This Report, and all other Publications of the Geological Survey, may be ordered from DAWSON BRO'S, *Montreal, or through any Bookseller in the Dominion.*

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SAMPSON, LOW & CO., 188 *Fleet Street, London.*

B. WESTERMANN & CO., 461 *Broadway, New York.*

GEOLOGICAL SURVEY OF CANADA.

REPORTS

OF

EXPLORATION AND SURVEYS.

1876-77.

GEOLOGICAL SURVEY OF CANADA,

MONTREAL, *April*, 1878.

The accompanying Reports, relating to the Surveys and Investigations of the Geological Corps during the season of 1876-77, are herewith transmitted by authority of Alfred R. C. Selwyn, Esq., F.R.S., Director of the Geological Survey, (now in Paris in connection with the representation of the Geological Survey in the International Exhibition,) to the Honourable David Mills, M.P., Minister of the Interior, for the information of His Excellency the Governor-General in Council.

J.B. Tyrrell

GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, F.R.S., F.G.S., DIRECTOR.

REPORT OF PROGRESS

FOR

1876-77.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

1878.

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Map No. XVI. will be ready for distribution in a few weeks.

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ILLUSTRATIONS.

MAPS.

ERRATA.

Page 4, line 4, *for* St. Jervais *read* St. Gervais.
" 7, line 2, *for* will be given in the next annual report *read* are given in this report.
" 117, *passim*, *for* Stickene *read* Stickeen.
" 122, foot note, *for* p. 85 et seq. *read* p, 35 et seq.
" 122, line 22, *for* 140,187 tons *read* 139,191 tons 15 cwt.
" 122, line 23, *for* 29,942 *read* 29,046 tons 15 cwt.
" 160, in title, *for* Cowichen *read* Cowitchen.
" 161, line 4, *for* Nanaimo *read* Nanoose.
" 162, line 16 from bottom, *for* 776 ft. 0 in. *read* 776 ft. 6 in.
" 162, line 14 from bottom, *for* 4,972 ft. 6 in. *read* 4,912 ft. 0 in.
" 163, lines 2 and 3, *for* and contains three coal seams, with an aggregate thickness of fifteen feet six inches, *read* with an aggregate thickness of one hundred and fifteen feet six inches, contains three coal seams.
" 163, line 10 from bottom, *for* Division 13 *read* Division B.
" 172, line 10, *after* fire clay *insert* †
" 281, line 16, *for* (2 and 3) *read* (2 and 4).
" 296, line 4, *for* Balwin *read* Baldwin.
" 307, *for*—*Cost of Mining and Transport of Apatite from Buckingham to Montreal and Portland.*—*read*—*Cost of Mining and Transport of Apatite from Buckingham and Portland to Montreal.*
" 322, line 6 from bottom, *for* Diggdeguash *read* Digdeguash.
" 328, line 22, *for* Monnaes *read* Moannes.
" 328, line 8 from bottom, *for* Dirorite *read* Diorite.
" 331, line 8, *for* Eanous *read* Cannouse.
" 331, lines 9 and 11, *for* Vanceborn *read* Vanceboro.
" 331, line 15, *for* St. Criox *read* St. Croix.
" 332, line 8, *for* Magadavic *read* Magaguadavic.
" 335, line 2, *for* L'Estang *read* L'Etang.
" 335, line 7 from bottom, *for* Lapreau *read* Lepreau.
" 337, line 3 from bottom, *for* Costal *read* Coastal.
" 338, line 2, *for* Costal *read* Coastal.
" 350, line 17, *for* Passumaquoddy *read* Passamoquoddy.
" 481, line 21, *for* 5,104 *read* 5·104.

Map facing p. 351. The arrow pointing across the map represents magnetic north, the line indicating true north should form an angle with it, to the east, of 20°.

SUMMARY REPORT

OF

GEOLOGICAL INVESTIGATIONS,

1876-77,

BY

ALFRED R. C. SELWYN, F.R.S., F.G.S.,

ADDRESSED TO

THE HONORABLE DAVID MILLS, M.P.,

MINISTER OF THE INTERIOR.

SIR,—In the report of the operations of the Geological corps, forming a volume of 432 pages royal 8vo, with maps and illustrations, which I had the honour to present last year, the details were given of the greater part of the work for the twelve months, ending the 30th of April, 1876.

Work at the Philadelphia Exhibition.

