of this island I visited a singular and thick vein which cuts the hydromica slates. It is a mass of mispickel and pyrrhotite; the gangue is quartz, but there is very little of it, the lode being almost a solid mass of mineral. A small hole had been made in the lode, and it was impossible to ascertain the strike or the thickness; however, the strike seemed to be E.W., and the thickness is over eleven feet. The mispickel is stated to be at times rich in cobalt (five, six, and as much as nine per cent), and the pyrrhotite to contain sometimes four to five per cent of nickel. If this be so, the vein would be exceedingly valuable; I collected specimens which will be analysed by Mr. Hoffmann. The average proportion of arsenic held by this ore must be thirty-five to forty per cent; this alone gives it a value of $12 to $15 per ton.

District of Clear Water Bay and Ptarmigan Bay.

Argyle Mine.—All the veins I have hitherto spoken of are situated S.E. of Rat Portage; I have now to say in conclusion a few words as to the veins found to the S.W., on Clear Water Bay. They are fewer in number and of less importance so far, and are outside of the great belt of fracture I have mentioned. They are perhaps on a smaller belt parallel thereto; at all events they are evidently connected with the massive granite visible on the shores of Granite Lake. At the Argyle Mine two veins having a strike of 100° intersect mica-schists very rich in quartz. The more northward of the two varies from one to two feet in thickness only; it is very badly defined. It is not a quartz vein sharply cutting the surrounding schist. It has been exposed for about a quarter of a mile, and within that distance four or five large pits have been made in the vein. At one of these pits the vein divides into two small branches which reunite again and enclose between them schists impregnated with iron-pyrites and mispickel; in addition to these mineral matters the quartz is mixed with calcite; I do not think it is very rich in gold. At a quarter of a mile further on, near the place where the stamp-mill has been erected, the following up of this small vein was discontinued and the work of exposing the vein was pushed on about 150 feet in another small vein from one foot to eighteen inches in thickness, which intersects the first at an angle of 60°. What is the object of all this work on these little veins? It is simply money spent for nothing.

Over a quarter of a mile further south is the second vein, with a strike of 100°; it dips south the same as the last mentioned vein, is wider (four to seven feet), and seems better defined. Two large pits, one on the shore of the lake, and a second, dignified with the name of shaft, a little further back on the hill, have been made in this vein, the quartz of which is very white and hard, and contains a little iron-pyrites, mispickel, copper-pyrites and calcite; I doubt whether it is very rich in gold. As I have already stated, the stamp-mill is set up near the first little vein. It is furnished with ten stamps, one large copper amalgamating plate, and two "Frue ore-concentrators." The question is, what are all these things for? For the mine to furnish the matter to be crushed at this crushing-house is impossible. The second vein, on which "the shaft" is situated is about half a mile from the crushing-house; there is no road through the wood over the hill, and the few tons of quartz taken from the two pits in this vein were brought to the crushing-house by way of the lake, in a scow in summer and on the ice in winter; and to cap the climax of blundering, the crushing-house itself is located some little way up on the hill, creating an additional difficulty in carrying the ore and the water up there. In view of all these facts, it will surprise no one to learn that the work had been suspended.

Manitoba Consolidated Mining Company.—This Company was sinking a vertical shaft, seven feet by eleven, on the eastern extension of the first little vein of the Argyle Mine, which here consists merely of thin seams of quartz running through the schist. The mouth of this shaft is on a small hill which falls perpendicularly into the lake, forming a bold bluff from which the shaft is only thirty or forty feet distant; four men were working at this shaft at the time of my visit, and it had reached a depth of fifty feet. Where is the vein intended to be worked by this shaft? The question is not easily answered. It can be no other than the most southern vein of the Argyle mine, which is from four to seven feet in thickness and which I have last described. But in order to reach it they will have to drive a level south across the strata, under the lake, 400 feet in length at least, and at a pretty great depth, for the lake is, it appears, very deep at the foot of the bluff I have mentioned. Thus we find here a fine vertical shaft and no vein; while at the Argyle Mine they have a vein, no shaft and a fine crushing-house half a mile away from the vein.

A few other veins are known on Clear Water Bay, and in particular at the Woodstock at the Thompson mines, but they are narrow veins and have as yet been but very little worked or not at all.

In short, as I have now shown, no serious work has yet been undertaken in this new gold district of the Lake of the Woods. The district is nevertheless one deserving attention, for it is intersected by numerous auriferous veins, several of which are without doubt capable of being profitably worked by companies, if their operations were properly conducted, and especially if they were operating on a large scale. Indeed to-day, thanks to the powerful means at the disposal of the Mining Engineer, ores formerly considered poor, and which are in fact very low grade ones, are often worked with large profits. The very extensive copper mines in the United States, on the south shore of Lake Superior, are brilliant instances of this; and in the colony of Victoria, in Australia, a new country like ours, where labor is very high, ores yielding an average of five dwts. of gold per ton (say $5.25) are esteemed rich, and others yielding only from two dwts. twelve grains to three dwts. ($2.62 to $3.15) per ton are sometimes worked to advantage.

These figures will give an idea of what can be done on the Lake of the Woods, for it is my impression that there several of the lodes of which I have spoken will prove to have a mean value of more than $12 per ton, which is the general average richness of all the reefs until now worked in Victoria, and of which official statistics have been published. I may also say that there are good reasons to hope that other numerous profitable veins will be discovered in that region, as auriferous lodes are known on Lake Superior, a few miles north of the "Slate Islands," 350 miles east of the Lake of the Woods, as well as at several other places in the interval (Prince's Location S.W. of Thunder Bay; Huronian Mine S.W. Shebandowan Lake, and another locality W. of "Lac des Milles Lacs"); and it must be remembered that all these veins cut the Huronian rocks, so well developed in that region, and so often upheaved and fractured by granitic eruption with which the metaliferous veins seem to be in close connection.

In conclusion, I shall take the liberty of warning the miners on the Lake of the Woods against the idea so generally spread amongst them that the richness of an auriferous quartz must naturally increase with depth. On the contrary, following in that Sir Roderick Murchison, the decrease in depth of the richness in gold of quartz veins was for a long time by many considered a law. Dr. Selwyn first, since 1854, again in 1856 (see 1st edition Siluria of Sir R. Murchison), and also in his "Notes on the Physical Geography, Geology and Mineralogy, of Victoria, 1866," has strongly refuted this theory; and now that the "Reefs" in Australia are explored to great depths, experience shows that he was right when saying: "That the extraction of gold from quartz reefs, if properly conducted, may be regarded as an occupation which will prove as permanently profitable in Victoria as tin and copper mining have been in Great Britain," (see Sir Roderick Murchison, 4th edition of Siluria, pp. 464–467). For it is a fact that gold quartz mining is in Victoria more remunerative now than ever, as proved by the statistics to be seen in the quarterly reports of the "Mining Surveyors and Registrars" of that colony. The following table, from these statistics, shows that if you take the two years 1876 and 1882, six years interval, the average yield in gold per ton is only less in two districts, is the same in two others, and is greater for the last three districts:—

1876.				DISTRICTS.	1882.			
Quartz Crushed.	Average Yield of Gold per ton.				Quartz Crushed.	Average Yield of Gold per ton.		
	Oz.	Dwt.	Grs.			Oz.	Dwt.	Grs.
315,407 t.	0	6	14·16	Ballarat............	466,754 t.	0	6	14·41
95,639 t.	0	11	6·61	Beechworth	33,570 t.	0	12	15·35
356,927 t.	0	11	22·86	Sandhurst..........	264,513 t.	0	13	7·29
32,605 t.	0	8	18·66	Maryborough	59,258 t.	0	8	7·38
111,716 t.	0	7	14·45	Castlemaine	107,215 t.	0	5	20·51
88,729 t.	0	16	22·47	Ararat	67,784 t.	0	6	6·88
40,784 t.	1	3	12·58	Gippsland..........	28,732 t.	1	4	6·66

Another table, taken at random from these statistics, serves to illustrate how greatly variable is the average yield of gold per ton in the "New Chum Reef," now being worked at great depths :

			Oz.	Dwts.	Grs.
At about 460 feet	432 t.	Of quartz have given an average yield of gold per ton of.	0	4	17·44
At 540 feet ...	279 t.	do	0	8	15·91
	684 t.	do	0	6	12·69
At 700 "	1,949 t.	do	0	9	3·3
At 800 "	1,305 t.	Maximum do = $38.58	1	16	18·13
At 850 " ...	759 t.	do	0	10	12·2
	811 t.	do	1	7	20·92
	814 t.	do	1	0	23·58
	1,639 t.	do	0	13	19·81
At 868 " ...	2,319 t.	do	0	7	12·89
	1,533 t.	do	0	11	11·6
	474 t.	do	0	9	20·25
At 900 " ...	1,980 t.	do	1	2	9·6
	1,788 t.	do	1	10	5·15
At 977 " ...	1,334 t.	do	1	1	4·11
	1,582 t.	do	0	18	21·98
At 1026 " ...	2,285 t.	do	0	11	7·61
	2,197 t.	do	0	9	22·72
	2,999 t.	do	0	9	21·42
At 1030 "	3,101 t.	do	0	12	1·39
At 1106 "	410 t.	do	0	13	15·74
At 1140 "	334 t.	do	0	8	0.21

The average yield, as seen, changes all the time, vertically as well as horizontally; this is the "Bonanza" feature so well recognised everywhere for the other metals, and gold certainly must not be excepted; for this metal, as well as for the others, the decrease of the richness in depth cannot be made a law more than the increase. The gold quartz miner, in consequence, must bear in mind that the richness of his quartz is liable to change every foot, on the level or in the shaft, and he should always explore in advance the underground, keeping careful records of the quartz crushed from the new levels and of the gold obtained; it is the only means at his disposal to know whether his rock is paying or not: assays of selected specimens, or a certain richness at one time will not teach him much, and will often induce him to incur an unremunerative expense.

E. Coste.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

OF

OBSERVATIONS IN 1883,

ON SOME

MINES AND MINERALS

IN

ONTARIO, QUEBEC AND NOVA SCOTIA.

BY

CHAS. W. WILLIMOTT,

ASSISTANT CURATOR AND COLLECTOR MINERALOGICAL SECTION.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.

1884.

To Alfred R. C. Selwyn, Esq., LL.D., F.R S., F.G.S., &c.

Director of the Geological and Natural History Survey of Canada.

Sir,—In accordance with your instructions I visited during the past summer a number of mines and mineral localities, which were deemed important, both from a scientific as well as from an economic point of view. About forty mines were visited in the Provinces of Ontario, Quebec, and Nova Scotia, from all of which collections were made. The observations recorded, although not so complete as I could wish, nevertheless suffice to show that the mining industry generally is not on the decline. A lack of enterprize may be apparent in some localities, but it is more than counterbalanced by the evident progress in others. Over one hundred characteristic minerals were collected, some of which appear in the Museum for the first time, and others represent localities not before recorded. I was assisted during the summer by Mr. H. P. Bennett, whose zealous interest in mineralogy made his services valuable.

I have the honor to be

Sir,

Your most obedient servant,

CHAS. W. WILLIMOTT.

REPORT

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ONTARIO.

Elliott's Mine.

Apatite.

On Lot 7, Range I, of Ross, several openings have been made on a limestone band, holding an abundance of crystals, apatite, scapolite and titanite. Crystals of the latter often enclosing crystals of the former. Large bedded masses of dark green lamellar pyroxene are of frequent occurrence studded with crystals of titanite. In one instance a portion of a large crystal of pyroxene was observed penetrated by Ross. crystals of apatite, the latter mineral enclosing calcite.

It is questionable whether, even this large amount of crystals could be separated from the matrix with profit, but in this case much depends upon the fluctuations of the market price for crystals. The prospecting work done on this lot seems confined to the above bands. It is conformable with a gneissic rock, cut by small veins of a massive apatite, possibly leaders to more remunerative deposits, but no attempt has been made to develop these small veins. About one ton of crystals had been extracted. Black hornblende crystals are very numerous and may be detached from a pink disintegrating limestone. Fine prisms of scapolite, laterally striated, with both terminations well preserved, occur in a limestone band.

Cole's Mine.

This property comprises Lot 13, Range VI. of Ross, and consists of a small opening in limestone overlaid by a foot or so of horizontal gneiss. The apatite is chiefly in the shape of crystals, accompanied by grains of purple fluorite. The latter mineral also occurs in bedded masses two feet in width, varying from colorless through various shades of blue, and it often encloses bronze-brown crystals of scapolite. Where there is any demand for this mineral it could in all probability be mined more remuneratively to the proprietor than the associated apatite.

At another opening on this lot the limestone is mixed with an abundance of black mica (biotite) and aggregated masses of large crystals of orthoclase. Rough crystals of pyroxene and titanite are also associated.

Park's Mine.

Sebastopol.

This property is situated on Lot 23, Range XII, of Sebastopol. Only prospecting work had been done at the time of my visit. The openings that had been made were principally in limestone, holding an abundance of apatite crystals. These crystals, which are sometimes semi-transparent, differ from those of Ottawa county by having, almost invariably, the apex of the pyramid replaced by a plane, and crystals measuring one foot in length will be but three inches in diameter. A similar crystal to those described was seen in the possession of Mr. Townsend, of not less than twenty pounds weight. Very frequently the lateral planes appear cracked, and in translucent varieties give off coloured reflections.

In traversing this lot numerous small chasms are met with, often many feet in depth, the walls of which are covered with large crystals of orthoclase, hornblende, pyroxene and apatite. One crystal of orthoclase measured twelve inches in length and eight inches through.

At one of the openings on this lot the orthoclase crystals, when broken, exhibit the golden reflections that constitute the variety Avanturine.

Meany's Mine.

This mine is situated on Lot 31, Range XI, of Sebastopol. Several openings have been made on it; the most important is a pit twenty-five feet in depth, sunk on a mixed vein of apatite and pyroxene, intersected by small veins of pink calcite. This vein having a N. E. and S. W. course and varying in width from six to sixteen feet can be traced into the next lot, where, however, the pyroxene is replaced by calcite, often enclosing immense crystals of apatite and orthoclase.

Large crystals of apatite and orthoclase.

Meany's mine was first opened in 1880, and since then about 300 tons have been raised at intervals, with an average daily labour of five men.

Smart's Mine

is situated on Lot 31, Range X. of the same township. At the time of my visit operations had been suspended, and I was unable to obtain any reliable information respecting the mine.

The house was occupied by Mr. Townsend, who had secured the right to explore the lot and collect specimens of minerals of scientific interest. He had made a very large collection, embracing fine crystals of zircon, titanite, and apatite. He had two crystals of zircon, doubly terminated with the termination of a third crystal projecting from one of the lateral planes. They were of a brilliant hyacinth red color, and were valued by the owner at $25 each. The titanite crystals were also remarkable for their brilliancy, being often translucent, exhibiting internal reflections. Sometimes these crystals are aggregated with zircon and make up large masses. They all occur in a band of limestone. **Zircon crystals.**

Bluish-green amazon stone occurs on this lot, but how associated I did not ascertain.

Turner's Mine

is situated on Turner's Island, in Lake Clear, and comprises a number of openings, the most conspicuous of which is an open cutting about eighteen feet wide, thirty feet deep, and fifty yards long, on a mixed vein of apatite, scapolite, pyroxene, titanite, and a bright pinkish red calcite. The scapolite is generally in large semi-translucent white crystals, and together with large prisms of titanite, often 40 lbs. in weight, makes up a large proportion of the whole vein.

Similar calcareous deposits, penetrated by apatite crystals, have been stripped in many places on the island.

This mine was first opened in 1879, and up to the year 1882 about 200 tons had been extracted with an average of six men.

Adams' Mine

is in the township of North Burgess. The property includes about 1350 acres, being Lots 5 and 6 in Range VII. W. ½ of Lot 2, 5, and 6 in Range VIII., and Lot 5, Range IX. **North Burgess.**

Captain Robert C. Adams, of Montreal, is the managing owner.

There are about 300 openings on this property. Many of them were worked by contract, and have been left in a bad condition. In carrying on such work the contractor removes as little dead rock as possible, and when he becomes cramped for room in the opening it is abandoned for a fresh outcrop. This manner of working has of course proved the distribution of the apatite over a large area, and although the depth, as yet tested, does not exceed seventy feet, there is every reason to suppose that the mineral continues to far greater depths.

The judicious expenditure of a little money under experienced direction would put these openings again in working order.

There are about fifty openings on Lot 6, Range VIII, the deepest is about seventy feet. This pit alone has yielded 600 tons of a high grade apatite, but, owing to the influx of water from the recent heavy thaw, it had been temporarily abandoned.

The above mines have been worked continuously for the last five years under the superintendence of Mr. W. Davies, whom I have to thank for much information concerning this important property. He states that during the five years over 5000 tons of apatite have been mined, or an average of nearly ninety tons a month. The largest out-put for one year was 1350 tons, and in 1883 about 800 tons were extracted.

Cost of mining and transport.

Nearly all of it was mined under the contract system, at a cost of from $4.50 to $7.00 per ton. The cost per ton of drawing to the Rideau Canal, about four miles distant, is 75 cents in winter and $1 in summer. The distance from Perth railroad station to the mine is only five miles, also affording easy means of transport.

Hitherto the work has been carried on, on a very limited scale, without machinery of any kind, except a small horse-power in connection with some of the derricks. It is thought, during the coming season, operations will be extended, and this promising property more fully developed.

MOLYBDENITE.

Elliott's Mine.

Ross.

This mine is situated on the 7th Lot, in the 9th Range of Ross: and consists of a vein or bed, probably the latter, of limestone, holding bright polished masses of molybdenite, apatite, scapolite, titanite and pyrite. Some time ago, when this mine was fresh opened, a few pounds of its extraction was sent to England, as a sample, but the demand being so very limited was abandoned.

Rose's Mine.

This mine is situated on Lot 22, Range II, of the same township, and consists of a vein of quartz about two feet wide, running with and enclosed by gneiss. And judging from the small opening that has been made, and the course taken by the quartz, I am inclined to think it may possibly be an intercalated mass, rather than a true vein. Strike of gneiss N. E. and S. W., dipping at about 50°. The molybdenite is distributed rather abundantly through the quartz in polished masses, generally coated with a pulverulent, yellow powder, the acidulated oxide of molybdenite.

BISMUTH.

Smith's Mine

is on Lot 34, Range III. of Tudor. It was worked about twelve years ago by Messrs. Hill and Curshaw, with what result I could not ascertain. Two shafts were sunk to the respective depths of twenty and fifty feet, the veins of quartz striking into the enclosing limestone. At the time of my visit the shafts had partly caved in, and could not be examined. The veins, however, crop out near the shaft and maintain an almost horizontal position from one shaft to the other. They vary in width from one to twelve feet, consisting of an intermixture of quartz and a talcoid, schistose rock, associated with black tourmaline, in abundance, and fibro-lamellar masses of bismuthinite often penetrated by accicular prisms of tourmaline.

Tudor.

GALENA.

Canadian Lead Mining Company (limited).

This company, composed almost entirely of English stockholders, commenced operations in 1874 with a capital of over $100,000.

The company owned the east half of Lot 3 Range VIII, of Lansdowne, also the mining rights of Lots 4 and 5 in the same range. On Lot 3 smelting houses have been erected, also two boarding houses, two blacksmiths shops, one powder house, engine house, steam sawmill, &c., all of which now stand as monuments of indiscretion and reckless enthusiasm. The suspension of the works is attributable to mismanagement and reckless expenditure on surface works before the extent and nature of the deposit had been proved.

Lansdowne.

Several of the openings that had been made on this property were visited, and judging from the amount of dead rock extracted in proportion to the excavations made, the yield of ore could not have been great. The galena appears to have been very much scattered through a calcareo-barite gangue.

I have since heard that the amount of ore smelted did not exceed two tons. The company remained in operation for about two years, employing from thirty to sixty men.

PYRITE.

Brockville Chemical Company's Mine, in the township of Brockville, has been closed since 1879. The chemical works are, however, still in operation. The pyrite at present used by the company is being brought from New Hampshire at the rate of a car-load a day.

Brockville.

There are sixteen kilns in operation, each having a capacity for 300 lbs of ore. The kilns are charged every hour, and produce about eighty-five carboys of sulphuric acid a day.

In the distillery there are twenty-four glass retorts attached to glass receivers for redistilling the crude acid. Besides the above, about fifteen carboys of nitric and hydrochloric acids can be produced per day. In this case iron retorts and earthen receivers are used. The company employ twenty-six men.

IRON.

Zainesville Iron Company's Mine.

is on Lot 3, Range VI, of Bedford. An open cutting has been made across the stratification for 100 yards, and to the depth of seventy feet, exposing a number of beds of magnetite varying from one foot to several feet in thickness, showing in all about 150 feet of beds.

Bedford.

Pyrite, although of frequent occurrence in concretionary masses, seldom impregnates the magnetite sufficiently to detract from its value. Cavities lined with scalenohedrons of calcite, and occasionally crystals of sphalerite, occur in the pyrite. Serpentine, either massive or fibrous, is intercolated between the iron ore beds, which, in places, become mixed with calcite holding a pseudomorphus mineral after pyroxene with a hardness of (2.)

Besides the above opening, two shafts have been sunk to the depth of 100 feet, known as No. 1 and No 2. At the time of my visit operations were for the most part confined to No. 1. In this shaft the magnetite had been worked about twenty-five feet across the beds, and had penetrated them to the depth of fifty feet. The hanging wall which crops out at the surface has an exposed thickness of about fifty feet. The foot wall which has not been reached is gneiss. These beds strike N. E. and S. W. dipping at about 45°.

The texture of the ore is medium grained. An analysis by Mr. M. E. Reed gave the following results :

	1	2	3
Metallic Iron	61.87	62.32	63.80
Silica	9.78	10.67	8.30
Manganese	.59	.51	.47
Sulphur	Trace.	.39	.12
Lime	.68	.64	.09
Magnesia	2.01	.98	4.01
Phosphorus	.015	.010	.011

This mine was opened about fifteen years ago by Mr. John Chaffey. The Glen Gower Iron Mining Company, of Elmira, N.Y., leased the property from Mr. Bowden, and took out during their years of possession about 7000 tons of ore. It is said this company expended about $40,000 before abandoning it.

Folger Brothers then purchased the mining rights from Mr. Bowden, from whom it passed, in 1882, into the hands of the present owners, the Zainesville Iron Mining Company, of Ohio, and up to August, 1883, they had extracted about 3000 tons.

The present owners have made many improvements. Numerous buildings have been erected, including six dwelling-houses, boiler and engine-house, with a "National Air Compresser," worked by a 100 horse-power engine. The compresser is said to be capable of driving fifteen drills, striking 150 blows to the minute, with a stroke of six inches. A receiver is attached to the compresser, with a reservoir sixteen feet long and six feet in diameter, worked at a pressure of 60 lbs. to the square inch.

The Cameron pumps, worked by compressed air, keep the shafts free of water. The hoisting is also done by the same agent in one of the shafts, steam being employed in the other.

Thirty men are engaged in the mine. A branch railroad is about to be laid from the mine to Bedford station, a distance of three miles. At the time of my visit a party of surveyors were locating this road.

Wollaston Iron Mine

is in the township of Wollaston, but was not visited. The following particulars are given on the authority of Mr. Cole, of Madoc, his father being one of the proprietors. Wollaston.

The mine was first opened in 1881, but active operations did not begin until February, 1883, and since that time about 25,000 tons of magnetite have been taken out. The workings at present are confined to the surface. In one opening sixty-seven feet of ore is between the walls, and in another cut it widens to eighty feet. A diamond drill is used at the mine for testing purposes.

Forty men are employed.

Wallbridge's Hematite Mine.

This well-known mine, in the township of Madoc, was still in active operation at the time of my visit. Over 1000 tons of hematite lay Madoc. awaiting shipment. The ore is of a steel-grey color, weathering to a dark-brick red, enclosing cavities filled with black, glistening crystals of specular iron.

Twenty men are employed.

ANTIMONIAL ORE.

Barrie.

Specimens of an antimonial ore presented by Mr. Sheppard, of Aylmer, are exhibited in the Museum, and are said by that gentleman to occur in quartz veins, traversing Lots 21, 22 and 23, 8th Range of Barrie. An average sample is said to have assayed 1 oz. of gold and 29 oz. of silver to the ton, besides yielding 6½ per cent. of antimony.