During the first seven months of the year, to which the present report relates, or from the 1st of May to the 31st of December, a large portion of my own time, and of that of several members of the staff, was occupied in connection with the Philadelphia Exhibition. The attendance at Philadelphia having been as follows:—

Mr. Selwyn	85 days
Dr. Harrington	28 "
Mr. Richardson	111 "
Mr. Bell	29 "
Mr. Weston	53 "
Mr. Webster	52 "

A further portion of time was likewise absorbed in the early part of the year in the preparation, and in attending to the printing of the descriptive catalogue of the Canadian Mineral Exhibits, a pamphlet of 150 pages royal 8vo, of which 4,000 copies were printed for distribution. Besides its use in connection with the exhibition, this catalogue will be of permanent value as a guide to the mineral resources of Canada.

Expenditure on Exhibition.

The total expenditure connected with the work of the Exhibition, including the printing of the catalogue above referred to, and paid through the Geological Department, was $11,235.15. A sum of $5,000.00 was placed at my disposal by the Canadian Commission, and $1,875.36 was provided jointly by the Canadian Commission and the British Columbia Advisory Board. The latter sum represents the total expenditure—the greater part of the freight excepted—on account of the British Columbia exhibits of all kinds, both manufactured and raw products.

These figures show a balance of $4,359.79, and this amount has been charged to the Geological Survey appropriation.

Collections exhibited.

Besides the stratigraphical collection of Canadian rocks and fossils, containing 1,074 specimens, the mineral and geological section contained 489 exhibits; 306 of these were contributed, either through the Geological Survey or directly, by 208 exhibitors, and the remainder were collected and exhibited by the Survey.

Medals awarded.

Forty-one medals were awarded by the International Judges, and twenty-eight by the British Judges in the special "Canadian competition," making a total of sixty-nine medals to exhibitors in this section. And the arrangement of the collection was universally commended as being the most perfect and instructive in the whole Exhibition. I may perhaps also quote in this connection the following passage from an article on the Geological Survey of Canada, in the July number of "Nature," page 235:—

"The Philadelphia Exhibition absorbed much of the time and thought which would otherwise have been expended on the field-work, laboratory and museum duties of the officers. But the Director need not regret this temporary suspension of the usual operations of his staff, for there can be no doubt that the display of rocks, minerals and fossils made by Canada at the Centennial Exhibition, so universally admired, brought the mineral resources of the Dominion, and the skill of its Geological Survey, before the world with such prominence as could hardly have been attained with the ablest maps and memoirs."

Reports and maps now printed.

In my last summary report it was stated that surveys and investigations had been continued in Ontario by Mr. H. G. Vennor, but that it was considered expedient to defer publishing in detail the conclusions arrived at until they had been further verified by more extended observations. Also, that Mr. James Richardson had completed the examination of the Nanaimo and Comox coal areas in Vancouver Island, and would be able to furnish a complete map and final report on these coal fields. During the past winter the reports and maps relating to the investigations above named have been prepared, and are now presented, together with others embracing the details of the labours of myself and colleagues for the twelve months ending 30th of April, 1877. From these it will be seen that the field work of the geological corps, notwithstanding the interruptions already mentioned, embraced several important explorations and surveys.

Surveys in British Columbia.

In British Columbia, Mr. G. M. Dawson examined a large tract of country between the Cascade Mountains and the Fraser River, including all the alternative routes through this region which have been recently surveyed for the Pacific Railway. Also, late in the autumn he made a hurried examination of the Nicola Valley coal fields, with the result of showing that the coal beds there probably extend over a very considerable area. He likewise visited the Cariboo gold fields, with a view of giving advice and information to persons interested in the development of the quartz reefs.

North shore of great lakes.

In Ontario, Mr. R. Bell made a minute examination of a portion of the eastern shores of Lake Superior, west of the Michipicoten River. A portion of the Valley of Garden River, and the country around Echo Lake, were likewise examined, as well as the vicinity of She-ba-o-na-ning and the whole of the north-east shore of Georgian Bay. A partial examination was also made of the country between Parry Sound and Lake Nipissing, and a reconnoissance of the region between the latter and the Ottawa River.

Ottawa region.

In the counties of Renfrew, Pontiac and Ottawa, a very large area was examined by Mr. H. G. Vennor, including measurements of nearly 1,150 miles required for geographical purposes, and for fixing the position of important bands of limestone.

Goderich salt boring.

Some exceedingly interesting and important explorations by deep boring with the diamond drill have been made during the year by Mr. Henry Attril, in the Goderich salt region. The cores which were brought up have been examined by Dr. T. Sterry Hunt, and he has kindly placed at my disposal, for publication with the reports of the survey for the year, a very valuable and interesting report on this deep boring, which he communicated in February last to a meeting of the American Institute of Mining Engineers in New York.

Eastern Townships.

In the Province of Quebec, a re-examination has been made of nearly 1,900 miles of country in the Eastern Townships, and fifty-two miles of section lines have been chained and levelled by Mr. A. Webster.

During the month of August—the only time that could be spared from other duties—I made a preliminary examination of the coast from Little Metis to River Pierre, on the Gulf of St. Lawrence, a distance of about 150 miles, with a view to ascertain from personal observation the true

Relations of Quebec group.

relations of the various members of the Quebec group to each other, and to the supposed Potsdam rocks of Bic, &c. And I think it can now be shown that the limestone conglomerates and associated graptolitic strata of Point Levis, the Island of Orleans, St. Jervais, Kamouraska, Bic, Little Metis, and Ste. Ann River are all at about the same horizon, and really belong to the Levis formation of the Quebec group; further, that the coarse sandstones ("Pillar sandstones" of the report of 1845, by Sir W. E. Logan) of the Light-house Point, at Little Metis, of Cape Chatte, Cape Whale and other points along the coast, hitherto supposed to belong to the Sillery formation, and to occupy a higher position than the Levis conglomerate limestones, are really beneath the latter, and constitute, probably, the lowest member of the fossiliferous portion of the Quebec group. And it would certainly appear that the fossils, supposed to be characteristic of the Potsdam period, found in the Bic conglomerates are in derived fragments, or else that we have in this region a mingling of the two faunas. A good deal more of careful investigation of the stratigraphy is, however, still required before the true structure can be finally determined. Progress will, it is hoped, be made in this investigation during the coming summer.

New Brunswick.

In New Brunswick, Mr. Ells, Prof. Bailey and Mr. G. F. Matthew have continued their explorations, chiefly in Albert and Westmorland Counties, including an examination of the celebrated Albertite mines, and a careful survey and examination of the Beliveau, Albertite and Oil Company's property, a special report on which has been furnished to the Directors. The examination has extended over 220 square miles of country, and 160 miles of roads and streams have been measured by odometer and chain.

Nova Scotia.

In Nova Scotia, Mr. Scott Barlow has continued the survey and examination of the Cumberland county coal region, including a line of section chained and levelled, from River Philip across the Cobequid mountains to the Basin of Mines, twenty-four and a-half miles in length. He has also made measurements for completing the map of the district, and for fixing accurately the limits of the formations, amounting to about 140 miles.

Cape Breton.

In Cape Breton, a combined geographical and geological examination and survey has been made of a part of the counties of Cape Breton, Victoria and Richmond, by Mr. Fletcher, who has also visited and examined several localities where discoveries of gold, copper and coal were reported to have been made.

In my last annual report I alluded to the interruption of the palæontological work, caused by the continued illness of Mr. Billings; within two months from that date his death followed, and the country has thus been deprived of the services of one who had for more than twenty years ably and efficiently fulfilled the duties of this important branch of the Geological Survey.

Death of Mr. Billings.

In July, Mr. J. F. Whiteaves, F.G.S., late Recording Secretary to the Montreal Natural History Society and Curator of the Society's Museum, was nominated to succeed Mr. Billings. He has since completed Part I., Vol. I., "Figures and Description of the Mesozoic Fossils of Canada," containing ten Plates, with ninety-two pages of descriptive matter, and a map. This has been published during the year, and forms a valuable and important addition to the literature of Canadian palæontology.

Appointment of Mr. Whiteaves.

During the winter careful examinations were made of the fossils collected in 1875 on the Upper and Lower Peace, Arthabaska and Clearwater Rivers, and likewise of those from the Matagami or south branch of Moose River, and the result has already been published in the Report of Progress for 1875–76.

Palæontological work.

A partial examination has also been made of the fossils collected by various members of the staff in 1876; especially of a most interesting series of Mesozoic fossils obtained by Mr. G. M. Dawson at Iltasyouco River, in British Columbia, showing that the altered Jurassic rocks of the Sierra Nevada extend northwards into the Cascade range of British Columbia.

The extensive collection made by Mr. James Richardson in the years 1871 to 1875, from the coal bearing rocks of Vancouver and the adjacent islands in the Gulf of Georgia, have also been carefully examined. The series comprises about one hundred species, mostly of mollusca, which will be described and figured in Part II., Vol. I., of "Canadian Mesozoic Fossils," of which a commencement has been made.

Mr. Whiteaves further states that he has made a preliminary examination of the contents of the cabinets and safe in the Curator's room; also of those of the drawers under the table cases in the Museum.

Museum,

About 200 boxes of fossils in the store room have been unpacked, and the specimens examined. These contained, for the most part, either duplicates of common species, or fragments of fossiliferous rock of no value. A few types of species described in the publications of the Survey, but which have not hitherto been exhibited, were, however, found. These have been mounted on tablets and labelled, and will shortly appear in their proper places in the Museum. All duplicates that could be used for school collections or exchange were separated, and a catalogue made of them. A large quantity of refuse material, the accumulation of many years, has been rejected, and the number of full boxes reduced to 180.