GOLD.

Sheppard's Gold Mine.

Tudor.

This property is mentioned on the authority of Mr. Sheppard. It is said to be on Lot 12, Hastings road, in the township of Tudor. A vein of quartz, eleven feet thick in granite, has been traced for about 200 feet, the whole of which distance, distinct traces and colors of gold were met with. A pit has been sunk to the depth of fifteen feet; specimens taken from the bottom of the pit are said, by Mr. Sheppard, to have assayed as high as 5 oz. of gold to the ton.

The Canada Consolidated Gold Mining Company.

Marmora.

This property, situated in the township of Marmora, has recently been leased by Messrs. Stevens, Newberry and Rothwell, and, judging from active operations going on at the time of my visit, they are preparing to work this hitherto promising property to its fullest capacity.

There are already on the property six shafts sunk to various depths ranging from forty to 130 feet. In connection with which new hoisting-drums have been put up. Capacious buildings have been erected, including a boiler and engine-house, 28×50 feet; mill for concentrating purposes, 40×80 feet; boiler-house, 20×40 feet; furnace house, clorination and arsenic chambers, 60×220 feet; miner's houses and a number of other buildings.

At the time of my visit about one hundred men were employed, principally renovating the plant and buildings and otherwise improving the property.

Assay by Carnot of Paris.

The auriferous ore mined on this property is almost exclusively mispickel distributed in granular masses or imbedded crystals through a gangue of quartz and calcite. An assay of the mispickel made by Carnot, of Paris, gave:

Arsenic	42.00
Sulphur	20.27
Iron	35.60
Silica	1.50
	99.37

It is stated that pulverized samples of the mispickel will readily indicate to the experienced eye the richness of the ore, and in consequence of the friability of the latter compared with the hardness of the quartz, the first screenings are the richest.

The ore as it comes from the mine is drawn up an inclined tramway to the height of fifty feet, to a large Blake crusher, taking in blocks 9x14 inches. The crushed ore then passes through a wooden chute to a pair of smaller crushers which reduced it to the size of beans. It next passes through the first set of steel rolls (thirty-six inches in diameter, forty revolutions a minute), after which it is dried in a revolving cylinder and again put through the second set of rolls similar to the last. It is then elevated and passed through screens of one-twelfth of an inch mesh. The sifted powder is then passed over sizing screens, which divide it into sizes, ranging from one millimeter to dust. The coarse sizes are then concentrated on old fashioned "Hartz Jigs," and the finer or below four-tenths millimetre is ready for roasting without further concentration. The concentrated nearly pure mispickel, carrying from fifty to ninety dollars gold per ton is again crushed in small rolls, and then mixed with the above named fine powder. This mixture is then roasted, having been previously dried if necessary. At present there is only one roasting cylinder, but this will shortly be replaced by two new cylinders. In the first the greater part of the arsenic and sulphur is volatitized. The former condensing in a series of condensing chambers, of which there are seventeen. The ore leaving the first cylinder runs into the second, where the roasting is completed, converting the remaining arsenic into arsenious acid; the sulphur into sulphurous acid; and the iron into peroxide. The roasted ore always contains a trace of arsenic and sulphur, which goes with it into a lead-lined revolving iron cylinder (chlorinator) which is kept rotating for about two hours. The gold is dissolved or chlorinated by chlorine gas, made from chloride of lime and sulphuric acid. The liquid charge is then emptied into a sand filter and washed until the solution contains only a slight trace of gold chloride. The gold is then precipitated by hydrogen sulphide (made from paraffine and sulphur) as a sulphide. The precipitate is collected on a specially constructed pressure filter. This gold sulphide is then dried and roasted in pans, after which it is melted. The bars of gold thus produced average from 990 to 998 fine.

Treatment of the ore.

The crude arsenical fumes carry $97\frac{1}{2}$ per cent. of pure arsenious acid, and condense to a light grey or white color furthest from the furnace; this is sold as crude powdered arsenic. The sublimate in the nearer chambers is mixed with quartz dust and oxide of iron. This is again re-sublimed and sold as "refined;" "powdered white;" "arsenic glass, or lump arsenic."

One ton of pure mispickel will make about half a ton of arsenious acid.

The crushing and concentrating mill has a capacity of about fifty tons in ten hours.

The roasting cylinder treats in two operations an average of five or six tons in twenty-four hours. Unless the ore is well roasted the gold will not chlorinate.

Chrysotile.

Elliott's Mine.

Ross.

This property is on Lot 8, Range IX, of Ross. Two or three openings have been made in a serpentine limestone, exposing in one cutting a vein of silky asbestus (chrysotile), the fibres of which are over one foot in length, but inseparable, becoming brittle on exposure. In another opening a four-inch vein of separable fibre was cut, and although slightly coarser than the townships asbestus might nevertheless be employed in the preparation of incombustible paints. This vein, like similar ones in the townships, is flanked by a long fibrous picrotite, the filaments of which, repose at right angles to the fibrous chrysotile.

This mineral occurs also on Lot 9, Range VIII, of the same township.

Mica.

Sheppard's Mica Mine.

Palmerston.

This mine is on Lot 24, Range II, of Palmerston, but was not visited. The specimens presented by Mr. Sheppard are remarkably transparent; the plates are, however, occasionally marred by brownish dendritic markings.

The vein is said to be from four to seven feet wide, in granite, and has been stripped for the distance of 440 feet and tested to the depth of nine feet. Plates fourteen by eighteen inches are said to have been taken out.

A similar vein is said to occur in the township of Miller, on Lots 4 and 5, Range XI, varying in width from nine to eleven feet, and plates as large as eighteen inches are said to have been taken out.

Graphite.

South Burgess.

A small opening on Lot 10, Range I, of South Burgess, was made about twenty years ago, in an orthoclase rock, holding large foliated masses of graphite. A quantity of the mineral was shipped, but with what result I could not ascertain.

Limestone, &c.

Ferguson's Quarry.

This quarry, on Lot 22, Range IV, of Ross, is in a fine grey crystalline limestone, striking N. and S., with an easterly underlie. In burning, it produces a somewhat granular lime, but makes a hard-setting mortar. Ross.

The kiln has a capacity of only about 300 bushels, which amount is produced about six times a year.

This stone, on account of its fine texture, might be applicable for building purposes, or would also, I have no doubt, constitute a handsome marble.

On Lot 7, Range IX, bands of a coarse crystalline white dolomite occur, which is said to burn to a good lime.

A similar band occurs on Lot 23, Range IV., slightly coarser in texture, and when struck with a hammer, shows a momentary red phosphorescent glow.

Either of these dolomites would be susceptible of a high polish. But as the outcrop indicates a very limited thickness, it is doubtful whether it could be worked with profit.

On Lot 20, Range IX, of Bathurst, fine terminated crystals of pyroxene, hornblende, orthoclase, scapolite, apatite and titanite occur in a calcareous vein, cutting granite.

On Lot 23, Range IV, of Ross, a band of tremolitic dolomite, traceable across several lots, affords in many places long translucent rhomboidal columns and interlacing blades of tremolite, the former often one foot long and one inch across.

Small specks of apatite were noticed in a disintegrating limestone, that is occasionally mixed with the dolomite.

Large crystals of zircon have been recently found in the township of Brudenelle. Those seen by myself from this locality were five inches long and 1½ by 2 inches across, weighing 2¼ lbs. These crystals occur in a fine grained felspathic rock, and on account of the toughness of the gangue, can rarely be detached without disfiguration. Brudenelle.

QUEBEC.

Apatite.

Scott's Mine.

Hull. This mine is situated on Lot 15, Range X. of Hull, and consists of a small opening, from which about six tons of apatite were extracted about five years ago. The mineral now exposed is greatly mixed with pyroxene, running conformably with, and in close proximity to, quartzite bands.

On the same property a bed of jasper can be traced for 150 yards. It probably parts the quartzite above mentioned from an orthoclase rock, and varies in thickness from one to two feet. It is bright red to chocolate brown, and portions are mottled with yellow, the latter color sometimes prevailing. Blocks of a fair size might be easily obtained with little outlay. It would constitute, when polished, a handsome material for ornamental purposes. Loose blocks of it are of common occurrence on Lot 14, Range VIII of the same township.

Prudhomme's Mine.

On Lot 9, Range XII. of Hull, two or three small openings have been made in a somewhat drusy orthoclase rock, penetrated by irregular spurs of apatite, and calcareous veins holding crystals of the same mineral.

Davies' Mine.

The same band continues across the next Lot No. 9, Range XI, where similar openings have been made, but in both cases with unsatisfactory results.

Portions of the above orthoclase band often contain patches of graphic granite. Some good illustrations occur on Lot 9, Range XII. The graphic characters are often beautifully depicted on the surface. With a view of obtaining a block for the Museum, a blast was put in, which had the effect, of not only removing the specimen required, but also a large portion of the adjoining rock, into which the graphic granite passes, at the depth of a few inches.

On the south half of Lot 6, Range XII. of Hull, a beautiful bluish or greenish felspar resembling amazon-stone, mixed with white translucent masses of quartz, and more sparingly with large crystals of black brittle tourmaline, occurs in a band striking E. and W. A quantity of loose sea green apatite seems to have been scattered over the surface of the rocks here, and to have been also mixed with the debris of recent blasting operations. In some instances open joints and partings have been completely packed with apatite. The resemblance between the green felspar and the imported apatite, is, especially to the unaccustomed eye, perhaps sufficient to encourage unsuspecting persons in an attempt to work this property.

I am not prepared to say whether apatite occurs *in situ* on this lot or not, but I could not find any.

Gow Mine.

This mine is situated on Lot 10, Range XII, of Hull, the property of Mr. Gemmell, of Ottawa. At the time of my visit operations had been suspended about twelve months. The most important opening on this lot consists of a pit sunk to the depth of 150 feet, on a bed of limestone, dipping at a high angle, and a drift on its strike 190 feet in length. Six or seven hundred tons of apatite were extracted from this opening, and several other openings of less importance have been made at various places on the same lot.

The total output, since the property was first worked, 1878, to the present time, may be estimated at 3,000 tons.

McLennan Mine.

This mine is very similar to the last mentioned and is probably in the continuation of the same band. It is on the south half of Lot 10, Range XIV, of Hull. The openings reveal the usual abundance of apatite and mica crystals, which characterise the band of limestone running through the township of Hull into Wakefield. Numerous small veins of apatite also cut the limestone, some of which have been profitably worked.

The McLennan Mine was first opened five years ago, and during its progress yielded about 900 tons.

Barber's Mine.

This mine is on Lot 16, Range XVI, of Hull. It appears to be in a large cavernous vug lined with huge crystals of pyroxene, the interior of which has been filled with apatite. This cavern or vug was worked to the depth of thirty-five feet and followed for about forty feet, tapering out at each end. With the aid of eight men, in the winter of 1882, about 120 tons of apatite were taken out of it.

2

Moore's Mine.

Wakefield.

This mine situated on Lot 18, Range II, of Wakefield, was reported on last summer, but since then, some interesting discoveries have been made. At the time of my visit I was surprised to find some of the best pits full of water. I was informed that the influx of water was so great, it was thought expedient to make new openings.

In drifting in the side of a hill another cave was struck, which is thirty feet in length, eight feet wide, and five feet in height. The walls, as in the one already described, are covered with large crystals of pyroxene and mica. Along the centre of the floor of this cave a channel has been worn in the smooth rock by running water.

Mr. Moore had just stripped what appears to be a limestone vein, and judging from the abundance of crystals of apatite distributed throughout the exposed portion, and the facility with which they can be removed, more than a hundred tons of these crystals might be taken out.

At another opening, a vein of garnet and epidote, holding cavities of stilbite, was mined to the extent of two or three tons, the former mineral being mistaken for apatite.

Wilson's Mine.

This mine was also mentioned in the last report, 1882-83. Operations at it have been since suspended owing to the great influx of water. Since it was first opened in 1880 to May 1882, it yielded about 300 tons, being worked only at intervals between the dates mentioned.

Haldane's Mine.

This mine situated on Lot 12, Range I, of Wakefield, was also noticed last year. An opportunity offered during the present summer to visit the mine, and a few additional notes from personal observation are now given. The vein mentioned, as cut by the Big Pit, is over nine feet wide. It traverses a gneissic rock, and although it is continuous to a depth of 125 feet, the walls cannot be said to be well defined. The filling material of the vein consists of a dark green granular apatite, pyroxene, pyrite, epidote, scapolite, chabazite, and another zeolite resembling natrolite. The two latter occur in cavities in the pyroxene.

Pyrite occurs in great abundance, both massive and in crystals, often affording splendid examples of the secondary forms. The massive variety often encloses crystals of apatite and scapolite.

At the opening known as the tunnel, a vein of limonite one foot wide was cut, flanked by a less altered ferruginous rock holding black shining crystals of tourmaline.

The total output from this mine since it was first opened in 1878 may be estimated at about 2,600 tons. At the time of my visit seven men were employed.

Gemmell's Mine.

The mining property of Mr. Gemmell extends over several lots in the township of Wakefield, but only those where operations were seen in progress will be noticed.

On Lot 24, Range V, a number of openings have been made, and at the time of my visit operations were confined to several levels driven in the gneiss, which rises abruptly to about 100 feet, exposing several bedded masses of dingy red apatite said to assay as high as 82 per cent. One bed was followed across the strike for 180 feet, and on the dip 200 feet, at an inclination of 45°.

The gneiss is generally epidotic, and encloses lenticular patches of scapolite.

In another opening a large vein of crystallized hornblende was intersected while sinking on a vein of pale yellowish-green apatite, mixed with pyroxene, tourmaline, scapolite, and occasionally zircon.

On Lot 23, Range V, two or three men were employed on a small band of pink disintegrating limestone, collecting crystals of apatite, which are easily detached from the soft calcareous gangue. Most of these crystals are terminated at both ends, and in some instances the prism is so short that they appear as two pyramids joined at their bases. They also occur in bent and other distorted forms. About one ton of these crystals had been collected.

At the opening on the south half of Lot 22, in Range V, work had been suspended, the cutting, like one of the already described openings, is in gneiss, and consists of some small veins of apatite and pyroxene crossing the stratification.

Mining operations were first commenced in the year 1878, and about 3,000 tons have since been raised. The boring is done by Rhand's steam drills, using one and a half inch bits. Two dwelling houses have been erected, besides a number of other buildings. Ten men are employed.

Harri Mine.

This mine was not visited. The manager states as follows respecting it: It is situated on the south half of Lot 30, Range IX, of Wakefield, and was first opened in 1879. Since then 400 tons have been taken out at intervals. There are said to be about fifteen openings, and with the exception of one pit thirty-five feet in depth, are mere strippings. Five men are employed.

BUILDING STONE.

On Lot 14, Range VIII., of Hull, a considerable exposure of white crystalline limestone occurs, striking nearly N. and S., having an exposed thickness of about seventy feet, in beds of three inches to several feet, most of which is of a pure white color, and comparatively free from joints.

In texture it varies from fine grained to coarse, and is sometimes slightly marred, by inclosing small plates of a silvery mica.

The higher beds are serpentinous inclosing semi-concentric masses of chrysotile, the fibre of which rarely exceeds one inch in length.

Above the serpentine beds are others of less note holding apatite crystals.

Blocks of a fair quality, and of almost any size, might be obtained with great facility, and its value is greatly enhanced by being in close proximity to the main road.

Hull. On Lot 9, Range XIII., of Hull, beautiful greyish green terminated crystals of pyroxene occur in a bed of pink limestone and make up more than one-half of the bed.

Hornblende, tourmaline and idocrase fill small pockets in the accompanying.

NOVA SCOTIA.

Copper.

At the mouth of Bishop's Brook, three miles east of the village of Margaretville, on the Bay of Fundy a short adit has been driven in the basalt, from which it was intended to sink a shaft that might penetrate a lower stratum supposed to be rich in native copper. This cupriferous basalt crops out at low water. The project, however, was soon abandoned.

The rocks between Chute's Cove in Annapolis county and Cape Blomidon in Kings' county were carefully examined for this metal, the result of which would not, as far as my observations went, justify an expenditure of much money in developing it. Copper can be found at many places between the points mentioned, in plates and dendritic masses; even pieces, of several pounds weight, have been found by the inhabitants. But unless the lower stratum, visible at only one or two places at low water, exhibits more encouraging features, its extraction would in all probability result in disappointment and loss.

Manganese.

Stephens' Mine.

This mine is situated near the village of Walton, in Hants county, and consists of an excavation of about thirty feet in depth, in a reddish shaly limestone, striking E. and W., with a southerly dip. Pockets and irregular veins of manganite and pyrolusite can be traced along the strike for about 400 yards.

Nothing beyond the preliminary prospecting work, scarcely sufficient to develop this promising mine, had been done at the time of my visit. Mr. Stephens informed me that about ten tons of fair grade ore had been taken out during the progress of their investigations.

The situation of this mine offers great facilities for mining, being in close proximity to a pool two or three acres in extent, which discharges through a subterranean channel into one of the neighbouring rivers. A small dam has been constructed at the outlet, by which a sufficient force of water is secured, and utilised in flushing the jigging tables.

Churchhill's Mine.

his mine is located a short distance N.E. of Stephen's mine, and consists of an open cutting about 200 feet in length in a rock similar to the last, but in a very advanced state of decomposition. The manganese which exists in detached pieces, from half-a-pound to three tons in weight, is easily removed with a pick and shovel.

Between the months of April and June, 1883, with the assistance of three men, twenty tons of ore were extracted.

The mineral consists, for the most part, of a compact vesicular manganite, the vesicles being often filled with black shining acicular and other undeterminable crystals. Large brilliant diverging masses and rounded geodes of pyrolusite occur intermixed with the manganite.

This mine was first opened in 1881, and since then the mineral has been gradually rising in value. I was informed by a person interested in this mine, that they received $100 a ton for the last shipment of ore.

About five miles N.E. of the village of Walton, and on the road to Teny Cape, loose masses of a silicious conglomerate are of frequent occurrence, the pebbles of which are cemented with manganite.

Teny Cape Mine.

This mine is situated about half way between the villages of Walton and Noel in Hants county. Some years ago a shaft was sunk to the depth of fifty feet on beds of limestone, dipping about 45°, which was followed for some distance, intersecting another shaft 160 feet in depth. Other shafts have been sunk from time to time on this property, but with what result I could not learn. The work now, however, is confined to an open cutting, following the strike for 400 feet, and trenched to the depth of seventy feet through beds of limestone, dipping 5°. Strike E. and W. This shaly limestone is penetrated by veins, or interlaminated by bedded masses of manganese, both the anhydrous and hydrated oxides being represented. A short time ago a pocket was struck near the surface from which 1000 tons of pure ore were extracted.

Limonite occurs sparingly in lenticular bedded masses in the limestone, the latter rock often holding large geodes of nail-head and dog-tooth spar, crystallised, varying from colourless to black, according to the amount of manganese present.

This property belongs to Mr. T. W. Stephens, purchased about seven years ago, from Mr. Hill. Since he has had possession he has made considerable improvements. Four neat dwelling houses have been erected, also a church and schoolroom, a large commodious store, and several other buildings, including a mill 50 x 40 feet. I was informed by the proprietor's son that their average output would aggregate about 120 tons a year. For the first three years of possession the mineral sold for $60.00 a ton, the four succeeding years it increased annually to its present price, $120 a ton.

The ore is crushed at the mines at the rate of ten to fifteen tons a day. This crushed material is then further reduced by passing it between a pair of stones, and lastly, by the aid of ordinary shaking tables, concentrated to a marketable grade. It is then put up in barrels for shipment.

A 40-horse power engine is used in connection with the crusher and jigs.

Fifteen men are employed in the mines.

Cheverie Mines.

In the vicinity of the village of Cheverie, in Hants county, mining operations, on a very limited scale, have been carried on at intervals for the last few years. I was informed by Mr. Stephens, of Walton, that a year or two ago an attempt was made to work one of the deposits, but owing to the poor quality of the ore, and the difficulty experienced in freeing it from its silicious conglomerate gangue, the enterprise, after extracting about sixty tons of an inferior grade of manganite, was abandoned.

Black Rock Mine.

This property is situated in the village of Clifton, Colchester county, at the mouth of the Shubenacadie River. Some flat interbedded masses of a ferruginous manganesian ore occur in a limestone that crops out at low water mark, and judging from the smallness of the heap of inferior ore that had been extracted, and its partly submerged position, I hardly think the enterprise proved a source of much profit.

BARYTES.

Eureka Mine.

This mine is situated near the village of Five Islands, in Colchester county, and was worked about eight years ago by an American company.

About fifteen levels have been driven in the side of a hill, the longest of which would be about 100 yards, cutting a soft calcareous disintegrating rock, often enclosing masses of impure bituminous coal. Alternating with the above soft beds are others of a harder nature, being more decidedly argillaceous.

The decaying timbers, supporting the roof of the levels, and the threatening sliding nature of the rock, offered no inducement to explore their walls, even for a few feet.

A small opening has been recently made by the proprietor, developing a portion of the decomposing calcareous rock, cut by large aggregated masses of calcite crystals, the members of which are easily detached in highly modified forms. The secondary planes are often so complicated as to obliterate almost all traces of the rhombohedron.

The barite, however, is quite as conspicuous, often protruding several inches in milk white lamellar masses, invested by tabular crystals of the same mineral.

Masses weighing more than one hundred pounds, beautifully crystallised, have been found, associated with dog-tooth spar, chalcopyrite, and specular iron ore.

I am inclined to think that the mineral is in pockets and irregular veins, rather than in a continuous bed or vein.

The total amount said to have been extracted since the mines were first opened may be estimated at over 3000 tons.

Gypsum.

Gypsum of a fibrous nature occurs at many places in the Basin of Minas in small beds of a pinkish or pinkish-white color, but can scarcely be considered of any commercial value, except perhaps as a fertilizer for local use.

About one mile N.W. of Cape Blomidon, and at the junction of the sandstone and trap, several beds of a fibrous and foliated gypsum (selenite) occur in the former rock from one inch to one foot in width. These beds are about 250 feet above the sea, and can be approached only with great difficulty.

Notes on the occurrence of Zeolites in the Amygdaloid of the South shore of the Bay of Fundy and Minas Basin.

It should be understood that the localities here recorded may, from the downfall of the cliffs, be at times entirely inaccessible, and the general aspect so changed that they could not be recognised. The avalanches that are constantly taking place, accelerated by the percolating waters, are ever revealing fresh crops of these beautiful minerals, and a good collecting ground one year becomes covered up the next by the falling debris.

The basaltic rocks exposed at Chute's Cove form a low sloping beach down to the sea. A short distance west of the breakwater the beach is strewn with an abundance of pebbles, often beautifully variegated, or exhibiting various grotesque designs, the outlines of which are sometimes as sharp as if drawn by hand.

About a quarter of a mile east of the breakwater, the columnar structure of the basalt, developed on the worn surfaces is made still more conspicuous, by hollows, worn in the centres of the vertical columns, and sometimes nearly corresponding with their pentagonal shapes.

This columnar trap is cut by numerous, nearly parallel N. E. and S. W. veins of chalcedony and agate.

About one mile up the bay the amygdaloid is seen cropping from beneath the superincumbent basalt. The amygdules, owing to their greater hardness, give rise to orbicular surfaces. The cavities are often filled with zeolite crystals, which are also common in the amygdaloid all along the south shore of the Bay of Fundy. Irregular veins of stilbite, and pockets of a beautiful pinkish white, semi-transparent mineral were also observed at the point above named. The latter occurs in diverging prisms, sometimes five inches in length, associated with greenish apophyllite. It may frequently be seen passing from a slight fibrous, silky looking mineral into compact prismatic masses. It will be examined and described by Mr. Hoffmann.

The basaltic cliffs at St. Croix Cove, still incumbent on the amygdaloid, rise to the height of seventy feet above the water and can only be approached after half ebb tide. Some small veins of laumonite occur at this place.

At Port George the amygdaloid is again hidden by a low, sloping beach of basalt which extends under the sea. The surfaces exhibiting the before mentioned columnar structure.

Numerous veins of chalcedony, jasper and agate, from one to four inches thick, cut the basalt, and on account of the inferior hardness of the latter, give rise to silicious ridges, standing several inches above the walls of the veins.

About half a mile up the bay, the amygdaloid again comes to the surface, and was followed for a mile further. It is here intersected by many veins of stilbite often beautifully crystallized; apophyllite, in semi-transparent greenish crystals, fills some of the numerous pockets in the cliffs, but owing to their inaccessible position we were prevented from securing the best specimens.

Pearly heulandite of a pink or white color is of frequent occurrence, both in cylindrical shaped foliated masses and aggregates of crystals.

Natrolite, although more sparingly distributed, may, nevertheless, be found in handsome radiating and diverging masses, made up of white translucent prisms often four inches in length. Masses many pounds in weight may frequently be met with, and when occurring above high water mark, present fine terminations. These radiating masses are often invested by small conical bunches of finer prisms, and are so placed that their line of divergence meets the investing mineral at an oblique angle. On the road from Margaretville to Melvern Square, about two miles from the latter place, amygdaloid crops out on both sides of the road, and owing to its friable nature is fast commingling with the soil and disappearing. At the same time liberating large radiating masses of natrolite, the prisms of which are frequently one-eighth of an inch in diameter and five inches long. Masses of twenty to thirty pounds weight, weathered externally to a rusty red color, may be found amongst the stones scattered over the fields. About one mile and a half from Margaretville lighthouse and east of Stronach Brook, on the shore of the bay, fine specimens of natrolite, stilbite and apophyllite occur in the amygdaloid. The latter often transparent. The natrolite appears as radiating stars connected by delicate hair like prisms, and so interwoven and matted together, that to attempt their removal, can only result in their destruction. The nuclei from which these prisms radiate, often show pretty tints arranged in concentric bands and graduating from one shade into another.

Laumonite generally accompanies the other minerals named, and in variety of forms is not surpassed any where along the south shore of the bay. It sometimes occurs in radiating foliæ penetrated by long needle-like prisms of natrolite.

About one hundred yards west of Margaretville light-house, veins of stilbite occur, often associated with transparent prisms of natrolite. The beach at this place is covered with a flat pavement of amygdaloid intersected by numerous veins of pink laumonite, beautifully crystallized, and pockets of distorted forms of analcite; sometimes the latter mineral encloses small specks of native copper. About one hundred yards east of the light-house, apophyllite and stilbite occur in pockets in the amygdaloid.

About one hundred yards east of the village of Morden, moss agate occurs in a vein, with a ferruginous looking stilbite. Heulandite, stilbite, natrolite and apophyllite occur at intervals along this shore, the latter in greenish modified crystals.

Mordenite.

The amygdaloid at this place, is studded with nodules of a white, faintly fibrous mineral, having a somewhat silky lustre. It is probably the mineral mordenite described by the late Prof. How, of Windsor, N. S. Short distances east and west of the breakwater at Victoria Harbor; or more commonly known as Church vaults, handsome stilbite in sheaf-like and fan-like masses, of a lemon yellow color, occurs in veins and pockets. Patches of this mineral, often several yards square, are exhibited on the side of the cliffs, and good specimens may frequently be removed by the hand alone. One pocket was met with lined with transparent crystals of heulandite, and globular masses of a mineral, which at first glance might be taken for stilbite, but on close examination it was found to be only a thin coating of that mineral, enveloping an opake pinkish white compact substance giving off argillaceous odour, with a hardness between one and two. These semi-spherical masses are generally invested by numerous small crystals of laumonite. Numerous veins of agatised quartz, agate and a granular variety of quartz; the latter often enclosing crystals of stilbite, occur in the amygdaloid. The latter rock is also cut by a vein of soft argillaceous brownish sandstone traversed by small veins of stilbite, and which by gradations passes into jasper. Apophyllite in large milk-white crystals associated with stilbite, natrolite and small pink crystals of heulandite is of common occurrence.

Near the village of Black Rock, the amygdaloid is inter-veined with quartz and jasper. Beautiful plumose masses of white stilbite adorn the cliffs, but generally too brittle to be removed. It is often accompanied by heulandite. About one hundred yards west of the breakwater at Hall's Harbour, the amygdaloid with its vesicles filled with bright pearly pink crystals of heulandite, and radiating natrolite, may perhaps be said to be the principal object of attraction at this place. Some irregular veins of stilbite mixed with crystals of heulandite were noticed.

About one mile and a half east of the harbour and at a point known as "The Race," veins of stilbite occur, associated with apophyllite, and more rarely natrolite, generally accompanied by large vitreous masses of analcite.

At Sheffield Vault, about three miles west of Baxter's Harbour, veins of stilbite occur, often invested by small dodecahedrous of analcite. The enclosing amygdaloid also affording heulandite and analcite in pockets. In one large pocket crystals of the latter, two inches across, line the walls, assuming a weathered appearance, otherwise their physical characters are well developed. Owing to the crumbling nature of the overhanging cliffs, and the trembling motion caused by the concussion of hammers, we prudently but reluctantly left these rocks and were prevented from collecting any but loose specimens.

About one and a half miles to the east of Scott's Bay breakwater, the basaltic rocks form an uneven sloping beach interrupted by numerous large worn-out hollows. The basalt is cut by numerous veins of agate, jasper and chalcedony, and also encloses these minerals, in nodules, and large dome-shaped masses. Moss and fortification agate, more especially the latter, often occur, of great beauty. A smoky semi-transparent chalcedony, sometimes enclosing a nucleus of amethyst is also worthy of notice. A curious pocket of stilbite was met with in the basalt, forming a dome-shaped mass invested by perfect crystals of the same mineral. Heulandite and natrolite, although both occur, are not as well characterised as elsewhere. Amethyst is of frequent occurrence in pockets. Blomidon shore, opposite Cape Sharp, in the Basin of Minas, was examined for about one mile and a half, and although handsome crystals of heulandite are known to occur there, none worthy of special mention were met with.

Irregular veins of semi-transparent apophyllite of a light sea-green color, occur in the amygdaloid, affording handsome rectangular prisms, sometimes two inches in length, with their solid angles more or less beveled. These crystals are generally accompanied by others of heulandite and analcite.

Fine specimens of agate and varieties of amethyst of an intense purplish color, natrolite, stilbite, and apophyllite in agate, occur frequently amongst the *debris* of the shore.

Steelite.

This mineral was first described by the late Prof. How, of Windsor, Nova Scotia, and named after its collector, Mr. J. Steele, of Scot's Bay.

The specimen kindly given me by Mr. Steele consists of a pinkish-white hemispherical mass, weathered on the surface to a soft pulverulent substance, in which are embedded crystals of a yellowish stilbite.

Mr. Steele informs me that this mineral often contains a cavity filled with a white fluid substance, having the consistency of cream.

Many attempts have been made to procure more specimens of it, but without avail. The original locality that afforded about twenty specimens is at Cape Split.

Between Two Islands and Swan Creek the amygdaloid which forms rugged bluffs is studded with transparent crystals of analcite, aggregated in bunches of a smoky color.

Acadialite.

Fine rhombohedral prisms of acadialite, generally in penetrating twins, occur in the amygdaloid. Their colour varies through several shades of yellow. The minerals, stilbite, natrolite, calcite, and apophyllite occur at intervals along this shore. Some veins of very fine jasper and chalcedonic varieties of quartz, often more than a foot thick, cut the basalt.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., Director.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA.

COALS AND LIGNITES

OF THE

NORTH-WEST TERRITORY.

BY

G. CHRISTIAN HOFFMANN, F. Inst. Chem.,
Chemist and Mineralogist to the Survey.

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MONTREAL:
DAWSON BROTHERS.

1884.

To

ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., F.G.S.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I have the honor herewith of laying before you the results of an investigation, carried out by me, with the object of determining the economic value of the Coals and Lignites of the North-West Territory. The specimens were in all instances collected by officers of the Survey —some by yourself, a few by Prof. J. Macoun, one by Mr. R. W. Ells, the remainder and greater number by Dr. G. M. Dawson and Mr. R. G. McConnell. The information in regard to the geological age of the various deposits was kindly furnished by Dr. G. M. Dawson.

I have the honor to be,

Sir,

Your obedient servant,

G. CHRISTIAN HOFFMANN.

OTTAWA, May 31st, 1884.

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Introductory Remarks.

The majority of the fuels under consideration are from the Bow and Belly river districts—a region which may be defined as extending from the 111th meridian westward to the Rocky Mountains, and as being bounded south and north by the 49th and 51st parallels of latitude. A few are from the region immediately east of this, whilst others are from the region north and west of that first mentioned. Two are from the Pine River, British Columbia. Strictly speaking, the analyses of these are out of place in this report, they were however deemed of sufficient interest to justify their insertion here.*

It is very interesting to note the gradual change in the physical and chemical character of the fuels of the Bow and Belly river districts as we proceed from east to west, a change which would appear to have been brought about by the disturbances to which the enclosing strata in and near the vicinity of the Rocky Mountains have been subjected. Assuming this region to be divided into three imaginary belts running parallel to the base of the mountains, we find, as a whole, that whereas

* Analyses of fuels Nos. 1, 14, 15, 17, 18, 19, 21 and 34 were published in one of my former reports, since then, however, further work has been done in connection with most of them, thereby making the analyses more complete.

the fuels of the outer or most eastern belt have all the characters of lignite *, those of the central belt (and consequently somewhat nearer the mountains), the lignitic coals *, have a character intermediate between that of lignite and true coal, whilst those of the innermost belt, and therefore close to the base of the mountains, have all the characters of true coal *—finally we have occurring in the mountains, the anthracitic coal and semi-anthracite.

The coal of the Wellington mine, Vancouver Island, British Columbia, has been selected as a standard of comparison. It is of the same geological age as many of the fuels here referred to—is extensively used, and has the reputation of being an excellent fuel for steam and domestic purposes.—See analysis No. 33.

Brief Outline of Some of the Methods Employed in The Prosecution of this Enquiry.

Methods of analysis, etc.

I. DETERMINATION OF THE SPECIFIC GRAVITY.—The coal or lignite was reduced to the state of a coarse powder by crushing it in an iron mortar, the application of more force than was absolutely necessary to effect this being carefully avoided, so as to obviate, as far as possible, the production of fine particles and dust. The material was subsequently freed from this latter by shaking it upon a sieve of ninety holes to the linear inch. The specimen having been introduced into the specific gravity bottle, and sufficient water added to thoroughly immerse it, the whole was placed under the receiver of an air-pump, and exhaustion very gradually proceeded with: the exhaustion was repeated at intervals and until no more bubbles were seen to come off. The bottle was then removed, and the necessary adjustments having been made, weighed—after which, a portion of the water having been withdrawn, it was again placed under the receiver of the air-pump, etc. Temperature 60 ° F., the same, I may here remark—having omitted to do so on those occasions—as that observed in determining the specific gravity of the various specimens of graphite and apatite which formed the subject of some former reports.—Reports of Progress, 1876–77, p. 489 and 1877–78, p. 1 H.

II. DETERMINATION OF THE WATER.—The loss by dessication at 110° C. was estimated as hygroscopic water.

III. DETERMINATION OF THE SULPHUR. — This was effected by the method proposed by Mr. Nakamura.† The process is exceedingly simple and affords most accurate results. The details of the method, as given

* See under "Generalizations on the physical and chemical characters, and applications of these fuels." Pages 5 M–10 M.

† Journ. Chem. Soc., xxxv. 785.

by him, are as follows: "Take three or four parts of the mixed alkali carbonates, or of sodium carbonate, to one part of coal in very fine powder. Intimately mix in a large platinum dish or crucible with a dry glass rod, and heat the mixture in the dish or crucible, loosely covered, at first so gently as not to volatilize hydrocarbons, that is, so that no smell or only a very faint aromatic odor is observable, a matter much more easy of execution than might be supposed. Use an argand spirit-lamp instead of a Bunsen's burner, to avoid possible absorbtion of sulphur from the flame of coal gas. Keep at a low temperature for some time; then raise the heat by slow degrees without letting it reach that of visible redness, until the surface, which is at first of a dark-grey color, becomes only faintly grey. No smoke or odorous gases should escape during the whole of the oxidation. When the surface becomes only faintly grey, raise the temperature to a faint red heat, and keep it stationary for about forty to sixty minutes, at the end of which time the mass will become almost perfectly white, or reddish if the coal contains iron, from the complete combustion of the coal. The mass is then treated with water, filtered, and the sulphate is determined in the filtrate as usual after acidification."

Methods of analysis, etc., cont.

It is important that the coal should be very finely pulverized. The mixture should not be stirred during ignition, as this, so far from hastening, retards the operation. The ignition may be conducted in a platinum dish or crucible, the former is to be preferred.

The vessel employed by me was a thin, flat-bottomed, platinum dish, having a diameter, at the base, of four and a half centimetres. Reagent, sodium carbonate. Source of heat, a Berzelius' argand spirit-lamp.

The sulphur existing as sulphate (gypsum) was estimated by boiling the finely pulverized coal with a solution of sodium carbonate, etc., etc.

IV. DETERMINATION OF THE CARBON AND HYDROGEN.—The combustion was effected in a current of oxygen gas, in a tube open at both ends, one of which was placed in connection with the absorbtion-bulbs and tubes, the other with the apparatus for purifying and drying the air and oxygen gas. As prepared for combustion, the tube—commencing with the anterior end—presented the following arrangement:—an asbestos plug, immediately upon which followed a four inch column of a loosely packed mixture of woolly asbestos and lead dioxide, then another asbestos plug, succeeded by a column of granulated cupric oxide kept in place by a loose plug of asbestos, and behind this the platinum boat containing the material to be analyzed. The heating was effected in an Erlenmeyer's furnace, closely attached to the one end of which was a four and a half inch square sheet-iron air-bath, provided with two holes, one on either side, for the passage of the com-

Methods of analysis, etc., cont.

bustion tube, and a tuberlature at the top for the reception of a thermometer—the position of the latter was just a little on one side (forward) of the centre, the bulb being on a level with and almost touching the combustion tube. When the latter was in position, that part containing the column of asbestos and lead dioxide mixture, extended over the furnace proper, passing into the air-bath, which completely enclosed this portion of the tube. The bath which was heated by a separate burner, was maintained throughout the operation at a temperature of 150° to 170° C.

The results of a preliminary analysis of cane sugar were as follows: Employed 0.3083 gram of chemically pure sugar, dried at 100° C., this gave 0.4755 gram carbon dioxide, and 0.1794 gram of water: hence percentage composition of sugar:

	Found.	Calculated.	Difference.
Carbon	42.06	42.10	— 0.04
Hydrogen	6.46	6.43	+ 0.03
Oxygen	51.48	51.47	
	100.00	100.00	

Specimens numbers 2, 26, 28, 30, 31, 32, 33 and 35 all contained more or less calcite. The total amount of carbon dioxide was in each instance determined, as was also the amount remaining in the ash, and corrections made for it in calculating the composition of these fuels.

V. CALORIFIC POWER.—*Experimental.* The determinations were made in a Thompson's calorimeter. The method of procedure recommended in the use of this instrument was closely followed, and every attention was paid to the various details which recent experience has shown to be essential to the obtaining of trustworthy results. These latter are expressed in calories (calorie = one gram of water raised through 1° C. of temperature) and as pounds of water evaporated per pound of fuel: the numbers given in the text, in connection with the analyses are those indicated by the instrument. The corrections to be applied for heat rendered unavailable by reason of the hygroscopic and combined water, are given under Remarks on Tables I. and II.—page 43 M.

V[1]. CALORIFIC POWER.—*Theoretical.* Data employed in the calculation: calorific power of carbon, 8080—calorific power of hydrogen 34,462—calorific power of sulphur, 2221—latent heat of steam, 537° C. In consideration of the amount of sulphur in these fuels being, with one exception, so very small, the heat units due to the combustion of this element have been disregarded.

[In calculating the calorific power of a fuel from its elementary composition, it is assumed that the oxygen is in combination with hydrogen and that only the excess of that element beyond that required for such combination is available as a source of heat; it is further assumed that the calorific power of the carbon and hydrogen as it exists in the fuel is the same as when these elements are in their free or uncombined state: we really have, however, no knowledge as to how the elements are combined nor their state of condensation in the coal, hence the results obtained in calculating the calorific power from its elementary composition can at best be only regarded as an approximation to the truth, sufficiently so, however, to be of value for practical purposes.

Methods of analysis, etc., cont.

Dr. Percy, speaking on this subject, remarks*: "The proximate constitution of coal is wholly unknown; we are ignorant whether force is liberated or absorbed during the decomposition—previously to, or at the moment of combustion—of the various compounds of carbon, hydrogen and oxygen, of which the organic part of coal must be composed. Again the hydrogen and oxygen are present in the solid state, and we are unable to determine what amount of force may be absorbed during their conversion into the gaseous state."]

VI. TREATMENT WITH A SOLUTION OF CAUSTIC POTASH.—These experiments were carried out almost simultaneously and under precisely similar conditions, the results therefore admit of a fair comparison. The fuels were all reduced to the same degree of fineness: specific gravity of the potash solution 1.12. The amount of alkaline solution, weight of fuel employed, and length of time occupied in the digestion was in all instances the same.

Generalizations on the Physical and Chemical Characters, And Applications of the Fuels in Question.

The fuels under consideration may—having regard to their physical characters and chemical composition,—perhaps not inappropriately, be arranged under the three following headings, viz., Lignites, Lignitic Coals, and Coals.

Physical and chemical characters.

I. LIGNITES.—Numbers 1 to 21 (inc.).—On exposure to the atmosphere all—with one exception, No. 21—the fuels included in these numbers, have a greater or less tendency to disintegrate and fall to pieces. This property necessarily varies in degree with the different fuels: some resist exposure, especially when well protected, for a tolerably lengthened period, and in the freshly won condition admit of transportation, whilst others break down very speedily and are too friable to bear carriage. If used in their natural state, they should, by reason of their then sounder condition, be employed as freshly

* Percy's Metallurgy; Refractory Materials and Fuel, London, 1875.

Physical and chemical characters, cont.

mined as possible. They all communicate a deep brownish-red color to a boiling solution of caustic potash. The hygroscopic water ranges (No. 21 being disregarded) from, say, 10 to 22 per cent.—in the greater number of cases (excluding Nos. 1, 2, 3, and 21) from 10 to 15 per cent., the average for the seventeen specimens being 12.17 per cent. This high percentage of moisture acts prejudicially in two ways; firstly, it diminishes the relative percentages of the combustible ingredients; and secondly, it (in conjunction with the combined water, of which, the fuels of this class contain a much larger proportion than is found in coals of Carboniferous age) diminishes the heating effect of the fuel by reason of the large amount of caloric which is absorbed in its vaporisation. This defective characteristic of lignites is not, however, exclusively confined to them, it has also been observed in certain American coals of the Carboniferous; some specimens of Iowa coals having been found to contain as much as 12.45, 13.02, and 14.95 per cent. of water. In considering the ash numbers 9, 14 and 20 have been excluded, it being in these instances exceptionally high, number 13 has also been disregarded, as this lignite does not form a separate bed. In the remainder it ranges from, say, 3 to 9 per cent., in five instances only exceeding 7 per cent., the average for the seventeen specimens being 5.83 per cent. The ash, like the moisture, lowers the relative percentages of the combustible ingredients, and hence the heat producing power of the fuel. The value of the latter is influenced not only by the amount but also by the nature of this constituent (when used for household purposes, where the heat of combustion is comparatively moderate, the amount, rather than the character of the ash, is the chief consideration). Combustibles containing a large proportion of ash are prevented from burning completely by reason of the impediment it offers to the draught—when fusible, it forms clinkers upon the bars, impeding the passage of the air and entailing extra labor in stoking and loss of heat from the cooling effects of the rush of cold air through the flues while the grate is being cleared. These fuels are all non-caking—in no instance was a coherent coke obtained either by slow or fast coking, number 17, it is true yields by fast coking a slightly fritted coke, but this is most probably due to the resin which is diffused through its substance.

II. LIGNITIC COALS.—Numbers 22 to 27 (inc.). Of these numbers 22, 23, 24, and 27, may be said to be tolerably firm coals—on exposure to the air they become slightly fissured but do not readily disintegrate; numbers 25 and 26 are hard and firm and well suited for transportation. In appearance they are not unlike some varieties of coal of the Carboniferous—numbers 23, 24 and 25 show slickensides. These fuels all communicate a brownish-red coloration to a boiling solution of caustic potash, which although far less intense than that afforded by any of the fuels considered under I., is nevertheless much deeper than that which would be imparted by any true coal. The percentage of hygroscopic water ranges (omitting No. 24) from, say, 5 to 9 per cent., the average being 6.84 per cent. The amount of ash is very variable. None of these fuels yield, by slow coking, a coherent coke—by fast coking they give, however,—with the exception of No. 22—a slightly fritted coke.

Physical and chemical characters, cont.

III. COALS.—Numbers 28 to 35 (inc.). All these fuels are hard and firm, and would, it may be inferred, bear transportation without serious waste by reduction to fine coal. Numbers 31, 32, 33, 34 and 35, in appearance, closely resemble some varieties of coal of the Carboniferous; numbers 29 and 31 show traces of slickensides. Only one of these coals communicates any very appreciable coloration to a boiling solution of caustic potash, the remainder do not impart a greater depth of tint than that afforded by some coals of Carboniferous age. In common with all the preceding fuels, they yield, by slow coking a non-coherent coke—by fast coking, on the other hand, the result is a coherent coke, that of numbers 28 and 29 being tender, whilst in all other instances the result is a good firm coke. On referring to the ultimate analyses of these coals, as given in the text, it will be seen that the numerical relations between the carbon, hydrogen, and oxygen, inclusive of nitrogen, are the same as exist in some varieties of coal (British non-caking, rich in oxygen) of the Carboniferous system.

From the foregoing statements (and by reference to the various analyses) it will be seen that:

Whereas the fuels enumerated under the heading of Lignite, all have a greater or less tendency to disintegrate on exposure to the air; contain a large amount of hygroscopic water; communicate an intense coloration to a solution of caustic potash; yield a non-coherent coke *, and have a chemical composition very similar to that of many foreign lignites—those referred to under Lignitic coal, show a greater disposition to resist exposure to the air; are, on the whole, tolerably firm, and approximate in appearance to some varieties of coal of the Carboniferous; contain very much less hygroscopic water; do not impart so deep a coloration to a solution of caustic potash; show a slight caking tendency *, and in regard to chemical composition occupy a position between true lignites and true bituminous coals—whilst those designated as Coals, differ from the preceding in that, they resist exposure to the air; are hard and firm; contain but a small proportion of hygroscopic water; communicate but a very slight coloration to a solution of caustic potash; yield, in the majority of instances, a good firm

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Fast coking referred to.

coke*, and in respect to general appearance and chemical composition closely resemble some varieties of coal of the Carboniferous system.

Applications.

All the fuels referred to as coals are well adapted for the manufacture of illuminating gas, as are also, although in a somewhat lesser degree, the lignitic coals—and possibly some of the lignites might be used for the same purpose. The first mentioned being for the most part strongly caking, the coke obtained from them in the process of gas making will constitute a valuable fuel for many purposes; in the case of the lignitic coals and lignites, however, which yield respectively but slightly fritted and non-coherent cokes, the residuary coke, more especially that of the lignites, will most probably be found to be of somewhat limited application. It appeared desirable in the case of those fuels which are only slightly or non-caking, to ascertain what proportion of a caking coal would be required to be added to them in order to ensure the production of a coherent, serviceable coke, and with this object in view the undermentioned experiments were carried out. Number 26 was selected to represent the lignitic coals and number 2 the lignites: the caking coal employed was the well-known Youghiogheny gas coal (Pennsylvania). The materials were reduced to the same state of mechanical division (tolerably fine powder); the weight of mixture employed was in all instances the same, and the cokings were conducted as nearly as possible at the same temperature. The results were as follows:—

Coking experiments.

Number of experiment.	Proportions. Parts by weight, of		Character of the coke.
	Number 26. (lignitic coal)	Youghiogheny coal.	
1.	100	20	Firm, coherent, an excellent coke.
2.	"	15	" " " "
3.	"	10	" " somewhat inferior to the one immediately preceding, but still of good quality.
4.	"	5	Coherent, but tender—fairly good.
	Number 2. (lignite)		
5.	100	20	Firm, coherent — good quality — about equal to that of experiment 3.
6.	"	15	Coherent, somewhat tender, fairly good.
7.	"	10	Coherent, but tender, inferior.