One hundred and eighty species from the Quebec group, in the Province of Quebec and in Newfoundland, have been identified, mounted on tablets, labelled and placed in the show cases. Many of these had never been exhibited, and those which had been were neither mounted or named. Beside the species above mentioned, about one hundred species of types described in the "Palæozoic Fossils of Canada," but not in the cases in the Museum, have been recognised, mounted and labelled ready for exhibition. The collection of Upper Silurian fossils made by Mr. Curry, at Port Daniel, in 1872, has been examined and classified, and the best specimens have been selected and mounted for subsequent study and exhibition. It is, of course, very desirable that one or more good examples of every species which has been described in the publications of the Survey should be found in the Museum cases, and this will, I hope, ere long be accomplished.

Additions to palæontological collections.

The most important additions to the palæontological collections during the year, are as follows :—

1. From the upper Peace River, collected in 1875 by Mr. Selwyn.	110	specimens.
2. From Lower Peace, Arthabaska and Clearwater Rivers, collected in 1875 by Mr. Macoun........................	65	"
3. From Iltasyouco River, B. C., collected by Mr. G. M. Dawson.	100	"
4. From Mattagami River, collected by Mr. Bell............	38	"

Other small collections have also been received from various members of the staff, the most important of which is one made by Mr. Fletcher in Cape Breton, which contains five or six species of Lower Silurian forms. This, with the exception of the *Eophyton* found by myself at the Ovens in 1870,* is the first recorded discovery of undoubted Lower Silurian fossils in Nova Scotia.

Chemical investigations.

The work in the laboratory has included determinations of iron, copper, silver, lead and gold, in specimens from British Columbia and from the Lakes Superior and Huron regions, as well as from Quebec and Nova Scotia. In addition to the ores examined, specimens of coal, apatite, pyrites, limestone, dolomite and several minerals and rocks of scientific interest have been analysed, and the results are given in the report of Dr. Harrington now submitted.

The investigation of Canadian graphites, mentioned on page 419 of last

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* Report of Progress, Geological Survey of Canada, 1870-1871, pages 260, 271.

year's report, has been continued by Mr. C. Hoffmann, and the full results will be given in the next annual report.

Stratigraphical collection of rocks.

In the Museum, some improvements have been made, and considerable time has been devoted to labelling, numbering and preparing specimens. A new counter case, corresponding with those already in the Museum, has been placed in room No. 4, in the brick wing. This case is thirty-two feet long, and contains twenty-seven drawers and ten glass show cases. It is proposed to exhibit in this room a complete stratigraphical collection of rocks. The specimens will be all as nearly as possible of the uniform size of three by four inches, and will include examples of all the formations that have been recognised in the Dominion, from Cape Breton to Vancouver Island. Of the more interesting of the crystalline rocks, slices will be made for microscopic study, in order that their characters may be accurately determined and described. More than 1,000 specimens have already been prepared, and 500 have been placed in the cases.

In view of the probable establishment in the Dominion, at some future time, of a general National Museum, it has been deemed advisable to utilize the resources of the Survey as much as possible in obtaining specimens from other countries in exchange. A few valuable specimens were secured in this way at Philadelphia, while others have been promised, and it is hoped that the forthcoming Universal Exhibition in Paris will afford a favourable opportunity for further action in this direction.

Collections supplied.

A number of applications for collections have been received from educational and scientific institutions and individuals, and a total of 2,246 specimens (minerals and rocks) have been prepared and distributed as per list below, in compliance with these requests:

1. Geological Survey of North Carolina, Raleigh, U. S.
2. University of New Brunswick, Fredricton, N. B.
3. Albert University, Belleville. O.
4. Educational Department, Toronto, O., twelve sets, of fifty specimens each.
5. College de Ste. Therese, Q.
6. Ecole Normal de Jacques Cartier, Montreal, Q.
7. Seminaire de Nicolet, Q.
8. Central School, Galt, O.
9. Polytechnic School, Montreal.
10· Ontario School of Agriculture.
11. The Institute of American Mining Engineers., Philadelphia, U. S.
12. The Central Park Museum, New York, U. S.
13. The Academy of Sciences, Philadelphia, U. S.
14. Geological Survey of Italy, Genoa.

15. Smithsonian Institute, Washington, D. C., U. S.
16. Naturalists Club, Belleville, O.
17. Japanese Commissioner at Philadelphia.
18. Albert J. Hill, C.E., Nova Scotia.
19. John De Lamater, Millford, Del., U. S.
20. T. A. McLean, Toronto, O.
21. W. E. Morris, Perth, O.
22. Earl of Cavan, Ireland.
23. Geological Museum, Wellington, New Zealand.

Visitors to Museum.

From the 1st of May, 1876, to the 30th of April, 1877, 1,652 names have been registered in the visitors book.

A larger number than usual of valuable reports and publications, a list of which is appended, have been presented during the year to the library, in return for those of the Survey, of which 694 copies have been distributed during the twelve months ending 30th of April, 1877.

I have the honour to be,
Sir,
Your obedient servant,
ALFRED R. C. SELWYN.

Geological Survey Office,
Montreal, *May*, 1877.

ADDITIONS TO THE LIBRARY,

From 1st MAY, 1876, to 30th APRIL, 1877.

BY PRESENTATION.

Royal Society, London:—

Proceedings	Vol.	XXIII.,	No.	159-63
"	"	XXIV.,	"	164-70
"	"	XXV.,	"	1871-78

Manchester Geological Society:—

Transactions	Vol. XIV., Part 4-7

Royal Society of Edinburgh:—

Proceedings	Vol.	VIII.,	Sessions	1873-74
"	"	"	"	1874-75
Transactions	"	XXVII., Part 2,	"	1873-74

Philosophical Society of Glasgow:—

Proceedings				6 Nos.,	1841-48
"	Vol.	III.,	No.	1—6,	1848-55
"	"	IV.,	"	1—2,	1855-60
"	"	V.,	"	1—4,	1860-64
"	"	VI.,	"	1—4,	1864-68
"	"	VII.,	"	1—3,	1868-71
"	"	VIII.,	"	1—2,	1871-73
"	"	IX.,	"	1—2,	1873-75

Institution of Engineers and Ship Builders in Scotland:—

Transactions	Twentieth Session, 1876-77

Geological Survey of India.—Thomas Oldham, LL.D., Director:—

Palæontologia Indica,	Vol.	I-II.,	Series	9—2
" "	"	I-III.,	"	9—3
" "	"	I-IV.,	"	9—4
Records	"	VIII.,	Part	1—4
"	"	IX.,	"	1

Department of Mines, Nova Scotia:—

Report	1876

Nova Scotian Institute of Natural Science:—

Proceedings and Transactions	Vol. II.,	Part	2,	1867-68
" " "	" II.,	"	3,	1868-69
" " "	" II.,	"	4,	1869-70
" " "	" IV.,	"	1—2,	1875-76

Geological Survey of Newfoundland.—Alexander Murray, F.G.S., Director :—

Report of Progress 1875.

Department of Marine and Fisheries, Ottawa :—

Report on the Meterological, Magnetic and other Observations of the Dominion of Canada, for the Calendar Year ending 31st December, 1875.

Department of the Interior, Ottawa :—

Annual Report of the Department of the Interior, for the Year ending 1876.

Department of Public Works, Ottawa :—

General Report of the Minister of Public Works, for the Fiscal Year ending 30th June, 1876.

Map (three sheets) of part of the North-West Territory, including the Province of Manitoba. J. Johnston, Chief Draughtsman.

Canadian Pacific Railway,—Description of Route.

Board of Agriculture, Ottawa :—

Recensment du Canada, Vol. IV.

W. H. Bailey, F.L.S., Dublin :—

Figures of Characteristic British Fossils, with descriptive remarks, Part IV.

Report on Fossils from the upper old Red Sandstone of Kiltorcan Hill, in the County of Kilkenny, No. I.

United States Geological Survey of the Territories. Dr. F. V. Hayden, United States Geologist :—

A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country; by F. B. Meek.

A Monograph of the Geometrid Moths of the United States, Vol. IX.; by A. S. Packard Jr., M.D.

Meterological Observations made during the year 1873 and the early part of the year 1874, in Colorado and Montana Territories; by George B. Chittenden.

Sketch of the Origin and Progress of the United States Geological and Geographical Survey of the Territories, by F. V. Hayden.

Bulletin............................Vol. III., No. 1, 2, 3.
" National Museum......No. 3, by J. H. Kidder, M.D.
" " ..... " 4, " George N. Lawrence.
" " ..... " 5, " Geo. Brown Goode.

Catalogue of the Publications of the U. S. Geological and Geographical Survey of the Territories; by F. V. Hayden.

Drainage Map of Colorado.

Walter P. Jenny, E.M. :—

The Mineral Wealth, Climate and Rainfall, and Natural Resources of the Black Hills of Dakota.