From this it will be seen that—as far as experiments on the small scale are concerned—the addition of fifteen parts of a strongly caking

* Fast coking referred to.

coal to one hundred parts of the lignitic coal, ensures the production of a good strong coke: with ten parts of caking coal the product is still a good coke, and even the mixture containing only five parts of caking coal makes a coke which, although somewhat tender, might yet be found useful for some purposes. The lignite, it may be observed, requires a much larger addition of caking coal in order to ensure equally satisfactory results—the mixture containing twenty parts of caking coal does not make a stronger coke than that obtained from the mixture of lignitic coal containing only half that amount of caking coal: with fifteen parts of caking coal, the coke was tender, though possibly still a useful fuel; that made from the mixture containing ten parts of caking coal cannot be regarded as a useful coke.

Applications, cont.

From the foregoing experiments it may, therefore, be inferred that: —as regards the lignitic coal, the addition of fifteen parts of a strongly caking coal to one hundred parts of that fuel would be found to yield a good firm coke, and that about ten parts of caking coal is the smallest proportion that would be found to give satisfactory results:—in the case of the lignite an addition of not less than twenty parts of caking coal to one hundred parts of lignite would be required in order to ensure the production of a good coherent coke, and that fifteen parts of caking coal is the smallest proportion that can be employed with any probability of obtaining a fairly good coke.*

The lignites constitute a good fuel for the burning of lime and bricks, and very many of them in their sounder condition—that is to say when freshly or comparatively recently mined—will be found suitable for domestic purposes, either for cooking or warming; the better qualities might, step grates being used, be employed for heating steam boilers —there can be little doubt but that they might all be successfully utilized by means of gas producers.

The lignitic coals are good fuels and may be used with advantage for household purposes, for raising steam and in various metallurgical operations. The coals constitute excellent fuels and will be found to serve well for all domestic purposes, to be well adapted for stationary boilers and locomotives, and admirably suited for many metallurgical purposes. The anthracitic coal and semi-anthracite appeared, as regarded their application, to call for a few special remarks, these have been appended to their respective analyses.

With reference to the evaporative power of these fuels, as determined by Thompson's calorimeter—the results obtained are, it need scarcely be

* Experience has shown that, in the preparation of coke from a mixture of non-caking and caking coal, it is very desirable that the latter be reduced to a much finer state of division than the former. The two kinds of fuel should therefore be ground separately and afterwards mixed in the desired proportions.

Applications, cont.

said, higher than could be obtained in practice, where indeed the full capabilities of a fuel are never realized, and this may be ascribed to several causes:—the fuel is scarcely ever fully consumed, a part escapes combustion by passing off in the form of combustible gases and smoke, another portion falls through the grate with the ash; there is loss of heat by radiation and conduction, that by conduction not only occurs through the materials of the furnace, but also from the gaseous products and excess of air, which carry with them a considerable portion of the heat into the chimney and air; heat is also conducted away by the ash which falls through the grate, and a further portion is absorbed in vaporising the hygroscopic and combined water.

In the employment of fuel, its physical and chemical constitution must be taken into account, and the conditions ascertained which are most conducive to the development of its full calorific power:—the furnace should have its details arranged with special reference to the burning of a particular fuel, as may be found after a trial, the best and most economical arrangement for that fuel. With reference to the value to be attached to the experimental results obtained by actually burning a portion of the fuel under the boiler, the information which even this method affords for practical guidance is not always so reliable as might appear at first sight. Touching the evaporative power of coals, Dr. Percy says*—"Numerous costly and very elaborate experiments have been made in this and other countries to determine the relative values of different kinds of coal with reference to steam navigation; and I have no hesitation in expressing my conviction that some of the results may lead to very erroneous conclusions. A particular boiler—it may be an old one—is selected for the purpose of experiment and set over a particular fire-grate, etc. We will suppose two varieties of coal, say A and B, to be tested in this apparatus, and that, weight for weight, A is found to yield more steam than B; whereupon A is pronounced decidedly superior as a steam coal to B. But it is quite possible that this result may be due to the particular boiler and fire-grate being best suited to the manner in which A burns; and that under another boiler, and with another form of fire-grate, etc., B might be found superior to A. Experiments, indeed, have established that such is sometimes actually the case."

* Percy's Metallurgy; Refractory Materials and Fuel, London, 1875.

I. Analyses of Lignites.

1.—From the Souris River, one mile west of La Roche Percée, at the junction of Short Creek and Souris River. "Sutherland's" mine. Seam five feet thick. Geological position—Tertiary. Collected by Dr. A. R. C. Selwyn, and referred to by him in the Report of Progress for 1879–80, p. 5 A. Lignite from Souris River.

A brownish-black, compact lignite; ligneous texture very marked; lustre for the greater part dull, in more altered parts sub-resinous to resinous; tough; fracture on the whole uneven, occasionally however, verging on the sub-conchoidal; does not soil the fingers, powder black, with a brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air becomes more or less fissured.

Specific gravity 1.4168—Weight of one solid cubic foot 88.55 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	21.84	21.84
Volatile combustible matter	32.15	35.12
Fixed carbon	41.61	38.64
Ash	4.40	4.40
	100.00	100.00
Coke, per cent	46.01	43.04
Ratio of volatile combustible matter to fixed carbon	1:1.29	1:1.10

It yields—both by slow and fast coking, a non-coherent coke. The ash has a brownish-yellow color—exposed to a bright red heat it becomes slightly agglutinated.

2.—From the South Saskatchewan, south side, about ten miles above Medicine Hat. Lower seam. Seam four feet thick. Geological position—Cretaceous. Collected by Mr. R. G. McConnell. Lignite from the South Saskatchewan.

Structure coarse lamellar—the various layers differ somewhat in lustre; contains an occasional interstratified layer of mineral charcoal; color black; lustre along the plane of bedding dull, that of the cross fracture sub-resinous to resinous; fracture uneven, that of some of the layers not unfrequently conchoidal; the brighter portions do not soil the fingers; powder brownish-black; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits along the plane of bedding and falls to pieces.

Specific gravity 1.3972—Weight of one solid cubic foot 87.32 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	16.82	16.82
Volatile combustible matter	29.54	31.90
Fixed carbon	46.34	43.98
Ash	7.30	7.30
	100.00	100.00
Coke, per cent	53.64	51.28
Ratio of volatile combustible matter to fixed carbon	1:1.57	1:1.38

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	54.35	72.26
Hydrogen	3.34	4.44
Oxygen and Nitrogen	17.52	23.30
Sulphur	0.67	—
Ash	7.30	—
Hygroscopic water	16.82	—
	100.00	100.00

Calorific power of

Calorific power—determined by experiment:

Indicated power of fuel in calories 5144
Indicated evaporative power ....9.57 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke*; the gases evolved during coking burnt with a yellowish, somewhat luminous, slightly smoky flame. The ash has a reddish-brown color—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a more or less vitrified mass.

Lignite from the South Saskatchewan.

3.—From the South Saskatchewan, south side. From the same seam as the preceding specimen, but taken at a point somewhat further up the river, viz., ten and a quarter miles above Medicine Hat. Collected by Mr. R. G. McConnell.

Structure coarse lamellar—the successive layers differ somewhat in color and lustre, the former varying from black, with a brownish tinge, to pure black, and the latter from sub-resinous to shining resinous; some of the layers exhibit a very marked

* With respect to the preparation of a coherent coke from this fuel by admixture of the same with a caking coal, see page 8 M.

ligneous texture; fracture uneven, occasionally somewhat conchoidal; does not soil the fingers; powder brownish-black; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits along the line of bedding and falls to pieces.

Specific gravity 1.3722—Weight of one solid cubic foot 85.76 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	17.70	17.70
Volatile combustible matter	28.63	29.90
Fixed carbon	49.83	48.56
Ash	3.84	3.84
	100.00	100.00
Coke, per cent	53.67	52.40
Ratio of volatile combustible matter to fixed carbon	1 : 1.74	1 : 1.62

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, slightly luminous, almost smokeless flame. The ash has a dark reddish-brown color—exposed to a bright red heat it becomes agglutinated, at a most intense red heat it forms a slaggy mass.

4.—From the North Saskatchewan, right bank, abont forty miles below the confluence of the Brazeau River. Seam eighteen to twenty feet thick. Geological position—Laramie (Tertiary ?) or Cretaceous. Collected by Mr. R. W. Ells, 1875. Photographed and described in 1873 by Dr. A. R. C. Selwyn—Report of Progress for 1873–74, p. 49. Lignite from the North Saskatchewan.

Structure, coarse lamellar; made up of alternate layers of more or less dense, bright and dull coal, and numerous interstratified layers of mineral charcoal; the surface of the denser layers parallel to the plane of deposition present a ligneous structure; color black; lustre along the surface of bedding dull, that of the cross fracture sub-resinous to resinous; fracture uneven, that of the brighter layers somewhat conchoidal; the brighter portions do not soil the fingers; powder almost black; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air becomes fissured, preferably along the line of bedding, and falls to pieces.

Specific gravity 1.4341—Weight of one solid cubic foot 89.63 pounds.

Analyses of.

Analyses by slow and fast coking gave :

	Slow coking.	Fast coking.
Hygroscopic water	14.78	14.78
Volatile combustible matter	28.46	30.48
Fired carbon	50.69	48.67
Ash	6.07	6.07
	100.00	100.00
Coke, per cent	56.76	54.74
Ratio of volatile combustible matter to fixed carbon	1 : 1.78	1 : 1.59

Calorific power of.

Calorific power—determined by experiment :

Indicated power of fuel in calories 5289
Indicated evaporative power .... 9.84 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, slightly luminous, almost smokeless flame. The ash has a pale brownish-yellow color,—exposed to a bright red heat it becomes very slightly agglutinated, at a most intense red heat it becomes slightly fritted.

Lignite from the North Saskatchewan.

5.—From the North Saskatchewan, right bank, a short distance below Fort Edmonton. Seam six feet thick. Geological position—probably Laramie.

Structure very compact and homogeneous; color brownish-black; lustre dull, occasionally sub-resinous; tough; fracture large conchoidal; does not soil the fingers; powder black, with a brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air becomes more or less fissured.

Specific gravity 1.4256—Weight of one solid cubic foot 89.10 pounds.

Analyses of.

Analyses by slow and fast coking gave :

	Slow coking.	Fast coking
Hygroscopic water	12.89	12.89
Volatile combustible matter	32.19	33.79
Fixed carbon	52.17	50.57
Ash	2.75	2.75
	100.00	100.00
Coke, per cent	54.92	53.32
Ratio of volatile combustible matter to fixed carbon	1:1.62	1:1.49

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories....................5207

Indicated evaporative power..................9.69 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, somewhat luminous, slightly smoky flame. The ash has a dark brownish-yellow color—exposed to a bright red heat it becomes agglutinated, at a most intense red heat it forms a slaggy mass.

6.—From Red Deer River, at the mouth of Arrowwood River. Seam six feet thick. Geological position—Laramie. Collected by Mr. R. G. McConnell. Lignite from Red Deer River.

Structure very fine lamellar, the lines of bedding are however not unfrequently very indistinct—tolerably compact; color black; lustre sub-resinous to resinous; fracture uneven, occasionally verging on the conchoidal; does not soil the fingers; powder almost black; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air becomes somewhat fissured and in consequence has a tendency to fall to pieces.

Specific gravity 1.4027—Weight of one solid cubic foot 87.67 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	13.08	13.08
Volatile combustible matter	31.49	34.50
Fixed carbon	51.35	48.34
Ash	4.08	4.08
	100.00	100.00
Coke, per cent.	55.43	52.42
Ratio of volatile combustible matter to fixed carbon	1:1.63	1:1.40

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories....................5347

Indicated evaporative power..................9.95 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, slightly luminous, almost smokeless flame. The ash has a reddish-brown color—exposed to a bright red heat, it becomes very slightly agglutinated, at a most intense red heat, it forms a slaggy mass.

Lignite from Red Deer River.

7.—From the Red Deer River, two miles below the mouth of Arrowwood River. The seam, which here has a thickness of five feet, is the same as that from which the preceding specimen was taken—it is probably an extension of the seam at Blackfoot Crossing, Bow River (specimen No. 12). Geological position—Laramie. Collected by Mr. R. G. McConnell.

Structure very fine lamellar, the lines of bedding are, however, often almost obliterated—tolerably compact; color black; lustre sub-resinous to resinous; fracture uneven, occasionally approaching the conchoidal; does not soil the fingers; powder almost black; it communicates a deep brownish-red color to a boiling solution of caustic potash; cracks somewhat by exposure to the air and as a result has a tendency to fall to pieces.

Specific gravity 1.3929—Weight of one solid cubic foot 87.06 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	14.20	14.20
Volatile combustible matter	30.92	34.22
Fixed carbon	51.21	47.91
Ash	3.67	3.67
	100.00	100.00
Coke, per cent	54.88	51.58
Ratio of volatile combustible matter to fixed carbon	1:1.66	1:1.40

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, somewhat luminous, slightly smoky flame. The ash has a bright red color—exposed to a bright red heat, it becomes slightly agglutinated, at a most intense red heat it forms a slaggy mass.

Lignite from Red Deer River.

8.—From the Red Deer River, about seven miles above Hunter's Hill. Seam three and a half feet thick. Geological position—Cretaceous, below Pierre. Collected by Mr. R. G. McConnell.

Structure somewhat fine lamellar; contains an occasional interstratified layer of mineral charcoal; reticulated throughout with delicate laminæ of gypsum, those perpendicular to the lamination dividing it into small blocks of irregular shape, consequent upon which the cross fracture, which is very uneven, presents a highly characteristic appearance; lustre in the direction of the bedding dull, that of the cross fracture resinous; apart from the layers of mineral charcoal, does not soil the fingers; powder almost black; it communicates a deep brownish-red color to a boiling solution of caustic potash; after exposure to the air it parts somewhat readily into small fragments, the line of fracture being apparently determined by the films of gypsum.

Specific gravity 1.4257—Weight of one solid cubic foot 89.11 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	13.06	13.06
Volatile combustible matter	29.41	33.75
Fixed carbon	48.51	44.17
Ash	9.02	9.02
	100.00	100.00
Coke, per cent	57.53	53.19
Ratio of volatile combustible matter to fixed carbon	1:1.65	1:1.30

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories 5028
Indicated evaporative power ....9.36 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, somewhat luminous, slightly smoky flame. The ash has a brownish-yellow color,—exposed to a bright red heat, it becomes slightly agglutinated, at a most intense red heat, it forms a slaggy mass.

9.—From the Red Deer River, nine miles above Hunter's Hill. Seam one and a half foot thick. Geological position—Cretaceous, below Pierre. Collected by Mr. R. G. McConnell. Lignite from Red Deer River.

Structure fine lamellar—tolerably compact; color black; lustre of surface along the plane of bedding dull, that of the cross fracture resinous; fracture uneven, occasionally somewhat conchoidal; does uot soil the fingers; in parts coated with a slight deposit of ferric hydrate; powder black, faint brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits in the direction of the bedding and falls to pieces.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	13.63	13.63
Volatile combustible matter	31.31	34.01
Fixed carbon	41.81	39.11
Ash	13 25	13.25
	100.00	100.00
Coke, per cent	55.06	52.36
Ratio of volatile combustible matter to fixed carbon	1:1.33	1:1.15

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellowish, slightly luminous, almost smokeless flame. The ash has a pale reddish-yellow color—exposed to a bright red heat it does not become agglutinated, at a most intense red heat it forms a more or less vitrified mass.

Lignite from Red Deer River.

10.—From the Red Deer River, thirteen miles above Hunter's Hill. Seam fifteen inches thick. North-north-east extension of the "Coal Banks" seam (specimen No. 26). Geological position—Cretaceous, base of Pierre. Collected by Mr. R. G. McConnell.

Structure fine lamellar,—tolerably compact; color black; lustre along the plane of bedding dull, that of the cross fracture, resinous; fracture irregular; intersected throughout by numerous thin plates of gypsum; here and there coated with a slight deposit of ferric hydrate; does not soil the fingers; powder black, slight brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits along the line of bedding and falls to pieces.

Specific gravity 1.4221—Weight of one solid cubic foot 88.88 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	12.62	12.62
Volatile combustible matter	32.08	35.99
Fixed carbon	46.72	42.81
Ash	8.58	8.58
	100.00	100.00
Coke, per cent	55.30	51.39
Ratio of volatile combustible matter to fixed carbon	1:1.46	1:1.19

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellow, luminous, somewhat smoky flame. The ash has a pale dirty reddish-brown color,—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a slaggy mass.

Lignite from the Bow River (Grassy Island).

11.—From Grassy Island, Bow River. Main seam; seam four and a half feet thick. North-north-east extension of "Coal Banks" seam, (specimen No. 26). Geological position—Cretaceous, base of Pierre. Collected by Dr. G. M. Dawson.

Structure fine lamellar, tolerably compact; fracture uneven; lustre of surface parallel to the bedding dull, that across the bedding sub-resinous; color black; contains here and there an interposed patch of mineral charcoal, and is in parts coated with a slight film of ferric hydrate; apart from the patches of mineral charcoal, does not soil the fingers; powder black, slight brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits in the direction of the bedding and falls to pieces.

Specific gravity 1.4162—Weight of one solid cubic foot 88.51 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	11.90	11.90
Volatile combustible matter	31.20	35.02
Fixed carbon	50.97	47.15
Ash	5.93	5.93
	100.00	100.00
Coke, per cent	56.90	53.08
Ratio of volatile combustible matter to fixed carbon	1:1.63	1:1.34

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories.....5473
Indicated evaporative power.....10.19 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellow, luminous, somewhat smoky flame. The ash has a bright red color,—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a more or less vitrified mass.

12.—From Blackfoot Crossing, Bow River; in coulée six and a half miles east of old Blackfoot Agency buildings. The deposit consists of two seams, the upper averaging one foot eight inches in thickness, the lower three feet: they are separated by a foot of carbonaceous shale. This specimen was taken from the lower or three feet seam. Geological position—Laramie. Collected by Dr. G. M. Dawson. Lignite from the Bow River (Blackfoot Crossing.)

Structure fine lamellar, tolerably compact; color black; lustre in the direction of the bedding dull, that of the cross fracture resinous; contains here and there an interposed patch of mineral charcoal; fracture uneven, occasionally somewhat conchoidal; in parts coated with a slight deposit of ferric hydrate; powder black, faint brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits along the line of bedding and falls to pieces.

Specific gravity 1.3970—Weight of one solid cubic foot 87.31 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	11.91	11.91
Volatile combustible matter	30.04	33.25
Fixed carbon	54.78	51.57
Ash	3.27	3.27
	100.00	100.00
Coke, per cent	58.05	54.84
Ratio of volatile combustible matter to fixed carbon	1:1.82	1:1.55

Calorific power of.

Calorific power—determined by experiment:

Indicated power of fuel in calories 5531
Indicated evaporative power ....10.29 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellow, luminous, slightly smoky flame. The ash has a yellowish-brown color,—exposed to a bright red heat it becomes agglutinated, at a most intense red heat it forms a slaggy mass.

"Conchoidal" lignite.

13.—"Conchoidal" lignite found in some parts of the seam from which the preceding specimen was taken. Collected by Dr. G. M. Dawson.

Structure compact; homogenous, like jet—some fragments exhibited, although but faintly, a delicate ligneous texture; color velvet-black; lustre resinous; brittle; fracture conchoidal; feel smooth, does not soil the fingers; powder black, faint brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash.

Specific gravity 1.3850.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	12.31	12.31
Volatile combustible matter	29.82	32.83
Fixed carbon	55.75	52.74
Ash	2.12	2.12
	100.00	100.00
Coke, per cent	57.87	54.86
Ratio of volatile combustible matter to fixed carbon	1:1.87	1:1.60

It yields—both by slow and fast coking, a non-coherent coke. The ash has a dark brownish-yellow color.

This "conchoidal" lignite would appear to consist of fragments of the more solid portions—root, trunk, or branch—of some of the vegetable matter from which the bed of lignite has been derived.

14.—From the south side of Bow River, about four miles below Blackfoot Crossing. Geological position—Laramie. Collected by Prof. J. Macoun. Lignite from the Bow River (Blackfoot Crossing).

Structure somewhat coarse lamellar; contains an occasional layer of mineral charcoal; color black; lustre of freshly fractured surface, bright; some of the layers of lignite are reticulated throughout with films of gypsum, such, on pressure, crumble readily into small fragments; powder black, with a brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air has a tendency to split along the line of bedding. This specimen was slightly soiled with clay, which had also permeated some of the fissures.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	10.72	10.72
Volatile combustible matter	29.26	32.63
Fixed carbon	46.09	42.72
Ash	13.93	13.93
	100.00	100.00
Coke, per cent	60.02	56.65
Ratio of volatile combustible matter to fixed carbon	1 : 1.57	1 : 1.31

It yields—both by slow and fast coking, a non-coherent coke. The ash has a reddish-white color,—exposed to a bright red heat it becomes very slightly agglutinated.

15.—From Crowfoot Creek, four miles from its entry into Bow River. Seam six feet thick. Geological position—Laramie. Collected by Prof. J. Macoun. Lignite from the Bow River (Crowfoot Creek).

Structure fine lamellar; reticulated throughout with delicate laminæ of gypsum; fracture uneven: color black; lustre bright; powder black, with a brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by simple exposure to the air does not readily fall to pieces—when pressed between the fingers it parts into small fragments, the line of fracture being determined, apparently, by the films of gypsum.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	11.25	11.25
Volatile combustible matter	31.98	35.59
Fixed carbon	50.85	47.24
Ash	5.92	5.92
	100.00	100.00
Coke, per cent	56.77	53.16
Ratio of volatile combustible matter to fixed carbon	1 : 1.59	1 : 1.33

It yields—both by slow and fast coking, a non-coherent coke. The ash has a brownish-yellow color—exposed to a bright red heat it becomes slightly agglutinated.

Lignite from the Bow River (Horse-shoe Bend).

16.—From Horse-shoe Bend, Bow River. Seam four and a-half feet thick. This specimen was taken from the upper part of the seam. Geological position—Cretaceous, top of Pierre. Collected by Dr. G. M. Dawson.

Structure fine lamellar—tolerably compact; color black; lustre in the direction of the bedding dull, that of the cross fracture, resinous; fracture uneven, occasionally somewhat conchoidal; does not soil the fingers; powder black, with a brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air it becomes incrusted with a white efflorescence, resulting from the oxidation of the iron-pyrites, which is disseminated through this lignite in a very finely divided state—splits in the direction of the bedding and falls to pieces.

Analyses of.

Analyses by slow and fast coking gave;

	Slow coking.	Fast coking.
Hygroscopic water	11.13	11.13
Volatile combustible matter	36.52	38.75
Fixed carbon	43.16	40.93
Ash	9.19	9.19
	100.00	100.00
Coke, per cent	52.35	50.12
Ratio of volatile combustible matter to fixed carbon	1 : 1.18	1 : 1.06

It yields—both by slow and fast coking, a non-coherent coke. The ash has a dark brownish-red color,—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a slaggy mass.

17.—From the Smoky River, five miles below the mouth of Little Smoky River. Seam two and a-half inches thick. Geological position—Cretaceous, Dunvegan Group. Collected by Dr. G. M. Dawson, and referred to by him in the Report of Progress for 1879–80, p. 118 B. Lignite from Smoky River.

Structure coarse lamellar; made up of alternating layers of a dull and bright lignite and mineral charcoal, of which latter it contains a good deal; small fragments of a pale yellowish, sub-transparent resin also occur, diffused through certain portions of its substance; color black; powder black, with a brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	11.52	11.52
Volatile combustible matter	31.26	34.83
Fixed carbon	53.04	49.47
Ash	4.18	4.18
	100.00	100.00
Coke, per cent	57.22	53.65
Ratio of volatile combustible matter to fixed carbon	1 : 1.69	1 : 1.42

It yields—by slow coking, a non-coherent coke—by fast coking a slightly fritted coke, the fritting most probably being due to the presence of the resin. The ash has a pale reddish-brown color,—exposed to a bright red heat it becomes slightly agglutinated.

18.—From the Athabasca River, about fifty-five miles above the site of old Fort Assineboine. Upper seam; seam ten feet thick. Geological position—Laramie. Collected by Dr. G. M. Dawson, and referred to by him in the Report of Progress for 1879–80, p. 126 B. Lignite from Arthabasca River.

Structure coarse lamellar; it consists of bright and somewhat dull layers of lignite, and an occasional layer of mineral charcoal interstratified; color black; lustre of some of the layers, sub-resinous, that of others shining resinous; fracture uneven; some of the layers of lignite are reticulated throughout with delicate laminæ of gypsum; powder black, with a brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits along the line of bedding.

Specific gravity 1.4423—Weight of one solid cubic foot 90.14 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	11.47	11.47
Volatile combustible matter	28.96	32.09
Fixed carbon	50.92	47.7
Ash	8.65	8.65
	100.00	100.00
Coke, per cent	59.57	56.44
Ratio of volatile combustible matter to fixed carbon	1:1.76	1:1.49

Calorific power of.

Calorific power—determined by experiment:

Indicated power of fuel in calories 5424
Indicated evaporative power .....10.10 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellow, luminous, somewhat smoky flame. The ash has a light bluish-grey color—exposed to a bright red heat it becomes very slightly agglutinated.

Lignite from Arthabasca River.

19.—From the Athabasca River, about fifty-five miles above the site of old Fort Assineboine. Lower seam; seam three feet thick. Geological position—Laramie. Collected by Dr. G. M. Dawson, and referred to by him in the Report of Progress for 1879–80, p. 126B.

Structure somewhat coarse lamellar; made up of successive layers of a bright and dull lignite, with an occasional intervening layer of mineral charcoal; color black; fracture uneven; powder black, with a brownish tinge; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air it has a tendency to split in the direction of the bedding.

Specific gravity 1.4387—Weight of one solid cubic foot 89.92 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	10.58	10.58
Volatile combustible matter	29.29	32.79
Fixed carbon	53.69	50.19
Ash	6.44	6.44
	100.00	100.00
Coke, per cent	60.13	56.63
Ratio of volatile combustible matter to fixed carbon	1:1.83	1:1.53

It yields—both by slow and fast coking, a non-coherent coke.

The ash has a light grey color—exposed to a bright red heat it becomes very slightly agglutinated.

20.—From the northern side of Milk River Ridge. Seam one and a half foot thick. Southern extension of "Coal Banks" seam (specimen No. 26). Geological position—Cretaceous, base of Pierre. Collected by Mr. R. G. McConnell. Lignite from Milk River Ridge.

Structure fine lamellar, tolerably compact; color black; lustre along the plane of bedding dull, that of the cross fracture, sub-resinous; fracture uneven; does not soil the fingers; in parts coated with a film of ferric hydrate; powder brownish-black; it communicates a deep brownish-red color to a boiling solution of caustic potash; by exposure to the air splits in the direction of the bedding and falls to pieces.

Specific gravity 1.5140—Weight of one solid cubic foot 94.62 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	9.84	9.84
Volatile combustible matter	28.66	31.92
Fixed carbon	42.67	39.41
Ash	18.83	18.83
	100.00	100.00
Coke, per cent	61.50	58.24
Ratio of volatile combustible matter to fixed carbon	1:1.49	1:1.23

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories 4980
Indicated evaporative power ....9.27 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke; the gases evolved during coking burnt with a yellow, luminous, slightly smoky flame. The ash has a greenish-grey color—exposed to a bright red heat, it becomes very slightly agglutinated, at a most intense red heat it forms a more or less vitrified mass.

21.—From the Pine River, Coal Brook, two and a-half miles east of the Lower Forks. Seam six inches thick. Geological position—Cretaceous, Dunvegan Group. Collected by Dr. G. M. Dawson, and referred to by him in the Report of Progress for 1879-80, p. 117 B. Lignite from Pine River, Coal Brook.

Structure very fine lamellar; the lines of bedding, which are very numerous and close together, are almost obliterated—compact;

color black; lustre sub-resinous to resinous, occasionally in parts brilliant; hard and firm; shows well defined planes of cleat; does not soil the fingers; weathered surfaces in places coated with ferric hydrate; powder brownish-black; it communicates a deep brownish-red color to a boiling solution of caustic potash; resists exposure to the air; in appearance it resembles some varieties of coal of the Carboniferous system.

Specific gravity 1.4217—Weight of one solid cubic foot, 88.86 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	7.83	7.83
Volatile combustible matter	30.55	34.21
Fixed carbon	55.75	52.09
Ash	5.87	5.87
	100.00	100.00
Coke, per cent	61.62	57.96
Ratio of volatile combustible matter to fixed carbon	1 : 1.82	1 : 1.52

It yields—both by slow and fast coking, a non-coherent coke. The ash has a reddish-white color,—exposed to a bright red heat it becomes very slightly agglutinated, at a most intense red heat it becomes slightly fritted.

II. Analyses of Lignitic Coals.

Lignitic coal from Belly River.

22.—From the Belly River, five miles below the mouth of Little Bow River. Geological position—Cretaceous. Collected by Dr. G. M. Dawson.

Structure very fine lamellar, lines of bedding not unfrequently very indistinct or altogether obliterated—compact; contains an occasional interposed patch of mineral charcoal and here and there a thin plate of gypsum; color black, in parts iridescent; lustre of surface along the plane of bedding dull, that of the cross fracture, resinous, sometimes brilliant; fracture uneven, at times somewhat conchoidal; apart from the patches of mineral charcoal, does not soil the fingers; powder almost black; it communicates a brownish-red color to a boiling solution of caustic potash; by exposure to the air becomes slightly fissured, but is on the whole a tolerably firm coal; in appearance it resembles some varieties of coal of the Carboniferous system.

Specific gravity 1.3976—Weight of one solid cubic foot 87.35 pounds.

Analyses by slow and fast coking gave : Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	9.18	9.18
Volatile combustible matter	30.66	34.97
Fixed carbon	53.31	49.00
Ash	6.85	6.85
	100.00	100.00
Coke, per cent	60.16	55.85
Ratio of volatile combustible matter to fixed carbon	1 : 1.74	1 : 1.40

An ultimate analysis gave :

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	62.39	74.99
Hydrogen	3.99	4.79
Oxygen and Nitrogen	16.82	20.22
Sulphur	0.77	—
Ash	6.85	—
Hygroscopic water	9.18	—
	100.00	100.00

The total percentage of sulphur in this coal amounted to 0.816 of this 0.046 was present in the form of gypsum—representing 0.247 of that mineral.

Calorific power—determined by experiment : Calorific power of.

Indicated power of fuel in calories 5821
Indicated evaporative power ....10.84 pounds of water (at 100° C.) per pound of fuel.

It yields—both by slow and fast coking, a non-coherent coke ; the gases evolved during coking burnt with a yellow, luminous, slightly smoky flame. The ash has a brownish-yellow color,—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a slaggy mass.

23.—From the Highwood River, North Fork, five miles above Forks. Seam one and a-half foot thick. Geological position—Laramie. Collected by Mr. R. G. McConnell. Lignitic coal from the Highwood River.

Structure compact ; shows slickensides ; color black, lustre sub-resinous to resinous ; hard and firm ; fracture uneven ; does not soil the fingers ; it contains, in parts, a slight deposit of a white amorphous, aluminous mineral which, owing to insufficiency of material, was not identified ; powder black, slight brownish tinge ; it communicates a brownish-red color to a boiling solution of caustic potash; does not readily fall to pieces when exposed to the air; in appearance it resembles some varieties of coal of the Carboniferous system.

Specific gravity 1.4163—Weight of one solid cubic foot 88.52 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	6.12	6.12
Volatile combustible matter	26.87	31.92
Fixed carbon	54.93	49.88
Ash	12.08	12.08
	100.00	100.00
Coke, per cent	67.01	61.96
Ratio of volatile combustible matter to fixed carbon	1 : 2.04	1 : 1.56

Calorific power of.

Calorific power—determined by experiment:

Indicated power of fuel in calories 5980
Indicated evaporative power ....11.13 pounds of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a slightly fritted coke; the gases evolved during coking burnt with a yellow, luminous, smoky flame. The ash has a reddish-grey color,—exposed to a bright red heat it does not become agglutinated, at a most intense red heat it becomes slightly fritted.

Lignitic coal from the Highwood River.

24.—From the Highwood River, North Fork. This specimen is from the same seam as the one last under consideration, it was, however, taken at a point about one hundred yards distant from where that was procured.

The description given of the preceding specimen applies also to this one. The specific gravity was not determined.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	4.23	4.23
Volatile combustible matter	26.13	31.06
Fixed carbon	47.97	43.04
Ash	21.67	21.67
	100.00	100.00
Coke, per cent	69.64	64.71
Ratio of volatile combustible matter to fixed carbon	1 : 1.83	1 : 1.38

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories 5507
Indicated evaporative power .... 10.25 pounds of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a slightly fritted coke, which crumbles easily between the fingers; the gases evolved during coking burnt with a yellow, luminous, rather smoky flame. The ash has a light bluish-grey color,—exposed to a bright red heat it does not become agglutinated, at a most intense red heat it becomes slightly fritted.

25.—From the Government Indian Farm, south of Pincher Creek, about one mile from the farm buildings, up the valley of the small stream on which they are situated. Seam two feet thick where examined, but reported as considerably thicker where worked into. Geological position—base of Laramie. Collected by Dr. G. M. Dawson. Lignitic coal from Pincher Creek.

Structure foliated, highly contorted; shows slickensides; color black; lustre resinous; firm; fracture uneven; powder black, faint brownish tinge; it communicates a brownish-red color to a boiling solution of caustic potash; slightly soils the fingers; resists exposure to the air; in appearance it much resembles some varieties of coal of the Carboniferous system.

Specific gravity 1.3999—Weight of one solid cubic foot 87.49 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	5.38	5.38
Volatile combustible matter	27.19	33.19
Fixed carbon	58.34	52.34
Ash	9.09	9.09
	100.00	100.00
Coke, per cent	67.43	61.43
Ratio of volatile combustible matter to fixed carbon	1:2.14	1:1.58

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories 6241
Indicated evaporative power ....11.62 pounds of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a slightly fritted coke, which crumbles easily between the fingers; the gases evolved during coking burnt with a yellow, luminous, rather smoky flame. The ash has a pale reddish-brown color,—exposed to a bright red heat it does not become agglutinated, at a most intense red heat it becomes slightly fritted.

Lignitic coal "Coal Banks," Belly River.

26.—From the Belly River, main seam at "Coal Banks" (which is at the crossing of the Belly River by the trail to Benton). Seam averages about five and a-half feet thick. Geological position—Cretaceous, base of Pierre. Collected by Dr. G. M. Dawson.

Structure very fine lamellar, the lines of bedding, which are very numerous and close together, are almost obliterated—compact; it contains interstratified, more or less disconnected, lenticular layers of dense, pitch-black, highly lustrous coal, and an occasional patch of mineral charcoal; it is here and there intersected by thin plates of calcite as also by an occasional film of pyrite; it also contains in parts a little reddish-brown, translucent resin; color black; lustre resinous; fracture uneven, occasionally more or less conchoidal; hard and firm; apart from the patches of mineral charcoal, does not soil the fingers; powder black, with a faint brownish tinge; it communicates a brownish-red color to a boiling solution of caustic potash; resists exposure to the air; in appearance it closely resembles some varieties of coal of the Carboniferous system.

Specific gravity 1.3587—Weight of one solid cubic foot 84.92 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	6.50	6.50
Volatile combustible matter	31.59	38.04
Fixed carbon	54.36	47.91
Ash	7.55	7.55
	100.00	100.00
Coke, per cent	61.91	55.46
Ratio of volatile combustible matter to fixed carbon	1:1.72	1:1.26

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	65.30	76.60
Hydrogen	4.30	5.04
Oxygen and Nitrogen	15.65	18.36
Sulphur	0.70	—
Ash	7.55	—
Hygroscopic water	6.50	—
	100.00	100.00

Calorific power—determined by experiment:

Calorific power of.

Indicated power of fuel in calories.................... 6183
Indicated evaporative power.................. 11.51 pounds of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a slightly fritted coke, which crumbles easily between the fingers;* the gases evolved during coking burnt with a yellow, luminous, smoky flame. The ash has a brownish-yellow color,—exposed to a bright red heat it does not become agglutinated, at a most intense red heat it forms a vitrified mass.

27.—From the St. Mary River, seven miles above its junction with the Belly River. Southern exposure, on St. Mary River, of "Coal Banks" main seam (specimen No. 26). Geological position—Cretaceous, base of Pierre. Collected by Dr. G. M. Dawson.

Lignitic coal from St. Mary River.

Structure somewhat coarse lamellar; made up of alternating layers of a greyish-black, dull, and bright black coal, with an occasional interstratified layer of mineral charcoal; it is here and there intersected by thin plates of calcite and also by films of pyrite; fracture uneven,—it occasionally breaks into more or less rhombic fragments; apart from the layers of mineral charcoal, does not soil the fingers; in parts coated with a slight deposit of ferric hydrate; powder black, with a faint brownish tinge; it communicates a brownish-red color to a boiling solution of caustic potash; by exposure to the air becomes slightly fissured, but is on the whole a pretty compact and tolerably firm coal.

Specific gravity 1.3690—Weight of one solid cubic foot 85.56 pounds.

Analyses by slow and fast coking gave:

Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	7.02	7.02
Volatile combustible matter	29.41	36.47
Fixed carbon	57.28	50.22
Ash	6.29	6.29
	100.00	100.00
Coke, per cent	63.57	56.51
Ratio of volatile combustible matter to fixed carbon	1:1.95	1:1.38

Calorific power—determined by experiment:

Calorific power of.

Indicated power of fuel in calories.................... 6295
Indicated evaporative power.................. 11.72 pounds of water (at 100° C.) per pound of fuel.

* With respect to the preparation of a coherent coke from this fuel by admixture of the same with a caking coal, see page 8 M.

It yields—by slow coking, a non-coherent coke—by fast coking, a slightly fritted coke, which crumbles easily between the fingers; the gases evolved during coking burnt with a yellow, luminous, somewhat smoky flame. The ash has a reddish-brown color,—exposed to a bright red heat it becomes very slightly agglutinated, at a most intense red heat it becomes fritted.

III. Analyses of Coals.

Coal from the Bow River (Coal Creek).

28.—From Coal Creek, Bow River, between Morley and Calgary. Seam four and a-half feet thick. Geological position—base of Laramie. Collected by Mr. R. G. McConnell.

Structure coarse lamellar; contains occasional interposed layers of mineral charcoal; it is intersected by numerous very thin plates of calcite, which are perpendicular to the lamination of the coal; color black; lustre along the line of bedding, dull, that of the cross fracture resinous; fracture uneven, at times somewhat conchoidal; apart from the layers of mineral charcoal, does not soil the fingers; powder black, faint brownish tinge; it communicates a pale brownish-yellow color to a boiling solution of caustic potash; here and there coated with a slight film of ferric hydrate; does not readily become fissured when exposed to the air; a tolerably firm coal.

Specific gravity 1.4002—Weight of one solid cubic foot 87.51 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	4.93	4.93
Volatile combustible matter	27.22	33.55
Fixed carbon	52.54	46.21
Ash	15.31	15.31
	100.00	100.00
Coke, per cent	67.85	61.52
Ratio of volatile combustible matter to fixed carbon	1:1.93	1:1.38

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	62.59	78.91
Hydrogen	4.13	5.21
Oxygen and nitrogen	12.60	15.88
Sulphur	0.44	—
Ash	15.31	—
Hygroscopic water	4.93	—
	100.00	100.00

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories 5874
Indicated evaporative power .... 10.93 pounds of water (at 100 ° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a coherent but tender coke, the form of the original particles of coal from which it has been derived may be easily recognized; the gases evolved during coking burnt with a yellow, luminous, smoky flame. The ash has a reddish-brown color,—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a more or less vitrified mass.

29.—From the Old Man River, North Fork, one and a-half mile from the base of the Rocky Mountains. Seam five feet thick. Geological position—Cretaceous, lower than Pierre shales. Collected by Mr. R. G. McConnell. Coal from the Old Man River, North Fork.

Structure compact—lines of bedding somewhat indistinct; it contains a few thin layers of interstratified bright black coal; shows traces of slickensides; hard and firm; fracture uneven, that of the bright layers conchoidal; lustre sub-resinous to resinous; does not soil the fingers; in parts coated with a slight deposit of ferric hydrate; powder almost black; it communicates a brownish-yellow color to a boiling solution of caustic potash; resists exposure to the air.

Specific gravity 1.5299—Weight of one solid cubic foot 95.62 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	1.75	1.75
Volatile combustible matter	16.85	19.99
Fixed carbon	61.54	58.40
Ash	19.86	19.86
	100.00	100.00
Coke, per cent	81.40	78.26
Ratio of volatile combustible matter to fixed carbon	1:3.65	1:2.92

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	65.71	84.21
Hydrogen	3.56	4.56
Oxygen and nitrogen	8.76	11.23
Sulphur	0.36	—
Ash	19.86	—
Hygroscopic water	1.75	—
	100.00	100.00

Calorific power of.

Calorific power—determined by experiment:

Indicated power of fuel in calories 6082
Indicated evaporative power .... 11.32 pounds of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a coherent but tender coke, the form of the original particles of coal from which it has been derived may be easily recognized; the gases evolved during coking burnt with a yellow, luminous, rather smoky flame. The ash has a reddish-white color,—exposed to a bright red heat or even a most intense red heat it does not become agglutinated.

Coal from the Old Man River, Middle Fork.

30.—From the Old Man River, Middle Fork. Upper seam. Seam three feet thick. Geological position—probably Laramie. Collected by Dr. G. M. Dawson.

Structure very fine lamellar—the successive layers differing somewhat in lustre—compact; color black, but not pure black; lustre sub-resinous to resinous; fracture uneven; here and there intersected by a thin plate of calcite; does not soil the fingers; in parts coated with a slight deposit of ferric hydrate; hard and firm; powder black, slight brownish tinge; it communicates a pale brownish-yellow color to a boiling solution of caustic potash; resists exposure to the air.

Specific gravity 1.4316—Weight of one solid cubic foot 89.47 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	3.27	3.27
Volatile combustible matter	26.41	32.53
Fixed carbon	50.50	44.38
Ash	19.82	19.82
	100.00	100.00
Coke, per cent	70.32	64.20
Ratio of volatile combustible matter to fixed carbon	1:1.91	1:1.36

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	59.84	78.37
Hydrogen	4.17	5.46
Oxygen and nitrogen	12.35	16.17
Sulphur	0.55	—
Ash	19.82	—
Hygroscopic water	3.27	—
	100.00	100.00

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories 5980
Indicated evaporative power................11.13 pounds
of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a firm coke, a few particles retaining the form of those of the original coal were discernable in it; the gases evolved during coking burnt with a yellow, luminous, very smoky flame. The ash has a light bluish-grey color—exposed to a bright red heat it becomes but very slightly agglutinated, at a most intense red heat it becomes slightly fritted.

31.—From the Old Man River, Middle Fork. Lower seam. Seam about three feet thick. Geological position—probably Laramie. Collected by Dr. G. M. Dawson. Coal from the Old Man River, Middle Fork.

Structure compact; shows traces of slickensides; hard and firm; color black; lustre sub-resinous to resinous; fracture uneven, occasionally somewhat conchoidal; intersected by numerous thin plates of calcite; does not soil the fingers; powder brownish-black; it communicates only a just perceptible brownish-yellow tinge to a boiling solution of caustic potash; resists exposure to the air; in appearance it resembles some varieties of coal of the Carboniferous system.

Specific gravity 1.3111—Weight of one solid cubic foot 81.94 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	2.36	2.36
Volatile combustible matter	32.07	40.66
Fixed carbon	56.37	47.78
Ash	9.20	9.20
	100.00	100.00
Coke, per cent	65.57	56.98
Ratio of volatile combustible matter to fixed carbon	1:1.76	1:1.18

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	71.11	81.01
Hydrogen	5.04	5.74
Oxygen and Nitrogen	11.63	13.25
Sulphur	0.66	—
Ash	9.20	—
Hygroscopic water	2.36	—
	100.00	100.00

Calorific power of.

Calorific power—determined by experiment:

Indicated power of fuel in calories.......................7020
Indicated evaporative power................. 13.06 pounds
of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a firm compact coke, in concentric layers, in which the form of the particles of coal from which it has been derived is entirely obliterated; the gases evolved during coking burnt with a yellow, luminous, smoky flame. The ash has a pale dirty reddish-brown color,—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a slaggy mass.

Coal from the Upper Belly River.

32.—From the Upper Belly River, twenty-five and a-half miles above the mouth of Kootanie (Waterton) River. Seam one foot thick. Geological position—probably near marine base of Laramie. Collected by Mr. R. G. McConnell.

Structure fine lamellar, the lines of bedding are very close together and occasionally somewhat indistinct—it is interstratified with very thin layers of bright black coal, and contains here and there a patch of mineral charcoal; hard and firm; it is intersected by numerous thin plates of calcite, as also, here and there, by a few films of pyrite; color, greyish-black, almost black; lustre resinous; fracture uneven; shows tolerably well defined planes of cleat; apart from the patches of mineral charcoal, does not soil the fingers; powder brownish-black; it communicates a pale brownish-yellow color to a boiling solution of caustic potash; resists exposure to the air; in appearance it much resembles some varieties of coal of the Carboniferous system.

Specific gravity 1.3802—Weight of one solid cubic foot 86.26 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	3.91	3.91
Volatile combustible matter	30.93	38.01
Fixed carbon	53.83	46.75
Ash	11.33	11.33
	100.00	100.00
Coke, per cent	65.16	58.08
Ratio of volatile combustible matter to fixed carbon	1 : 1.74	1 : 1.23

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	66.19	80.15
Hydrogen	4.43	5.37
Oxygen and nitrogen	11.96	14.48
Sulphur	2.18	—
Ash	11.33	—
Hygroscopic water	3.91	—
	100.00	100.00

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories 6604
Indicated evaporative power .... 12.29 pounds of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a firm compact coke, in concentric layers, in which the form of the particles of coal from which it has been derived is entirely obliterated; the gases evolved during coking burnt with a yellow, luminous, smoky flame. The ash has a greyish-brown color,—exposed to a bright red heat it becomes slightly agglutinated, at a most intense red heat it forms a slaggy mass.

33.—From the Wellington mine, Vancouver Island, British Columbia. This mine is situated five and a-half miles north-west of Nanaimo and three miles west of Departure Bay. The seam, which is known as the Newcastle seam, has, in this mine a thickness of from six to ten feet. Geological position—Cretaceous. Coal from the "Wellington" mine, Vancouver Island.

Structure very fine lamellar, the lines of bedding, which are very numerous and close together, are almost obliterated—compact; color black; lustre resinous; hard and firm; fracture uneven; it is intersected in many places by thin films of calcite and contains, interstratified with it, an occasional thin calcareous layer consisting of what, at a first glance, appears to be the crushed fragments of somewhat minute shells—a close examination however led to the conclusion that the same was most probably not of organic origin. Powder brownish-black; it communicates only a just perceptible brownish-yellow tinge to a boiling solution of caustic potash; resists the action of the air. In appearance it resembles some varieties of coal of the Carboniferous system.

Specific gravity 1.3222—Weight of one solid cubic foot 82.64 pounds.

The material employed for analysis was regarded as a fair average of a large quantity of the coal.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	2 75	2.75
Volatile combustible matter	30.95	38.03
Fixed carbon	59.72	52.64
Ash	6.58	6.58
	100.00	100.00
Coke, per cent	66.30	59.22
Ratio of volatile combustible matter to fixed carbon	1:1.93	1:1.38

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	72.65	80.45
Hydrogen	4.89	5.41
Oxygen and nitrogen	12.77	14.14
Sulphur	0.36	—
Ash	6.58	—
Hygroscopic water	2.75	—
	100.00	100.00

Calorific power of.

Calorific power—determined by experiment:

Indicated power of fuel in calories.....7204

Indicated evaporative power.....13.41 pounds of water (at 100 ° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a firm compact coke, the form of the particles of coal from which it has been derived is perfectly obliterated; the gases evolved during coking burnt with a yellow, luminous, very smoky flame. The ash has a brownish-yellow color—exposed to a bright red heat, it does not become agglutinated, at a most intense red heat it becomes more or less fritted.