J. W. Powell, Washington :—

Report of the Geology of the Eastern portion of the Uinta Mountains and a Region of Country adjacent thereto, with Atlas. One vol. 4to.

Geological Survey of Illinois :—A. H. Worthen, Director :—

The Natural History of Illinois, Bulletin No. 1.

Geological Survey of Ohio.—Prof. J. S. Newberry, Chief Geologist :—

Report of the Geological Survey of Ohio, Vol. II., Part 2, Palæontology.

Ohio State Board of Agriculture :—

Twenty-ninth Annual Report, 1874.

Geological Survey of Pennsylvania.—Prof. J. P. Leslie, State Geologist :—

Report of Progress in the District of York and Adams Counties, 1874; by Persifor Frazer, Jr.

Report of Progress in the Green and Washington District, 1875; by J. J. Stevenson.

Measured Sections of the Palæozoic Formations in Middle Pennsylvania; by Charles A. Ashburner.

Geological Survey of New Jersey.—Geo. H. Cooke, State Geologist :—

Annual Report of the State Geologist of New Jersey, for the year 1876.

Catalogue of the Centennial Exhibit of the Geological Survey of New Jersey, 1876.

State Board of Agriculture, New Jersey :—

Third and Fourth Annual Report, 1875-6.

Geological Survey of Wisconsin.—T. C. Chamberlin, Chief Geologist :—

Annual Report of Progress and Results of the Wisconsin Geological Survey for the year 1876.

The State of Wisconsin, embracing Brief Sketches of its History, Position, Resources and Industries, and a Catalogue of its Exhibits at the Centennial at Philadelphia, 1876.

Geological Survey of New Hampshire.—C. H. Hitchcock, Chief Geologist :—

Report of Progress, 1870-2.

An Extract from Vol. II. of the Final Report upon the Geology of New Hampshire; by C. H. Hitchcock.

Geological Survey of Alabama.—Eugene A. Smith, Ph. D., State Geologist :—

Report of Progress for 1876.

Prof. N. H. Winchell, M.A., State Geologist of Minnesota :—

Bulletin of the Minnesota Academy of Natural Sciences for 1874.

Geological Report on the Black Hills; by Prof. N. H. Winchell.

Essex Institute, Salem :—

Bulletin of the Essex Institute. Vol. VII., 1875.

New York State Museum of Natural History.—James Hall, LL.D., Director :—

Fifty-seventh Annual Report of the Trustees of the New York State Library, 1874.

Boston Society of Natural History :—

Proceedings....Vol. XVIII., Part 3—4,
Memoirs...... " II., " 2, No. 4

Engineer Department United States Army, Washington:—

Report upon Geographical and Geological Explorations and Surveys West of the One Hundreth Meridan, in charge of First Lieut. Geo. M. Wheeler. Vol III., Geology. Vol IV., Part 1, Palæontology.

Harvard College, Cambridge, Mass., U. S.:—

Memoirs.................Vol. II., No. 9
" .... " IV., " 10
Bulletin .... " III., " 15—16
Annual Report of the Trustees of Harvard College........1876

American Philosophical Society, Philadelphia:—

Proceedings..............Vol. XV., No. 96
" .... " XVI., " 97—8

The American Association for the Advancement of Science, Salem, Mass.:—

Proceedings Twenty-third Meeting...Vol. XXIII., 1874
Memoirs.......................... " I., "

American Geographical Society of New York:—

Journal.................Vol. IV.
Bulletin.................No. 1, Session of 1875-6
" .... " 2 and 3, " " 1876-7

Astor Library, City of New York:—

Annual Report of the Trustees, 1876.

United States Coast Survey, Washington:—

Report of Progress of the Survey..........5 vols., 1869-73

Department of State, Washington:—

Reports of the Commissioners of the United States to the International Exhibition held at Vienna in 1873..........4 vols., 1—4.

Academy of Science of St. Louis:—

Transactions....................Vol. III., No. 3.

United States Naval Observatory, Washington:—

Instruments and Publications....................1845-76

New Zealand Institute.—James Hector, M.D., F.R.S.:—

Reports of Geological Explorations...............1870-2
The Official Hand-book of New Zealand.
Critical List of Mollusca of New Zealand.
Meteorological Report............................1869-72
Museum and Laboratory Report..................1873-6
Transactions and Proceedings..........8 Vols., 1—8.
Catalogue of the Marine Mollusca.
" " Land Mollusca.
" " Birds of New Zealand.
" " Tertiary Mollusca and Echinodermata.
" " Echinodermata.
" " Fishes of New Zealand.

Geological Survey of Victoria, Australia :—

Lectures delivered during the Autumn Session of 1871.

Official Record................................1872-3.