This coal is well known on the Pacific coast, and has the reputation of being of good quality both for steam and household purposes. Agreeably with the Report—for the year ending Dec. 31st, 1883—of the Minister of Mines for British Columbia, the output of coal from the Wellington Colliery for the twelve months ending Dec. 31st, 1883, amounted to 171,364 tons, 5 cwt., which with 2,443 tons, 2 cwt. coal in stock Jan. 1st, 1883, makes a total of 173,807 tons, 7 cwt., of this 47,333 tons were sold for home consumption and 124,748 tons, 15 cwt., were sold for exportation, leaving on hand Jan. 1st, 1884, 1,725 tons, 12 cwt.

The coal fields of Nanaimo and Comox, Vancouver Island, have been examined by Mr. J. Richardson and are described by him in his reports—Report of Progress 1876–77, p. 160 (and previous Reports of Progress)—information in regard to the same will also be found in the report of Dr. G. M. Dawson, Report of Progress 1876–77, p. 119.

34.—From the Pine River, five miles above the Lower Forks. Taken from the two-feet seam. Geological position—Cretaceous, Dunvegan Group. Collected by Dr. A. R. C. Selwyn, and referred to by him in the Report of Progress for 1875–76, p. 53, and by Dr. G. M. Dawson in Report of Progress for 1879–80, p. 117 B. Coal from the Pine River.

Structure very fine lamellar, the lines of bedding, which are very numerous and close together, are not unfrequently very indistinct or altogether obliterated—compact; color black; lustre of fracture parallel to the bedding dull, that of the cross fracture resinous, occasionally brilliant; hard and firm; fracture uneven; contains a brownish-yellow sub-transparent resin, chiefly in small particles, diffused through its substance; powder very dark brown, inclining to blackish-brown; it communicates only a just perceptible brownish-yellow tinge to a boiling solution of caustic potash; resists exposure to the air. In appearance it is not unlike some varieties of coal of the Carboniferous system.

Specific gravity 1.4169—Weight of one solid cubic foot 88.56 pounds.

Analyses by slow and fast coking gave: Analyses of.

	Slow coking.	Fast coking.
Hygroscopic water	2.45	2.45
Volatile combustible matter	27.87	33.76
Fixed carbon	54.58	48.69
Ash	15.10	15.10
	100.00	100 00
Coke, per cent	69.68	63.79
Ratio of volatile combustible matter to fixed carbon	1 : 1.96	1 : 1.44

Calorific power—determined by experiment: Calorific power of.

Indicated power of fuel in calories.................. 6295

Indicated evaporative power................11.72 pounds of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a firm, compact, and lustrous coke, the coking being doubtless materially influenced by the presence of the resin. Color of the ash, white—exposed to a bright red heat it does not become agglutinated, at a most intense red heat it becomes slightly sintered.

Coal from Mill Creek.

35.—From Mill Creek, about four miles above the mill. Seam eight to nine feet thick, with shaly partings. Geological position—Cretaceous or possibly Laramie. Collected by Dr. G. M. Dawson.

Structure fine lamellar; the specimen examined was made up of layers of a greyish-black, somewhat dull, and jet black coal of brilliant lustre—compact; fracture uneven, that of the brighter layers conchoidal; does not soil the fingers; hard and firm; powder black, with a faint brownish tinge; it communicates only a just perceptible brownish-yellow tinge to a boiling solution of caustic potash; in appearance it closely resembles some varieties of coal of the Carboniferous system.

Another specimen of this coal, had a somewhat coarse lamellar structure, contained an occasional interstratified layer of mineral charcoal, was of a uniform greyish-black color, had a sub-resinous to resinous lustre and showed traces of slickensides.

Specific gravity 1.4226—Weight of one solid cubic foot 88.91 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	1.63	1.63
Volatile combustible matter	22.61	28.43
Fixed carbon	63.39	57.57
Ash	12.37	12.37
	100.00	100.00
Coke, per cent.	75.76	69.94
Ratio of volatile combustible matter to fixed carbon	1 : 2.80	1 : 2.02

An ultimate analysis gave:

		Exclusive of sulphur, ash, and hygroscopic water.
Carbon	71.57	83.65
Hydrogen	4.05	4.73
Oxygen and nitrogen	9.94	11.62
Sulphur	0.44	—
Ash	12.37	—
Hygroscopic water	1.63	—
	100.00	100.00

Calorific power of.

Calorific power—determined by experiment:

Indicated power of fuel in calories 6604
Indicated evaporative power.................12.29 pounds of water (at 100° C.) per pound of fuel.

It yields—by slow coking, a non-coherent coke—by fast coking, a firm coke, a few particles retaining the form of those of the original coal were discernable in it; the gases evolved during coking burnt with a yellow, luminous, smoky flame. The ash has a greyish-white color—exposed to a bright red heat or even a most intense red heat it does not become agglutinated.

36.—Anthracitic coal—from Cascade River—two and three quarter miles from its confluence with the Bow—Bow River Pass, Rocky Mountains. Seam about twenty inches thick. Geological position —Cretaceous. Collected by Mr. E. Coste.

Anthracitic coal, Cascade River, Rocky Mountains.

The coal in this part of the seam—a point, apparently of exceptional disturbance—was found to be in a pulverulent condition.

An analysis by fast coking gave:

Analysis of.

Hygroscopic water	2.07
Volatile combustible matter	15.84
Fixed carbon	74.35
Ash	7.74
	100.00
Ratio of volatile combustible matter to fixed carbon	1:4.69

It yields a non-coherent coke. Color of the ash pale reddish-yellow. As far as chemical composition is concerned this is an excellent fuel, but, owing to its physical condition it could not well be used in its natural state—it might, however, be rendered available by converting it into artificial fuel by adding to it a certain proportion of ground pitch, and moulding the heated mixture, under pressure, into briquettes.

Mr. Coste also collected samples of coal from an outcrop which occurs on the same bank of the river, some four hundred and fifty yards distant—further down the stream—from that whence the succeeding specimen, No. 37, was taken. It has a crumpled flaky structure; shows slickensides; is firm; has a greyish-black to black color and a resinous to vitreous lustre; when fractured it parts into more or less flaky fragments. At present no analysis has been made of this specimen.

37.—Semi-anthracite—from Cascade River, Bow River Pass, Rocky Mountains.

Semi-anthracite, Cascade River, Rocky Mountains.

The locality in question was examined during the autumn of 1883, by Drs. A. R. C. Selwyn and G. M. Dawson, and was also subsequently visited by Mr. E. Coste, each of whom collected specimens. That brought by Dr. G. M. Dawson was the one selected for analysis, it was collected in such manner as to represent a fair average of the entire face of the seam—which at this point had a thickness of about four feet. Geological position—Cretaceous.

Structure very fine lamellar, the lines of bedding, which are numerous and close together, are almost obliterated, in many specimens entirely so—compact; shows slickensides, some specimens in an eminent degree; it contains interstratified, more or less disconnected, lenticular layers of pitch-black, highly lustrous coal in which no structure is visible, and an occasional patch of mineral charcoal; brittle; fracture, on the whole, uneven, that of the denser and more lustrous layers, imperfectly conchoidal; hard and firm; color greyish-black to black, varying with the layers, in parts iridescent; lustre resinous to vitreous; powder pure black; when heated it decrepitates, falling into small angular fragments.

Specific gravity 1.4272—Weight of one solid cubic foot 89.20 pounds.

Analyses of.

Analyses by slow and fast coking gave:

	Slow coking.	Fast coking.
Hygroscopic water	0.71	0.71
Volatile combustible matter	10.58	10.79
Fixed carbon	81.14	80.93
Ash	7.57	7.57
	100.00	100.00
Ratio of volatile combustible matter to fixed carbon	1:7.67	1:7.50

Calorific power of.

Calorific power—determined by experiment:

Indicated power of fuel in calories....................7852
Indicated evaporative power................14.62 pounds of water (at 100° C.) per pound of fuel.

It yields, in common with all anthracite,—both by slow and fast coking, a non-coherent coke; when heated in a covered crucible it evolves a small amount of pale yellow smokeless flame of feeble luminosity. It leaves a white ash, which does not agglutinate at a bright red heat, and at a most intense red heat becomes only slightly fritted.

The samples received, represent an excellent fuel—it does not disintegrate on exposure to the air, is sufficiently hard and firm to bear the abrasion incident to transportation, contains but a very small percentage of hygroscopic water, a by no means large amount of inorganic matter, and possesses a high evaporative power.

Prof. H. Darwin Rogers, in speaking of the semi-anthracites of Pennsylvania, says:

"The semi-anthracites crumble up or divide into small angular fragments more readily on the fire than less jointed hard anthracites; and this quality, inconvenient in some cases where the draught is feeble, by causing too dull a fire, is a real excellence wherever the draught can be regulated, and a sufficiently energetic one secured; for if only the additional influx of air is sufficient to overcome the increased friction consequent upon the increase of surface and multiplication of edges arising from the smallness of the lumps, these coals are found to engender almost as high a heat as the anthracites, while they can be made to burn both faster and more steadily. Their absolute efficiency for equal weights is perhaps a little less, proportioned to their smaller total quantity of carbon; but their actual efficiency in equal times is as great, or even greater, than that of the hard anthracites, by virtue of their superior quickness of consumption."

Remarks on Accompanying Tables.

Remarks on Tables I. and II.

Tables I. and II.—The numbers in the column preceding that of the locality, correspond with those employed to particularize the various specimens throughout the text. An asterisk is affixed to the number of those specimens of which ultimate analyses were made—the results of which are embodied in Table III. The calorific power was estimated by Thompson's calorimeter—the results are expressed in calories and as pounds of water evaporated per pound of fuel: the numbers in columns 1 and 2 are those indicated by the instrument: the numbers in columns 3 and 4 are obtained by deducting from the experimental results the heat units required to vaporise the hygroscopic water—the correction is in many instances but very trifling, it has nevertheless, for the sake of uniformity, been made throughout. In order to obtain a yet closer approximation to the truth, a further reduction has to be made for loss of heat incident upon the evaporation of the combined water: as the amount of this latter can only be learnt from an ultimate analysis, this correction can only be applied with exactitude in the case of those fuels of which ultimate analyses are given in Table III. On referring to this latter it will be seen,—under Calorific power II.—that the heat required for the conversion of the hygroscopic and combined water into vapor, results in a diminution of the evaporative power of one pound of the fuel which in the case of specimen

Remarks on Tables I. and II., cont.

Number	2 amounts to	0.35	lb.	Number	30 amounts to	0.16	lb.
"	22 "	0.27	"	"	31 "	0.15	"
"	26 "	0.23	"	"	32 "	0.16	"
"	28 "	0.18	"	"	33 "	0.15	"
"	29 "	0.11	"	"	35 "	0.11	"

By subtracting these amounts from the numbers given in column 2 (Table III.) of Calorific power I., we shall arrive at a very close approximation of the evaporative power of these fuels. Guided by a knowledge of the correction required in these instances it may perhaps be admissable to draw an inference as to the amount of correction to be applied in the case of those fuels of which no ultimate analyses were made, but which, in respect to general character, may be said to be represented by one or the other of those enumerated in Table III; allowing this,—the evaporative power of one pound of the fuel, as given in column 2 of Tables I. and II., of fuels numbers 4, 5, 6 and 8 should be reduced by, say, 0.35 lb.—that of numbers 11, 12 and 18 by 0.30 lb.—that of number 20 by 0.27 lb.—that of numbers 23, 24, 25 and 27 by 0.23 lb., and that of number 34 by 0.15 lb. of water.

Remarks on Table III.

Table III.—The specimens referred to in this Table, retain the numbers assigned them in Tables I. and II., and throughout the text.

Calorific power I.—Experimental—the figures given under this heading correspond with those of columns 1 and 2—calorific power—of Tables I. and II.

Calorific power II.—Theoretical—the theoretical calorific power under A is found by multiplying the percentages of carbon and disposable hydrogen (disregarding the sulphur) by their respective calorific powers; the sum of these two products is the number of heat units generated by the complete combustion of one unit of the fuel· Previous to calculating the combined water 1.25 has uniformly been deducted from the number indicating oxygen and nitrogen—upon the assumption that this approximately represents the percentage of nitrogen contained in these fuels. It represents the mean amount of nitrogen contained in some thirty fuels of similar age, embracing twelve lignite coals of Colorado (analyses referred by Prof. W. B. Potter to Mr. G. W. Riggs, Jr.), eight western lignites (U. S.—analyses by H. S. Munroe), eight coals from Vancouver Island (analyses quoted by Robert Brown), and two lignites from the North-west Territory (analyses by C. Tookey). The theoretical calorific power under B. is obtained by deducting from that under A. the heat units required to vaporise the hygroscopic and combined water—the figures under B. give therefore the closest approximation to the available heat.

TABLE I.—PROXIMATE ANALYSES OF COALS AND LIGNITES FROM THE NORTH-WEST TERRITORY.

Number of Specimen.	LOCALITY.	Specific Gravity.	Weight of one cubic foot—calculated from the Specific Gravity.	ANALYSIS BY SLOW COKING. Composition, per cent. Hygroscopic Water.	Volatile combustible matter.	Fixed Carbon.	Ash.	Ratio of Volatile to fixed combustible.	Percentage of Coke.	Character of the Coke.	ANALYSIS BY FAST COKING. Composition, per cent. Hygroscopic Water.	Volatile combustible matter.	Fixed Carbon.	Ash.	Ratio of Volatile to fixed combustible.	Percentage of Coke.	Character of the Coke.	COLOR OF THE ASH.	CALORIFIC POWER. EXPERIMENTAL. As recorded. 1 Expressed in calories.	2 Weight of water (at 100° C.) evaporated by 1 lb. of fuel.	After correction for hygroscopic water. 3 Expressed in calories.	4 Weight of water (at 100° C.) evaporated by 1 lb. of fuel.
1	Souris River, one mile west of La Roche Percée, at junction of Short Creek and Souris River.......	1.4168	88.55 lbs.	21.84	32.15	41.61	4.40	1:1.29	46.01	Non-coherent.	21.84	35.12	38.64	4.40	1:1.10	43.04	Non-coherent.	Brownish-yellow...........	undet.	undet.	....	....
2*	South Saskatchewan, south side, about ten miles above Medicine Hat. Lower seam.............	1.3972	87.32 "	16.82	29.54	46.34	7.30	1:1.57	53.64	do.	16.82	31.90	43.98	7.30	1:1.38	51.28	do.	Reddish-brown.............	5144	9.57 lbs.	5054	9.41 lbs.
3	South Saskatchewan, south side, about ten and a quarter miles above Medicine Hat. Lower seam.	1.3722	85.76 "	17.70	28.63	49.83	3.84	1:1.74	53.67	do.	17.70	29.90	48.56	3.84	1:1.62	52.40	do.	Dark reddish-brown.........	undet.	undet.	....	....
4	North Saskatchewan, right bank, about forty miles below the confluence of the Brazeau River......	1.4341	89.63 "	14.78	28.46	50.69	6.07	1:1.78	56.76	do.	14.78	30.48	48.67	6.07	1:1.59	54.74	do.	Pale brownish-yellow........	5289	9.84 lbs.	5210	9.70 lbs.
5	North Saskatchewan, right bank, a short distance below Fort Edmonton	1.4256	89.10 "	12.89	32.19	52.17	2.75	1:1.62	54.92	do.	12.89	33.79	50.57	2.75	1:1.49	53.32	do.	Dark brownish-yellow.......	5207	9.69 "	5138	9.57 "
6	Red Deer River, at the mouth of Arrowwood River.	1.4027	87.67 "	13.08	31.49	51.35	4.08	1:1.63	55.43	do.	13.08	34.50	48.34	4.08	1:1.40	52.42	do.	Reddish-brown	5347	9.95 "	5277	9.83 "
7	Red Deer River, two miles below the mouth of Arrowwood River	1.3929	87.06 "	14.20	30.92	51.21	3.67	1:1.66	54.88	do.	14.20	34.22	47.91	3.67	1:1.40	51.58	do.	Bright red.................	undet.	undet.	....	....
8	Red Deer River, about seven miles above Hunter's Hill..	1.4257	89.11 "	13.06	29.41	48.51	9.02	1:1.65	57.53	do.	13.06	33.75	44.17	9.02	1:1.30	53.19	do.	Brownish-yellow	5028	9.36 lbs.	4958	9.23 lbs.
9	Red Deer River, nine miles above Hunter's Hill...	undet.	....	13.63	31.31	41.81	13.25	1:1.33	55.06	do.	13.63	34.01	39.11	13.25	1:1.15	52.36	do.	Pale reddish-yellow	undet.	undet.	....	....
10	Red Deer River, thirteen miles above Hunter's Hill	1.4221	88.88 "	12.62	32.08	46.72	8.58	1:1.46	55.30	do.	12.62	35.99	42.81	8.58	1:1.19	51.39	do.	Pale dirty reddish-brown....	"	"	....	....
11	Bow River, Grassy Island.......................	1.4162	88.51 "	11.90	31.20	50.97	5.93	1:1.63	56.90	do.	11.90	35.02	47.15	5.93	1:1.34	53.08	do.	Bright red.................	5473	10.19 lbs.	5409	10.07 lbs.
12	Bow River, Blackfoot Crossing, six and a half miles east of old Blackfoot Agency buildings	1.3970	87.31 "	11.91	30.04	54.78	3.27	1:1.82	58.05	do.	11.91	33.25	51.57	3.27	1:1.55	54.84	do.	Yellowish-brown	5531	10.29 "	5467	10.18 "
13	Found in some parts of the seam from which the preceding specimen was taken	1.3850	...	12.31	29.82	55.75	2.12	1:1.87	57.87	do.	12.31	32.83	52.74	2.12	1:1.60	54.86	do.	Dark brownish-yellow.......	undet.	undet.	....	....
14	Bow River, south side, about four miles below Blackfoot Crossing	undet.	....	10.72	29.26	46.09	13.93	1:1.57	60.02	do.	10.72	32.63	42.72	13.93	1:1.31	56.65	do.	Reddish-white	"	"	....	....
15	Crowfoot Creek, four miles from its entry into Bow River..	undet.	....	11.25	31.98	50.85	5.92	1:1.59	56.77	do.	11.25	35.59	47.24	5.92	1:1.33	53.16	do.	Pale brownish-yellow.......	"	"	....	....
16	Bow River, Horse-shoe Bend..................	undet.	....	11.13	36.52	43.16	9.19	1:1.18	52.35	do.	11.13	38.75	40.93	9.19	1:1.06	50.12	do.	Dark brownish-red..........	"	"	....	....
17	Smoky River, five miles below the mouth of Little Smoky River	undet.	...	11.52	31.26	53.04	4.18	1:1.69	57.22	do.	11.52	34.83	49.47	4.18	1:1.42	53.65	Slightly fritted	Pale reddish-brown	"	"	....	....
18	Athabasca River, about fifty-five miles above the site of old Fort Assiniboine. Upper seam......	1.4423	90.14 "	11.47	28.96	50.92	8.65	1:1.76	59.57	do.	11.47	32.09	47.79	8.65	1:1.49	56.44	Non-coherent.	Light bluish-grey	5424	10.10 lbs.	5363	9.99 lbs.
19	Athabasca River, about fifty-five miles above the site of old Fort Assiniboine. Lower seam......	1.4387	89.92 "	10.58	29.29	53.69	6.44	1:1.83	60.13	do.	10.58	32.79	50.19	6.44	1:1.53	56.63	do.	Light grey.................	undet.	undet.	....	....
20	Milk River Ridge, northern side	1.5140	94.62 "	9.84	28.66	42.67	18.83	1:1.49	61.50	do.	9.84	31.92	39.41	18.83	1:1.23	58.24	do.	Greenish-grey..............	4980	9.27 lbs.	4927	9.17 lbs.
21	Pine River, Coal Brook, two and a half miles east of the Lower Forks	1.4217	88.86 "	7.83	30.55	55.75	5.87	1:1.82	61.62	do.	7.83	34.21	52.09	5.87	1:1.52	57.96	do.	Reddish-white..............	undet.	undet.	....	....

TABLE II.—PROXIMATE ANALYSES OF COALS AND LIGNITES FROM THE NORTH-WEST TERRIORY—*Continued.*

Number of Specimen.	LOCALITY.	Specific Gravity.	Weight of one cubic foot—calculated from the Specific Gravity.	ANALYSIS BY SLOW COKING.							ANALYSIS BY FAST COKING.							COLOR OF THE ASH.	CALORIFIC POWER. EXPERIMENTAL.			
				Composition, per cent.				Ratio of Volatile to fixed combustible.	Percentage of Coke.	Character of the Coke.	Composition, per cent.				Ratio of Volatile to fixed combustible.	Percentage of Coke.	Character of the Coke.		As recorded.		After correction for hygroscopic water.	
				Hygroscopic Water.	Volatile combustible matter.	Fixed Carbon.	Ash.				Hygroscopic Water.	Volatile combustible matter.	Fixed Carbon.	Ash.					1 Expressed in calories.	2 Weight of water (at 100° C.) evaporated by 1 lb. of fuel.	3 Expressed in calories.	4 Weight of water (at 100° C.) evaporated by 1 lb. of fuel.
22*	Belly River, five miles below the mouth of Little Bow River	1.3976	87.35 lbs.	9.18	30.66	53.31	6.85	1:1.74	60.16	Non-coherent.	9.18	34.97	49.00	6.85	1:1.40	55.85	Non-coherent.	Brownish-yellow	5821	10.84 lbs.	5772	10.75 lbs.
23	Highwood River, North Fork, five miles above Forks	1.4163	88.52 "	6.12	26.87	54.93	12.08	1:2.04	67.01	do.	6.12	31.92	49.88	12.08	1:1.56	61.96	Slightly fritted.	Reddish-grey	5980	11.13 "	5947	11.07 "
24	Highwood River, North Fork, one hundred yards from site whence preceding specimen was taken.	undet.	....	4.23	26.13	47.97	21.67	1:1.83	69.64	do.	4.23	31.06	43.04	21.67	1:1.38	64.71	do.	Light bluish-grey	5507	10.25 "	5485	10.21 "
25	Government Indian Farm, south of Pincher Creek, about one mile from farm buildings	1.3999	87.49 "	5.38	27.19	58.34	9.09	1:2.14	67.43	do.	5.38	33.19	52.34	9.09	1:1.58	61.43	do.	Pale reddish-brown	6241	11.62 "	6212	11.57 "
26*	Belly River, from the main seam at "Coal Banks."	1.3587	84.92 "	6.50	31.59	54.36	7.55	1:1.72	61.91	do.	6.50	38.04	47.91	7.55	1:1.26	55.46	do.	Brownish-yellow	6183	11.51 "	6148	11.45 "
27	St. Mary River, seven miles above its junction with the Belly River	1.3690	85.56 "	7.02	29.41	57.28	6.29	1:1.95	63.57	do.	7.02	36.47	50.22	6.29	1:1.38	56.51	do.	Reddish-brown	6295	11.72 "	6257	11.65 "
28*	Bow River, at Coal Creek, between Morley and Calgary	1.4002	87.51 "	4.93	27.22	52.54	15.31	1:1.93	67.85	Non-coherent.	4.93	33.55	46.21	15.31	1:1.38	61.52	Coherent but tender.	Reddish-brown	5874	10.93 "	5848	10.89 "
29*	Old Man River, North Fork, one and a half miles from the base of the Rocky Mountains	1.5299	95.62 "	1.75	16.85	61.54	19.86	1:3.65	81.40	do.	1.75	19.99	58.40	19.86	1:2.92	78.26	do.	Reddish-white	6082	11.32 "	6073	11.31 "
30*	Old Man River, Middle Fork, upper seam	1.4316	89.47 "	3.27	26.41	50.50	19.82	1:1.91	70.32	do.	3.27	32.53	44.38	19.82	1:1.36	64.20	Firm.	Light bluish-grey	5980	11.13 "	5963	11.10 "
31*	Old Man River, Middle Fork, lower seam	1.3111	81.94 "	2.36	32.07	56.37	9.20	1:1.76	65.57	do.	2.36	40.66	47.78	9.20	1:1.18	56.98	Firm and compact.	Pale dirty reddish-brown	7020	13.06 "	7007	13.05 "
32*	Upper Belly River, twenty-five and a half miles above the mouth of Kootanie River	1.3802	86.26 "	3.91	30.93	53.83	11.33	1:1.74	65.16	do.	3.91	38.01	46.75	11.33	1:1.23	58.08	do.	Greyish-brown	6604	12.29 "	6583	12.26 "
33*	Vancouver Island, British Columbia, "Wellington Mine," Newcastle seam	1.3222	82.64 "	2.75	30.95	59.72	6.58	1:1.93	66.30	do.	2.75	38.03	52.64	6.58	1:1.38	59.22	do.	Brownish-yellow	7204	13.41 "	7189	13.39 "
34	Pine River, five miles above the Lower Forks	1.4169	88.56 "	2.45	27.87	54.58	15.10	1:1.96	69.68	do.	2.45	33.76	48.69	15.10	1:1.44	63.79	do.	White	6295	11.72 "	6282	11.70 "
35*	Mill Creek, about four miles above the mill	1.4226	88.91 "	1.63	22.61	63.39	12.37	1.2.80	75.76	do.	1.63	28.43	57.57	12.37	1:2.02	69.94	Firm.	Greyish-white	6604	12.29 "	6596	12.28 "
36	Cascade River, two and three quarter miles from its confluence with the Bow, Bow River Pass, Rocky Mountains	undet.	....	....	....	....	....	....	....	....	2.07	15.84	74.35	7.74	1:4.69	82.09	Non-coherent.	Pale reddish-yellow	undet.	undet.	....	....
37	Cascade River, Bow River Pass, Rocky Mountains	1.4272	89.20 "	0.71	10.58	81.14	7.57	1:7.67	88.71	Non-coherent.	0.71	10.79	80.93	7.57	1:7.50	88.50	do.	White	7852	14.62 lbs.	....	....

TABLE III.—ULTIMATE ANALYSES OF COALS AND LIGNITES FROM THE NORTH-WEST TERRITORY.

No. of Specimen.	LOCALITY.	Composition, per Cent.						Calorific Power I. Experimental.		Calorific Power II. Theoretical.			
		Carbon.	Hydrogen.	Oxygen and Nitrogen.	Sulphur.	Ash.	Hygroscopic Water.	1 Expressed in calories.	2 Weight of Water (at 100° C.) evaporated by 1 lb. of fuel.	A Expressed in calories.	Weight of Water (at 100° C.) evaporated by 1 lb. of fuel.	B Expressed in calories.	Weight of Water (at 100° C.) evaporated by 1 lb. of fuel.
2	South Saskatchewan, south side, about ten miles above Medicine Hat—Lower seam......	54.35	3.34	17.52	0.67	7.30	16.82	5144	9.57 lbs.	4842	9.02 lbs.	4654	8.67 lbs.
22	Belly River, five miles below the mouth of Little Bow River...	62.39	3.99	16.82	0.77	6.85	9.18	5821	10.84 "	5744	10.70 "	5600	10.43 "
26	Belly River—from the main seam at "Coal Banks".......	65.30	4.30	15.65	0.70	7.55	6.50	6183	11.51 "	6137	11.43 "	6015	11.20 "
28	Bow River, at Coal Creek, between Morley and Calgary....	62.59	4.13	12.60	0.44	15.31	4.93	5874	10.93 "	5991	11.16 "	5896	10.98 "
29	Old Man River, North Fork, one and a-half miles from the base of the Rocky Mountains. ...	65.71	3.56	8.76	0.36	19.86	1.75	6082	11.32 "	6212	11.57 "	6157	11.46 "
30	Old Man River, Middle Fork, upper seam.................	59.84	4.17	12.35	0.55	19.82	3.27	5980	11.13 "	5793	10.79 "	5708	10.63 "
31	Old Man River, Middle Fork, lower seam................	71.11	5.04	11.63	0.66	9.20	2.36	7020	13.06 "	7038	13.11 "	6962	12.96 "
32	Upper Belly River, twenty-five and a-half miles above the mouth of Kootanie River....	66.19	4.43	11.96	2.18	11.33	3.91	6604	12.29 "	6413	11.94 "	6327	11.78 "
33	Vancouver Island, British Columbia, "Wellington Mine," Newcastle seam............	72.65	4.89	12.77	0.36	6.58	2.75	7204	13.41 "	7059	13.14 "	6974	12.99 "
35	Mill Creek, about four miles above the mill............	71.57	4.05	9.94	0.44	12.37	1.63	6604	12.29 "	6806	12.67 "	6745	12.56 "

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

FROM THE

LABORATORY OF THE SURVEY.

BY

G. CHRISTIAN HOFFMANN, F. Inst. Chem.,
Chemist and Mineralogist to the Survey.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.

1884.

Alfred R. C. Selwyn, Esq., LL.D., F.R.S., F.G.S.,

Director of the Geological and Natural History Survey of Canada.

Sir,—I beg to present herewith my report upon the work carried out in the Laboratory of this Survey during the past, and a portion of the present year.

Apart from the analyses and examinations here recorded, a very appreciable amount of work has been done, the nature of which was not deemed of sufficient general interest to merit insertion.

Such of the analyses and examinations as were conducted by Assistant Chemist, Mr. Frank D. Adams, have been duly credited to him, his name, in each instance, appearing in connection with the same. In justice to this gentleman, it should be mentioned, that his time has been about equally divided between chemical work and lithological investigations, including field work.

The investigation, in regard to the character and economic value of the coals and lignites of the North-West Territory, upon which I had entered at the time of writing my last report, has been completed—the results are embodied in accompanying Report M.

I have the honor to be,

Sir,

Your obedient servant,

G. CHRISTIAN HOFFMANN.

Ottawa, August 26, 1884.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

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LABORATORY OF THE SURVEY,

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BUILDING STONES.

1.—Dolomitic limestone—from Selkirk, Manitoba. Geological position—Cambro-Silurian. Color, white with a faint greyish or brownish tinge, with numerous patches of a light brown color—the stone, in consequence, presenting a blotched appearance. It has a close texture. Building stones. Dolomitic limestone. Selkirk, Manitoba.

Specific gravity, (temp. 60° F.) 2.7025. Weight of one cubic foot, (calculated from the specific gravity) 168.90 pounds.

Absorbing power —(the numbers represent the absorption obtained by the aid of the air-pump.)

Water absorbed, per cent., 3.471. Weight of water absorbed by one cubic foot of the rock, 5.86 pounds.

After drying at 100° C., its composition was found, by Mr. F. D. Adams, to be as follows :—

Carbonate of lime	82.612
Carbonate of magnesia	16.922
Ferric oxide and alumina	0.302
Silica (dissolved)	0.032
Insoluble matter	0.913
	100.781

2.—Dolomite—from Coboconk, Bexley, Victoria county, Ontario. This stone has a light greenish-grey color, is very fine-crystalline, and has a close and uniform texture. Dolomite. Coboconk, Ontario.

Building stones, cont.

Agreeably with the results of an analysis, conducted by Mr. F. D. Adams, it contains—after drying at 100° C.—

Carbonate of lime	50.745
Carbonate of magnesia	35.532
Insoluble matter	9.960

Sandstone. Curryville, New Brunswick

3.—Sandstone—from Curryville, Albert county, New Brunswick. Geological position—Carboniferous, Millstone Grit. This stone has a somewhat dark reddish-brown color, and is faintly striped with a darker shade of the same tint—is fine-grained and has a close and uniform texture.

Specific gravity, (temp. 60° F,) 2.7357. Weight of one cubic foot, (calculated from the specific gravity) 170.98 pounds.

Absorbing power—(the numbers represent the absorbtion obtained by the aid of the air-pump.)

Water absorbed, per cent., 3.901. Weight of water absorbed by one cubic foot of the rock, 6.67 pounds.

Sandstone. Lombardy, Ontario.

4.—Sandstone.—Locality—about nine miles above Smith's Falls and two miles from Lombardy, South Elmsley, Leeds county, Ontario. Geological position—Cambrian, Potsdam. Color, light grey, with a faint greenish tinge; it exhibits throughout blotches, of greater or less magnitude, of a pale reddish-brown color—is moderately fine-grained, and may, on the whole, be said to have a close texture.

Specific gravity, (temp. 60° F.) 2.5656. Weight of one cubic foot, (calculated from the specific gravity) 160.35 pounds.

Absorbing power—(the numbers represent the absorbtion obtained by the aid of the air-pump.)

Water absorbed, per cent., 3.138. Weight of water absorbed by one cubic foot of the rock, 5.03 pounds.

Sandstone. Newcastle, New Brunswick

5.—Sandstone—from Newcastle, Northumberland county, New Brunswick. Geological position—Carboniferous. The freshly fractured surface of this rock has a light brown color with a faint greenish tinge: color of a dressed surface, light ashy-brown.

Specific gravity, (temp. 60° F.) 2.6694. Weight of one cubic foot, (calculated from the specific gravity) 166.84 pounds.

Absorbing power—(the numbers represent the absorbtion obtained by the aid of the air-pump.)

Water absorbed, per cent., 7.126. Weight of water absorbed by one cubic foot of the rock, 11.89 pounds.

6.—For the purpose of comparison—in regard to absorbing power—with the foregoing stones, a specimen of the Ohio sandstone, known as "Amherst stone," was examined, and with the following results:— Building stones, cont. Sandstone. Ohio, U.S.A.

Specific gravity, (temp. 60° F.) 2.6598. Weight of one cubic foot, (calculated from the specific gravity) 166.24 pounds.

Absorbing power—(the numbers represent the absorbtion obtained by the aid of the air-pump.)

Water absorbed, per cent., 9.843. Weight of water absorbed by one cubic foot of the rock, 16.36 pounds.

COPPER ORES.

The two following determinations were carried out by Mr. F. D. Adams.

1.—From "Storm" or "Copper" Mountain, from outcrop four feet below the surface. Alberta Mining Company's location, Rocky Mountains, western part of the district of Alberta, North-West Territory. Copper ores. District of Alberta, North-West Territory.

It consisted of copper-glance, with green carbonate of copper and hydrated peroxide of iron, in association with quartz. It contained:—

Copper.............................. 23.27 per cent.

2.—From the mainland on the western side of Great Bras d'Or, opposite that part of Boularderie Island called Man of War Point, Victoria County, Nova Scotia. Victoria county, Nova Scotia.

The specimen consisted of copper-pyrites in a compact bluish gangue. It was found to contain:—

Copper.............................. 14.28 per cent.

GOLD AND SILVER ASSAYS.

Province of Nova Scotia.

1.—From the "St. Ann's Mountain Mine," opposite Englishtown, Cape Breton. Examined for Lieut.-Col. W. Bingham. Gold and Silver assays.

It consisted of a mixture of zinc-blende, tetrahedrite, galena, and copper-pyrites, in a gangue of greyish quartz, associated with a little finely disseminated calcite. It was found, by Mr. F. D. Adams, to contain:— Province of Nova Scotia.

Gold............ Trace.
Silver.......... 6.017 ounces to the ton of 2,000 lbs.

Gold and Silver asssays, cont.

Province of Prince Edward Island.

PROVINCE OF PRINCE EDWARD ISLAND.

Assays Nos. 2 to 5 inc. were conducted by Mr. F. D. Adams.

2.—From the Hughes and Peters, so-called, gold mine, Wolf Cape. Collected by Mr. R. W. Ells.

It consisted of a calcareous red conglomerate. Assays showed it to contain:—

Gold............ 0.044 ounce to the ton of 2,000 lbs.

3.—Another sample of this conglomerate was subsequently forwarded to the Survey for examination. The same was made up of specimens collected, in part at Wolf Cape and in part at a point about six miles north of the same. The sample weighed a little over twenty-seven and a-half pounds: the whole was reduced to powder and intimately mixed, in order to obtain a fair average sample. It was found to contain:—

Gold........................ Trace.

4.—The following two samples of sand were sent to the Survey for assay—they were stated to have come from township number seven, in the western part of the island.

Sample No. 1. A reddish highly quartzose sand. Weight of sample one pound fourteen and a quarter ounces. Assays showed it to contain:—

Gold.............	0.714 ounce to the ton of 2,000 lbs.			
Silver............	0.160	"	"	"

A portion of this sample was submitted to the panning process and the residue in the pan examined under the microscope. The gold was readily discernible in the form of minute thin shavings, or perhaps more correctly speaking raspings, having characteristic markings on their surface and sharp and frayed or jagged edges. It need scarcely be pointed out how highly improbable it is that gold—in the form here described—could naturally occur in a sand, all the component particles of which had, from constant attrition, been rounded off. There can be no doubt, but that the gold (with accompanying silver) found in this sample of sand was not originally present in the same, but had been introduced with fraudulent intent.

5.—Sample No. 2. Also a reddish, highly quartzose sand: but finer grained than the preceding. Weight of sample two pounds. Assays showed it to contain

Neither gold nor silver.

Gold and Silver assays, cont.

Province of New Brunswic

Province of New Brunswick.

Assays Nos. 6 to 12 inc. were conducted by Mr. F. D. Adams.

6.—From Albert County. Examined for E. B. Chandler, Esq.

A fine grained to compact, dark grey quartz, containing a large amount of finely disseminated iron-pyrites. It was found to contain :—

Gold............. Trace.
Silver............ 0.073 ounce to the ton of 2,000 lbs.

7.—From Alma, Albert County.

It consisted of specular iron-ore in a gangue of greyish translucent quartz : the former constituted about one-fifth of the whole. Weight of specimen one pound thirteen ounces. Assays showed it to contain :—

Gold...................... Trace.
Silver..................... Trace.

8.—From the same locality as the preceding.

Quartz stained with hydrated peroxide of iron : it contained a little chlorite and a small quantity of iron-pyrites. Weight of specimen thirteen ounces. It contained :—

Gold...................... Trace.
Silver..................... Trace.

9.—From New Ireland Road, Albert County.

Specular iron-ore in a gangue consisting of a greyish translucent quartz and a fine-granular, light-reddish colored mineral. (See under Miscellaneous Examinations No. 7). One fragment consisted of an impure serpentine. Weight of sample, one pound nine ounces.

It contained neither gold nor silver.

10.—From the farm of Mr. H. Turner, Rosevale, Albert County.

Consisted of a mixture, fine to coarse grained, of flesh-red colored felspar and a greyish translucent quartz, through which was disseminated a small amount of copper-pyrites. Weight of specimen, two pounds eleven ounces. It was found to contain :—

Gold............. Trace.
Silver............ 0.189 ounce to the ton of 2,000 lbs.

11.—From the same locality as the preceding.

A greenish colored, very fine grained, highly quartzose rock, in

Gold and Silver assays, cont.

places epidotic and chloritic,—traversed by small quartz veins, which latter contained a few specks of copper-pyrites.

It contained neither gold nor silver.

12.—From the north section of Alma.

A somewhat coarsely crystalline iron-pyrites. Weight of specimen, eleven and a half ounces.

It contained neither gold nor silver.

Province of Quebec.

Province of Quebec.

13.—From the eleventh lot of the fifth range of the township of Portland, county of Ottawa. Examined for Mr. J. C. Brennan.

It consisted of a coarsely crystalline galena in a gangue of white calcite. It was found, by Mr. F. D. Adams, to contain :—

Gold.............	Trace.
Silver............	0.548 ounce to the ton of 2,000 lbs.

Province of Ontario.

Assays Nos. 14 *to* 21 *inc. were conducted by Mr. F. D. Adams.*

Province of Ontario.

14.—This and the two following specimens were forwarded to the Survey for assay. They were stated to have come from the "Victoria Gold Mine," lot sixty-two of the thirteenth range of the township of Monteagle, North Hastings.

A greyish translucent quartz, associated with a small quantity of a chloritic mineral : the quartz, which was in parts coated with hydrated peroxide of iron, contained here and there a few visible specks of native gold. Weight of specimen, six ounces. It was found to contain :—

Gold...........	29.834 ounces to the ton of 2,000 lbs.
Silver..........	1.864 " " "

15.—Material said to have been obtained by the crushing and washing of one pound of rock. The specimen weighed only 1.5461 gram. It contained native gold in rounded grains, the associated matter appeared to consist principally of mispickel. Assay gave :—

Gold................................	16.406 per cent.
Silver..............................	0.133 "

16.—Also stated to have been obtained by the crushing and washing of one pound of rock. The specimen weighed but 0.9345 gram.

It contained :—

Gold and Silver assays, cont.

Province of Ontario, cont.

Gold	3.018 per cent.
Silver	0.107 "

17.—This and the four following specimens came from the "Highland Mine," which is situate twenty-eight miles north of Gun Flint Lake, on the International boundary. The nearest railway station accessible by water, with a few short portages, is Savanne, on the Canadian Pacific Railway.

A greyish-white translucent quartz, in parts coated with hydrated peroxide of iron. It contained here and there a little iron-pyrites and a small quantity of a grey sulph-arsenite of lead. Weight of specimen, one pound six ounces. It contained :—

Gold	Distinct trace.
Silver	0.076 ounce to the ton of 2,000 lbs.

18.—A greyish-white translucent quartz, containing a good deal of iron-pyrites: it was much stained with hydrated peroxide of iron. Weight of specimen, three pounds fourteen ounces. Assays gave :—

Gold	Distinct trace.
Silver	0.230 ounce to the ton of 2,000 lbs.

19.—A greyish translucent quartz, through which was disseminated a little copper-pyrites, iron-pyrites, and a very small quantity of galena. Weight of specimen, one pound thirteen ounces. It was found to contain :—

Gold	0.365 ounce to the ton of 2,000 lbs.
Silver	3.631 " " "

20.—A light to dark greyish quartz, carrying a little iron-pyrites, copper-pyrites and galena, and here and there strings of a chloritic mineral. A few specks of native gold were distinctly visible in some parts of this specimen. Weight of the specimen, four pounds four ounces. Assays gave :—

Gold	32.122 ounces to the ton of 2,000 lbs.
Silver	126.550 " " "

21.—A greyish translucent quartz, containing a good deal of disseminated iron-pyrites, with irregular bands of ferruginous dolomite mixed with quartz and a small amount of a chloritic mineral; these bands frequently hold much iron-pyrites. Weight of specimen, two pounds ten ounces. It contained :

Gold	Distinct trace.
Silver	0.160 ounce to the ton of 2,000 lbs.

Gold and Silver assays, cont.

District of Keewatin.

District of Keewatin.

With the exception of No. 22, all the specimens from this district were collected by Mr. Eugene Coste.

22.—From "Gates Ajar" on the Canadian Pacific Railway, between Lake Superior and Lake of the Woods.

A greyish translucent quartz—in parts stained with ferric hydrate—carrying a little iron-pyrites. The specimen, which consisted of numerous fragments, weighed twenty-four and three-quarter pounds. Assays, by Mr. F. D. Adams, showed

It to contain neither gold nor silver.

23.—"Pine Portage Mine" (shaft vein), ten miles south-east of Rat Portage. Lake of the Woods.

A faintly greyish-white translucent quartz, carrying small quantities of zinc-blende and copper-pyrites. The metallic sulphides constituted but a very small proportion of the whole. Weight of sample, a single fragment, two pounds three ounces. It was found to contain:—

Gold	12.775	ounces to the ton of 2,000 lbs.
Silver	20.416	" " "

24.—"Pine Portage Mine" (shaft vein), ten miles south-east of Rat Portage. Lake of the Woods.

A faintly greyish-white translucent quartz, associated with zinc-blende and containing, here and there, a little copper-pyrites. The metallic sulphides constituted about one-thirteenth, by weight, of the whole. The sample, a single fragment, weighed one pound ten ounces. It contained:—

Gold	9.683	ounces to the ton of 2,000 lbs.
Silver	8.925	" " "

25.—"Pine Portage Mine" (shaft vein), ten miles south-east of Rat Portage. Lake of the Woods.

A dark greenish schistose rock, intersected by numerous seams of calcite, and containing a good deal of iron-pyrites. The sample, which consisted of a single fragment, weighed two pounds nine ounces. Assays showed it to contain:—

Gold	Trace	
Silver	0.117	ounce to the ton of 2,000 lbs.

26.—"Pine Portage Mine" (bottom of the shaft; depth of shaft sixty-five feet), ten miles south-east of Rat Portage. Lake of the Woods.

A faintly greyish-white translucent quartz, associated with a dark green schist—the latter contained a good deal of iron-pyrites. Weight of sample, a single fragment, two pounds two ounces.

Gold and Silver assays, cont.

District of Keewatin, cont.

It contained neither gold nor silver.

27.—"Pine Portage Mine" (shaft vein), one mile from the bottom of Pine Portage Bay. Lake of the Woods.

A greyish-white translucent quartz, associated with a little coarse crystalline calcite, and containing, in parts, a trifling amount of iron-pyrites. Weight of sample, a single fragment, one pound one ounce. It was found to contain:—

Gold............	9.916 ounces to the ton of 2,000 lbs.
Silver...........	15.371 " " " "

28.—"Pine Portage Mine"—vein cutting shaft vein, outcropping on the hill south of the mine. Lake of the Woods.

A greyish translucent quartz, containing a very small quantity of pyrrhotite and a little copper-pyrites. The sample, a single fragment, weighed three pounds one ounce.

It contained neither gold nor silver.

29.—"Argyle Mine," south vein, shaft vein. Lake of the Woods.

A milky white quartz, containing in parts a little iron and copper-pyrites. The sample, which consisted of two fragments, weighed one pound seven ounces.

It contained neither gold nor silver.

30.—"Argyle Mine," vein near the mill—north vein, twenty-five miles south-west of Rat Portage. Lake of the Woods.

A white sub-translucent quartz, traversed, here and there, by thin seams of a dark green chloritic matter, and containing, in parts, a few specks of iron and copper-pyrites. The sample, which consisted of a single fragment, weighed one pound twelve ounces. It was found to contain:—

Gold.............	Trace.
Silver............	0.175 ounce to the ton of 2,000 lbs.

31.—"Argyle Mine," vein near the mill. Lake of the Woods.

A milky white quartz, associated with a somewhat dark greenish-grey schistose rock—the latter carrying a little iron-pyrites. Weight of sample, a single fragment, one pound two ounces. Assays showed it to contain:—

Gold............	0.641 ounce to the ton of 2,000 lbs.
Silver...........	0.058 " " "

Gold and Silver assays, cont.

District of Keewatin, cont.

32.—Maiden Island—small island three-quarters of a mile east of Heenan Point. Lake of the Woods.

The sample consisted of three fragments—the first, a greyish translucent quartz, associated with a small quantity of a greyish-green chloritic mineral, in parts coated with ferric hydrate, and containing, here and there, a little copper-pyrites—the second, a fragment of quartz much stained with ferric hydrate, contained in parts a little copper-pyrites—the third, a soft greyish-green schistose rock, associated with a little quartz, it was in parts coated with ferric hydrate, and contained, here and there, a little copper-pyrites. Weight of sample, two pounds fifteen ounces. It was found to contain :—

Gold.............	1.225 ounce to the ton of 2,000 lbs.
Silver............	0.175 " " "

33.—Canada Mining Company,—same vein as shaft vein of the "Winnipeg Consolidated Mine" (Assays Nos. 51, 52 and 53)—east of the shaft. Lake of the Woods.

A milky-white quartz, associated with a small quantity of a dark green chloritic mineral, and containing, in parts, a trifling amount of iron-pyrites. Weight of sample, a single fragment, one pound nine ounces.

It contained neither gold nor silver.

34.—Canada Mining Company—same vein as shaft vein of the "Winnipeg Consolidated Mine" (Assays Nos. 51, 53 and 55)—Lake of the Woods.

A dark grey quartzose rock, seamed with calcite—in parts coated with ferric hydrate and containing, here and there, a little pyrrhotite and copper-pyrites. The sample, which consisted of a single fragment, weighed two pounds eleven ounces.

It contained neither gold nor silver.

35.—Minnesabic Island (east vein), twelve miles south-east of Rat Portage. Lake of the Woods.

A greyish translucent quartz, associated with a little dark green chloritic matter and calcite, and containing, in parts, a small amount of copper-pyrites. The sample, a single fragment, weighed two pounds four ounces.

It contained neither gold nor silver.

36.—Minnesabic Island, south of "Winnipeg Consolidated Mine." Lake of the Woods.