Official Catalogue of Exhibits, Essays, &c., Centennial Exhibition..............................1876.

Mining Surveyors and Registrars, Victoria, Australia :—

Reports ....1875-6.

Department of Mines, New South Wales, Sydney :—

Annual Report for the year 1875.

Mines and Mineral Statistics ; by the Rev. W. B. Clarke and Prof. Liversidge.

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Regions
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Acknowledgments are due to the gentlemen engaged on the Canadian

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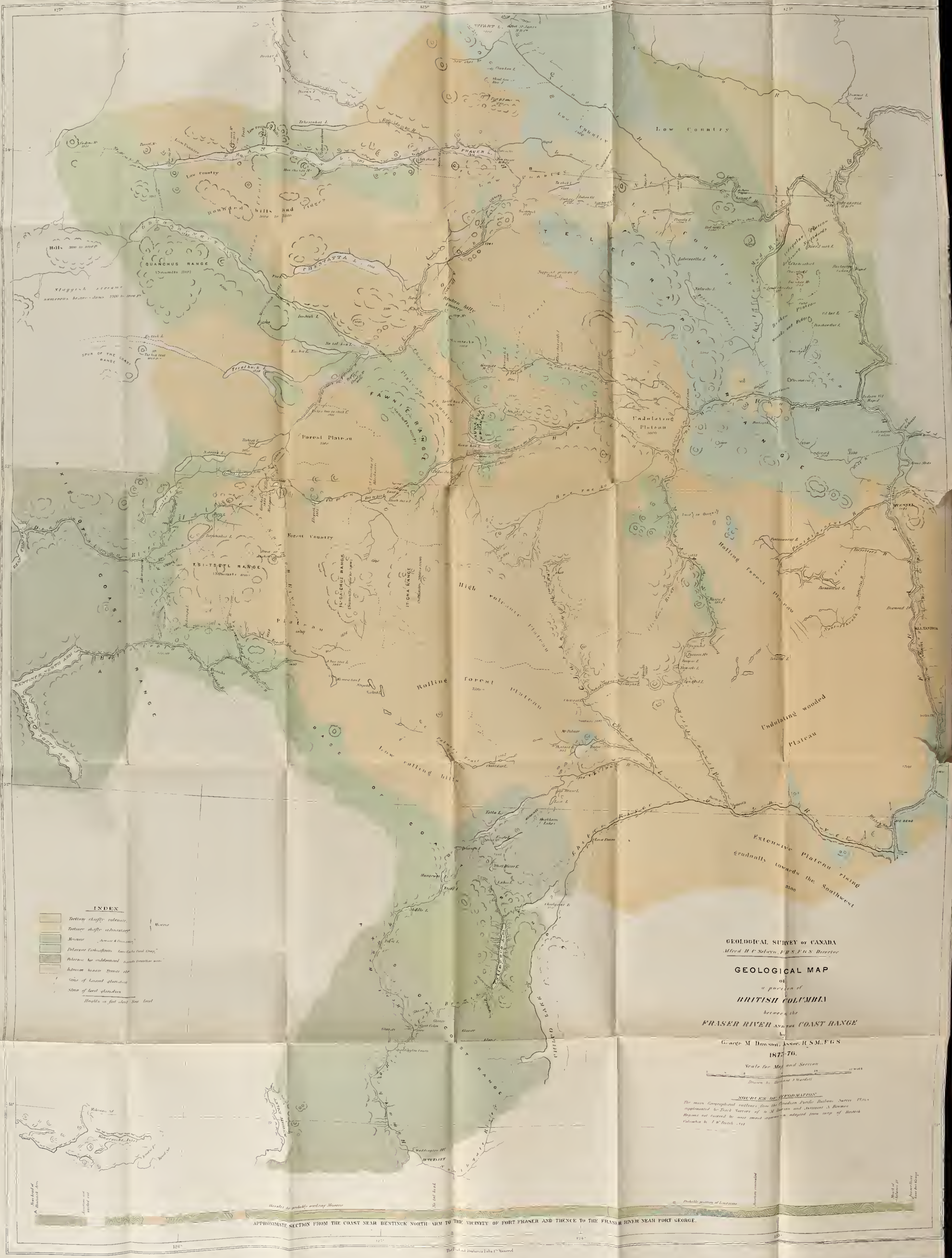

GEOLOGICAL SURVEY of CANADA
Alfred R. C. Selwyn, F.R.S., F.G.S. Director

GEOLOGICAL MAP
of
a portion of
BRITISH COLUMBIA
between the
FRASER RIVER** and the **COAST RANGE
by
George M. Dawson, Assoc. R.S.M., F.G.S.
1875-76.