A light to dark-greyish translucent quartz, carrying a little iron-pyrites. Weight of sample, a single fragment, one pound seven ounces. Gold and Silver assays, cont. District of Keewatin, cont.

It contained neither gold nor silver.

37.—"Woodchuck Mine," two miles west of "Argyle Mine," Clearwater Bay. Lake of the Woods.

A greyish translucent quartz, associated with a greenish chloritic rock and a little calcite. The sample, a single fragment, weighed one pound eight ounces.

It contained neither gold nor silver.

38.—East shore of Indian Bay, eight to ten miles south-east of Rat Portage. Lake of the Woods.

A dark-grey quartzose rock, for the most part thickly coated with ferric hydrate. Weight of sample, a single fragment, one pound five ounces.

It contained neither gold nor silver.

39.—Sultana lead (little vein), east shore of Indian Bay, eight to ten miles south-east of Rat Portage. Lake of the Woods.

A very fine grained greyish-white quartzite, holding, here and there, a few specks of pyrrhotite and iron-pyrites. The sample, a single fragment, weighed two pounds nine ounces. It was found to contain :—

Gold.............	0.992	ounce to the ton of	2,000 lbs.	
Silver............	0.467	"	"	"

40.—Sultana lead (big vein), east shore of Indian Bay, eight to ten miles south-east of Rat Portage. Lake of the Woods.

A greyish sub-translucent quartz, in parts coated with ferric hydrate. The sample, a single fragment, weighed two pounds one ounce.

It contained neither gold nor silver.

41.—G. Heenan Location—big copper lead, east outcrop—Hay Island. Lake of the Woods.

A dark green chloritic rock, through which was disseminated a very large amount of iron-pyrites. The sample, a single fragment, weighed eleven ounces. Assays showed it to contain :—

Gold..............	Traces.
Silver............	0.058 ounce to the ton of 2,000 lbs.

Gold and Silver assays, cont.

District of Keewatin, cont.

42.—G. Heenan Location—big copper lead, east outcrop—Hay Island. Lake of the Woods.

The samples consisted of two fragments—the one, a greenish-grey chloritic rock, associated with a little quartz and calcite, and containing a small quantity of iron-pyrites—the other, a greyish-white translucent quartz, associated with a coarse crystalline calcite, in parts stained with ferric hydrate and a little green carbonate of copper, and containing, here and there, a small amount of copper-pyrites. Weight of sample, two pounds twelve ounces.

It contained neither gold nor silver.

43.—G. Heenan Location—big copper lead, west outcrop—Hay Island. Lake of the Woods.

A faint greyish-white translucent quartz, associated with a coarse crystalline calcite and a greenish chloritic rock, and containing, in parts, a small quantity of copper-pyrites. The sample, a single fragment, weighed one pound eight ounces.

It contained neither gold nor silver.

44.—G. Heenan Location—shaft vein—Hay Island. Lake of the Woods.

A greyish translucent quartz, associated with a somewhat dark greenish-grey chloritic rock; it contained, in parts, a little iron-pyrites. Weight of sample, a single fragment, one pound eleven ounces.

It contained neither gold nor silver.

45.—Scottish Island, eight miles south of Rat Portage. Lake of the Woods.

Consisted almost exclusively of a fine crystalline iron-pyrites. The sample, which consisted of two fragments, weighed five pounds five ounces.

It contained neither gold nor silver.

This specimen was examined, by Mr. F. D. Adams, for nickel and cobalt; it contained traces of the latter.

46.—Copper Island, half a mile north-north-east of "Keewatin Mine." Lake of the Woods.

A somewhat dark-greenish schistose rock, associated with quartz: it contained, in parts, a little copper-pyrites. The sample, a single fragment, weighed one pound three ounces.

It contained neither gold nor silver.

47.—East shore of the Bay, east of Heenan Point, ten miles south-east of Rat Portage. Lake of the Woods. Gold and Silver assays, cont.

District of Keewatin, cont.

A greyish-white translucent quartz, in parts stained with ferric hydrate; it contained, here and there, a little copper-pyrites. Weight of sample, a single fragment, one pound five ounces.

It contained neither gold nor silver.

48.—"Keewatin Mine," west vein, eight to ten miles south-east of Rat Portage. Lake of the Woods.

A greyish-white to white translucent quartz, associated with iron-pyrites; it was in parts coated with ferric hydrate—the pyrites constituted rather more than one-half in bulk of the specimen. The sample, which consisted of a single fragment, weighed five pounds eleven ounces. It was found to contain:—

Gold	4.958 ounces	to the ton	of 2,000 lbs.
Silver	0.233 "	"	"

49.—"Keewatin Mine," west vein, eight to ten miles south-east of Rat Portage. Lake of the Woods.

A white quartz, in parts very much honeycombed; the cavities most probably at one time contained iron-pyrites, which has been removed by weathering: it was, here and there, stained with ferric hydrate, and contained a little iron-pyrites—minute specks of native gold were observed adhering to the walls of some of the cavities. The sample, a single fragment, weighed one pound three ounces. Assays showed it to contain:—

Gold	9.917 ounces	to the ton	of 2,000 lbs.
Silver	0.525 "	"	"

50.—"Keewatin Mine," east vein, eight to ten miles south-east of Rat Portage. Lake of the Woods.

A greyish, in parts milky-white, quartz, associated with a soft greyish-green chloritic rock; it contained a somewhat large amount of iron-pyrites. Weight of sample, a single fragment, four pounds seven ounces.

It contained neither gold nor silver.

51.—"Winnipeg Consolidated Mine," shaft vein. Lake of the Woods.

A greyish-green chloritic rock, in parts coated with ferric hydrate. The sample, a single fragment, weighed thirteen ounces.

It contained neither gold nor silver.

52.—"Winnipeg Consolidated Mine," shaft vein, east drift at the 80 feet level. Lake of the Woods.

Gold and Silver assays, cont.

District of Keewatin, cont.

A greyish translucent quartz, associated with a small quantity of a dark green chloritic mineral; it was, in parts, thickly coated with ferric hydrate, and contained a little copper-pyrites. The sample, which consisted of a single fragment, weighed one pound two ounces. Assays showed it to contain:—

Gold.............	2.567 ounces to the ton of 2,000 lbs.			
Silver............	0.466	"	"	"

53.—"Winnipeg Consolidated Mine," shaft vein, west drift at the 80 feet level. Lake of the Woods.

Quartz, associated with a somewhat dark-greenish chloritic rock and a small quantity of calcite; it contained a little copper-pyrites. The sample, a single fragment, weighed two pounds three ounces.

It contained neither gold nor silver.

54.—"Winnipeg Consolidated Mine," vein near the shore of the lake, north of shaft vein. Lake of the Woods.

A greyish translucent quartz, associated with a small quantity of chloritic matter; it contained a large amount of iron-pyrites, and was, in parts, thickly coated with ferric hydrate. Weight of sample, a single fragment, three pounds six ouncs.

It contained neither gold nor silver.

55.—"Winnipeg Consolidated Mine," vein near the shore of the lake, south of the shaft vein. Lake of the Woods.

Quartz, associated with a little chloritic matter; it contained, here and there, a little copper-pyrites, and was thickly coated with ferric hydrate. The sample, a single fragment, weighed ten ounces.

It contained neither gold nor silver.

56.—"Winnipeg Consolidated Mine," vein on the hill, south of shaft vein. Lake of the Woods.

A white translucent quartz, associated with a light green actinolite; it contained, here and there, a little pyrrhotite and copper-pyrites, and was, in parts, coated with ferric hydrate. The sample, which consisted of a single fragment, weighed one pound two ounces.

It contained neither gold nor silver.

57.—"Winnipeg Consolidated Mine," one and a-half mile east of the lake in the bush. Lake of the Woods.

A greyish-white to white translucent quartz, associated with a small quantity of a somewhat dark-greenish chloritic mineral, and containing a little copper-pyrites. Weight of the sample, a single fragment, one pound fifteen ounces. It was found to contain:— Gold and Silver assays, cont.

Gold............. Distinct traces.
Silver............ 0.233 ounce to the ton of 2,000 lbs.

58.—Lake of the Woods Mining Company,—vein two miles east of "Winnipeg Consolidated Mine."

A greyish translucent quartz, carrying iron-pyrites. Weight of sample, a single fragment, one pound fourteen ounces. It was found to contain:—

Gold............. Traces.
Silver............ 0.116 ounce to the ton of 2,000 lbs.

NORTH-WEST TERRITORY.

Assays Nos. 59 *to* 68 *inc. were conducted by Mr. F. D. Adams.*

59.—This and the five following specimens came from the Rocky Mountains, western part of the district of Alberta. North-West Territory.

This specimen consisted of a rusty quartz carrying galena, the latter in parts altered to carbonate of lead. The galena constituted but a small proportion of the whole. Weight of specimen, four and a-half ounces. Assays gave:—

Gold............. None.
Silver............ 2.246 ounces to the ton of 2,000 lbs.

60.—A white translucent quartz, associated with a small quantity of a ferruginous dolomite, and containing zinc-blende and galena. The metallic sulphides constituted but a very small proportion of the whole. Weight of specimen, ten ounces. It was found to contain:

Gold............. Traces.
Silver............ 0.467 ounce to the ton of 2,000 lbs.

61.—Consisted of quartz impregnated with a very finely crystalline pyrite. Weight of specimen, one and a quarter ounce.

It contained neither gold nor silver.

62.—A rusty quartz, associated with a little dolomite: it contained a very small quantity of finely disseminated pyrite. Weight of specimen, four and three-quarter ounces. Assays gave:—

Gold............. None.
Silver............ 0.269 ounce to the ton of 2,000 lbs.

63.—A white quartz, associated with a ferruginous dolomite.

It contained neither gold nor silver.

Gold and Silver assays, cont.

North-West Territory, cont.

64.—Copper-glance, in parts seamed and coated with green carbonate of copper, with a little quartz and dolomite, and here and there a speck of pyrite. Assays gave :—

Gold........................	None.
Silver........................	Traces.

65.—This and the three following specimens were taken from the locations of the "Alberta Mining Company," Rocky Mountains, western part of the district of Alberta.

From Twin Lakes: surface specimen, picked up back of the lode near the lake.

A somewhat finely crystalline galena, associated with a little iron-pyrites, in a gangue of dolomite and quartz; the metallic sulphides constituted but a small proportion of the whole. It was found to contain :—

Gold.............	None.
Silver............	0.510 ounces to the ton of 2,000 lbs.

66.—From "Storm" or "Copper" Mountain, from outcrop four feet below the surface.

It consisted of copper-glance, with green carbonate of copper and hydrated peroxide of iron, in association with quartz. It contained :—

Gold........................	None.
Silver........................	Traces.

The amount of copper in this specimen was also estimated; the results of the determination will be found given under Copper Ores, No. 1.

67.—From a vein running east and west on northern slope of "Storm" or "Copper" Mountain.

Consisted of an association of iron-pyrites with a little tetrahedrite, a small quantity of green carbonate of copper and some quartz.

It contained neither gold nor silver.

68.—From "Storm" or "Copper" Mountain, north side of summit, outcrop from thirty to forty feet wide.

It consisted almost exclusively of a hydrated peroxide of iron.

It contained neither gold nor silver.

Province of British Columbia.

Gold and Silver assays, cont.

69.—From Okanagon Lake.

Province of British Columbia.

A white translucent quartz, containing, here and there, minute scales of a pale golden-yellow colored mica; some of the fragments contained numerous small cavities; these and portions of the exterior were coated with hydrated peroxide of iron. Assays by Mr. F. D. Adams showed

It to contain neither gold nor silver.

MISCELLANEOUS EXAMINATIONS.

Miscellaneous examinations.

1.—Bog iron-ore—from the vicinity of the Brandon Hills, Manitoba. Examined for Mr. J. Holme.

Bog iron-ore, Manitoba.

The deposit is said to extend over an area of about forty acres and to have a thickness of about two feet: it is overlaid by from seven to twelve feet of soil. It contained:—

Metallic iron..................... 20.15 per cent.

2.—Micaceous iron-ore—from the farm of Mr. Robinson, which adjoins the Salmon River Indian Reserve, Richmond County, Nova Scotia. Examined for Mr. J. Morrison.

Micaceous iron-ore, Nova Scotia.

The specimen, which was supposed to represent a fair average of a large bulk of the ore, contained, apparently, a somewhat large amount of finely disseminated iron-pyrites. Analysis gave:

Sulphur........................ 2.963 per cent.

3.—Hematite.—A specimen of hematite from Sharbot Lake, county of Frontenac, Ontario,—examined for Mr. J. C. Brennan,—was found, by Mr. F. D. Adams, to contain:—

Hematite, Ontario.

Metallic iron..................... 50.13 per cent.

4.—Saline efflorescence—from the vicinity of the Bow River, North-West Territory. Precise locality and mode of occurrence not stated. A qualitative analysis, by Mr. F. D. Adams, showed it to contain:

Saline efflorescence, North-West Territory.

Potassa....................	A small quantity.
Soda........................	A rather small quantity.
Lime........................	A very small quantity.
Magnesia	A very large quantity.
Ferric oxide...............	A trace.
Alumina....................	A large quantity.
Sulphuric acid............	A very large quantity.
Chlorine....................	A trace.
Water	A very large quantity.
Insoluble (rock matter)....	A very small quantity.

Miscellaneous examinations, cont.

From this it will be seen that this material consists essentially of the hydrated sulphates of alumina and magnesia.

Saline residue from water of spring on bank of Clearwater River, North-West Territory.

5.—Saline residue—received from Dr. R. Bell. It was labelled, "Salt resulting from the evaporation of about five and a-half quarts of water of a spring situated on the north bank of the Clearwater River, about four miles below the Cascade Rapid, North-West Territory. From one-fifth to one-fourth more adhered to the kettle and was lost."

The contents of the package weighed 595 grains. The material had a dark ash-grey color, and contained numerous small fragments of charcoal, etc. Mr. F. D. Adams found it to contain:—

Potassa	A very small quantity.
Soda	A very large quantity.
Lime	A large quantity.
Magnesia	A large quantity.
Alumina	A very small quantity.
Ferric oxide	A very small quantity.
Sulphuric acid	A very large quantity.
Chlorine	A very large quantity.
Carbonic acid	A large quantity.
Insoluble residue	A small quantity.

Well water, Brandon, Manitoba.

6.—The following water was examined for Col. B. Chamberlain. It was labelled, "Water from shallow well on property north of Brandon, 12, xix, of R. D. Moodie."

This water when received had a most offensive odor, smelling strongly of sulphuretted hydrogen; on standing it deposited a large amount of sediment, consisting of a fine brownish-black calcareous mud. This having been filtered off, the clear water was found to contain, total dissolved solid matter—dried at 100° C.—267.9 grains to the imperial gallon. A qualitative analysis of the water showed the more important constituents of the dissolved solid matter to consist of:

Potassa and soda	A large quantity, soda predominating.
Lime	A large quantity.
Magnesia	A large quantity.
Sulphuric acid	A very large quantity.
Carbonic acid	A rather large quantity.
Chlorine	A rather small quantity.
Sulphuretted hydrogen	

The presence of the last-named is doubtless due to the reducing action of the organic matter on the sulphates, converting the latter into sulphurets, which in turn are decomposed by carbonic acid, giving rise to carbonates on the one hand, and sulphuretted hydrogen on the other.

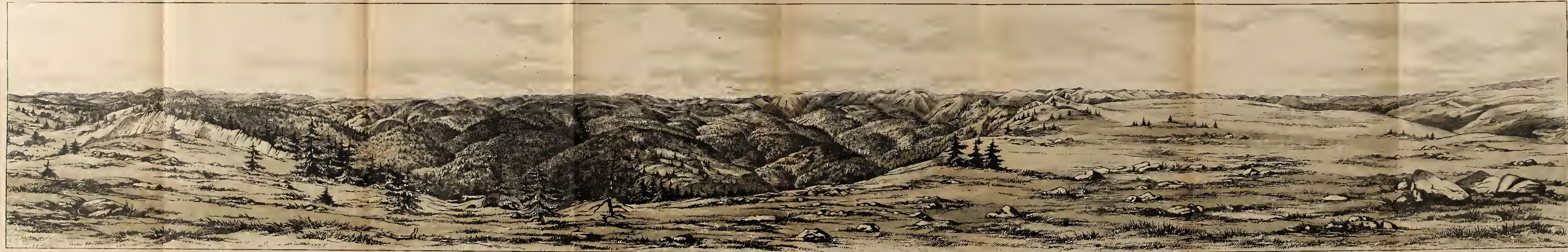
Miscellaneous examinations, cont.

The examination was conducted by Mr. F. D. Adams.

7.—Alunite.—The mineral referred to as constituting a portion of the gangue of the specimen of specular iron-ore from New Ireland Road, Albert county, New Brunswick—Assay No. 9—was examined by Mr. F. D. Adams, and found to have the chemical composition of alunite.

Alunite. Albert county, New Brunswick

NOTRE DAME OR SHICKSHOCK MOUNTAINS.



To illustrate Report of A. P. Low for 1883. Geological and Natural History Survey of Canada

NOTRE DAME OR SHICKSHOCK MOUNTAINS.

PENINSULA OF GASPE.

PANORAMIC VIEW FROM THE NORTH EAST PEAK OF MOUNT ALBERT—3560 FEET.

DRAWN BY L. LAMBE, FROM SKETCH BY A. P. LOW.

MAP

OF PART OF

ATHABASCA RIVER.


MAP
OF PART OF THE
ATHABASCA RIVER
To Illustrate
DR. R. BELL'S EXPLORATION.
Geological and Natural History Survey of Canada.
Alfred R. C. Selwyn LL.D. F.R.S. Director.
1884
GEOLOGICAL NOTES
BIRCH MOUNTAIN
LAKE ATHABASCA
Great Slave River

MAP

SHOWING WOODED AND PRAIRIE TRACTS, &c., IN THE REGION IN THE VICINITY OF THE

BOW AND BELLY RIVERS.

NOTES

[1] The generally wooded district ... the Rocky Mountains, with to the north, a considerable portion of the adjacent foot-hill country. Though described as generally wooded, this region is not continuously covered by forest, and different portions of it vary to a considerable degree in character. It is intended to designate, under this heading, all the country of which more than about one-half is woodland. The foot-hill portion of this district is interspersed with numerous small prairies and open glades, which generally occupy the valleys of the larger streams. In the mountains proper, the upper portions of the higher ranges and peaks rise above the limit of forest growth (which is at about 7000 feet), and many of those which do not reach this altitude are too rugged and bare about their summits to support forest. There are also along the valleys of the streams in that part of the mountains east of the main watershed range, frequent small meadows, and one or two considerable strips of country affording good pasturage. These last are indicated on the map.

The timber throughout this region varies much in character. There is a large proportion of good quality for the manufacture of lumber, but some of this is situated in localities which are very difficult of access. Fires have destroyed considerable tracts in many places, particularly in the vicinity of Sheep Creek, both within the mountains and in the foot-hills. Coniferous trees largely preponderate, the white spruce (*Picea Engelmanni*) and black pine (*Pinus Murrayana*—*P. contorta var latifolia*) covering the greatest areas, and frequently forming very dense forests. The first-named species frequently exceeds three feet in diameter of trunk, the second rarely reaches two feet. The Douglas fir (*Pseudotsuga Douglasii*) occurs in the foot-hills and on the lower portions of the valleys of the larger streams in the mountains. It reaches a considerable size, though not nearly equal to that attained by it on the west coast. The white-barked pine (*Pinus albicaulis*) occurs in a few places in the foot-hills and frequently toward the upper limit of forest in the mountains. It is a tree of small size. The balsam spruce (*Abies subalpina*) is abundant and attains a considerable size in the higher valleys and mountain slopes to the timber-line. The mountain larch (*Larix Lyallii*) is in some places moderately abundant but strictly alpine in habit, forming a fringe along the timber-line at about 7000 feet. The aspen poplar (*Populus tremuloides*) forms groves in many of the valleys in the mountains, and covers extensive tracts in some parts of the foot-hills. The cottonwoods (*Populus balsamifera* and *P. monilifera*), often fringe the larger streams in the mountains and foot-hills and frequently attain a large size. *Thuya gigantea* and *Pinus monticola*, found on the western slope of the Rocky Mountains and in the Selkirks—the former abundantly, the latter sparingly—were not observed in any part of the region covered by the present map.

[2] The district designated as partly wooded blends in most places so completely with the wooded country that it is difficult to draw any precise dividing line. In this region, while some tracts are thickly dotted with groves and copses—generally of aspen—others, (particularly in the Porcupine Hills) are characterized by a very open growth of Douglas fir. Toward its eastern margin, except in the river-valleys, groves of any considerable size are quite exceptional. The eastern line of this division is drawn where the swales and hollows cease altogether to hold thickets of aspen, or willow brush and the country becomes an open prairie. The river-valleys throughout this district are wooded. Cottonwoods (*Populus monilifera* with *P. angustifolia* and *P. balsamifera*) and aspen, with narrow fringes of white spruce and Douglas fir, occurring in such situations. The district is for the most part an excellent grazing country, with a long and luxuriant growth of grass, locally known as "bunch grass." Grass of this character—indicating a more abundant rain-fall than that met with further east—extends to a variable distance beyond the eastern edge of the partly wooded country. Its limit is approximately indicated by the dotted line. [3] Westward from this line, throughout the foot-hill country, the soil is generally composed to a considerable depth of vegetable mould. It is very fertile and susceptible of cultivation in many of the valleys and lower tracts.

[4] The character of that portion of the great plains included in the map is fully described in the accompanying report. These plains are covered almost everywhere by a short, thick growth of grass comprising a number of species, but locally known under the general name of "buffalo-grass." This affords nutritious pasturage at all seasons. In some places—owing to the dry character of the soil—the grass becomes thin and scanty. In the hollows, coulées and river-valleys—owing to the greater amount of moisture present—and on some of the "ridges" or plateaus, a longer growth of grass is found, and in the vicinity of the innumerable little lakes and sloughs which diversify the general surface, grass suitable for making hay frequently occurs. Of the lakes and sloughs above mentioned, a great number dry up completely before the end of the summer, and others are more or less saline, but many afford good water at all seasons.

These plains are absolutely treeless, the wood being confined strictly to portions of the valleys of the larger rivers. The cottonwoods (*Populus monilifera* with occasionally *P. angustifolia* and *P. balsamifera*) are the most abundant and characteristic of the trees occurring in these valleys, but the aspen and ash-leaved maple (*Negundo aceroides*) also appear. Near the western edge of this district a few isolated examples of coniferous trees are seen in parts of the valleys well sheltered from the sweep of fires. The shrubby growth of the valleys includes several species of willows, the western birch (*Betula occidentalis*) the choke-cherry (*Prunus Virginiana*), service-berry (*Amelanchier alnifolia*), snow-berry (*Symphoricarpus occidentalis*) buffalo-berry (*Shepherdia argentea*) several roses, the silver-berry (*Elæagnus argentea*) and in the south-eastern and drier portion of the district, the last-named species with sage (*Artemisia cana*) and grease-wood (*Sarcobatus vermiculatus*).

The soil throughout this district is generally good, and in many places excellent, consisting of a brown or gray loam (which passes in some cases into a sandy or clayey loam) overlain by a variable, though generally small, depth of dark vegetable mould. Over considerable tracts the vegetable mould is, however, almost entirely wanting, even where the soil is otherwise of very good quality.

GEOLOGICAL MAP
OF THE REGION IN THE VICINITY OF THE
BOW AND BELLY RIVERS.


GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA,
ALFRED R.C. SELWYN, LL.D., F.R.S. DIRECTOR.
GEOLOGICAL MAP
of the Region in the Vicinity of the
BOW AND BELLY RIVERS
Embracing the Southern portion of the District of Alberta and part of Assiniboia
NORTH WEST TERRITORY.
by
GEORGE M. DAWSON D.S., F.G.S., &c.
ASSISTED BY
R.G. McConnell B.A.
1884.
Scales
Geographical Miles
BRITISH COLUMBIA
ROCKY MOUNTAINS
PORCUPINE HILLS
MONTANA
SWEET GRASS HILLS OR THREE BUTTES
SECTION IN THE VICINITY OF THE LINE OF THE CANADIAN PACIFIC RAILWAY, FROM COAL CREEK ON THE BOW, TO MEDICINE HAT ON THE SOUTH SASKATCHEWAN.