Scale for Map and Section

Drawn by Bernard J. Wardell

SOURCES OF INFORMATION

The main Geographical outlines from the Canadian Pacific Railway Survey Plans supplemented by Track Surveys of G. M. Dawson and Assistant A. Bowman. Regions not covered by more recent information adapted from map of British Columbia by J. W. Trutch

The Burland Desbarats Lith. Co. Montreal

REPORT

ON

EXPLORATIONS IN BRITISH COLUMBIA,

Chiefly in the Basins of the Blackwater, Salmon, and Nechacco Rivers, and on François Lake,

BY

GEORGE M. DAWSON, Assoc. R.S.M., F.G.S.,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Regions examined during the season.

In April last, as soon as the weather permitted, regular field work was begun by the preliminary examination of the country in the vicinity of Leech River, Vancouver Island. A short visit, for which opportunity offered, was then made to Bute Inlet, and on the 19th of May I left Victoria for the interior of British Columbia, where the greater part of the summer was spent. The routes followed, and particular localities examined are described in the following pages. In conformity with instructions received, attention was devoted to the area between the Fraser River and the Coast Range, to the east and west, the Bella Coola Valley, and François Lake, to the south and north. In this country various lines were in course of examination as possible railway routes, and it also formed a natural extension of that in which the reconnoissance work of the summer of 1875 was carried on.

Short excursions were made late in the autumn to the Cariboo region and to the Nicola Coal Basin. Some results of these, with other details of purely economic interest, have been published as *Appendix R* in the lately issued General Report on the Canadian Pacific Railway Surveys, and appear again in a revised form in connection with the present report.

Acknowledgments.

Acknowledgments are due to the gentlemen engaged on the Canadian

Pacific Railway Survey, for their uniform courtesy in furnishing transport, supplies, &c., even in cases where doing so might have entailed some inconvenience to themselves. During the season's work on the mainland, I was ably assisted by Mr. Amos Bowman, to whom my thanks are due, as well as to Professor Macoun and Dr. G. Engelmann, who have since aided in determining some of the botanical specimens collected.

With the exception of incidental references in connection with the general description of the country, the superficial geology, including the history of the glacial period and its deposits, is not treated of in this report, the time at present at command being insufficient for that purpose.

True bearings.

The bearings given throughout this report are with reference to the true meridian.

Spelling of Indian names.

(In the Indian names of places, where a conventional mode of spelling has not become too firmly fixed by long usage or previous publication, the orthography of the Smithsonian Standard Vocabulary has been followed as closely as possible without the use of special type; *oo*, however, being sounded as in "pool." The words thus spelt according to pronunciation are divided into syllables by hyphens.)

General Description of Country, and Routes Travelled.

Vegetation at Quesnel.

From Quesnel to Blackwater Bridge.—In approaching Quesnel from the south, many of the plants of the dry regions of the interior plateau disappear, and are replaced by others suited to a moister climate. In conjunction with this, it is found that grain may be grown without irrigation at this place, and northward. On the 28th and 29th of May of last year, the service-berry (*Amelanchier Canadensis*), the high bush cranberry (*Viburnum pauciflorum*), and wood violet (*Viola Canadensis*) were found in full flower. The wild strawberry (*Fragaria Virginiana*) still showed many blossoms; and the floral bracts of the pigeon-berry (*Cornus Canadensis*) were beginning to whiten. The berries of *Shepherdia Canadensis* were formed, though small.

Benches.

On leaving the river bank opposite Quesnel, the trail gradually ascends over broken ground, due to former slides affecting the edges of the terraces with which the river valley is fringed. The two best marked of these are elevated 150 and 560 feet respectively above the flood level of the Fraser; the last named again appears at an elevation of 100 feet above the stream called West River, ten miles from Quesnel. The

Plateau between Quesnel and Blackwater.

general level of the plateau is here about 850 feet above the Fraser, or 2,550 feet above the sea. On its surface terrace-flats cease to appear, and are replaced by low rolling hills and hillocks, formed of boulder clay, here a hard, partly arenaceous material of pale fawn colour, charged with rolled pebbles and boulders of very various origin, but for the most part of rocks which may be attributed to the Lower Cache Creek series. Basalt is not seen in place on the part of the plateau over which the trail passes, but in boulders is pretty abundant where the plateau-level is first reached, on leaving the Fraser Valley. In some places the low drift hills show a very general tendency to north and south arrangement of their longer axes, and in one locality a small rocky hill, projecting through the thick drift covering, was seen with a fan-shaped mound of detrital matter on its south side. A range of low hills rising above the plateau to the south-west of the trail, appears to run with a general course of N. 55° W. The summits may stand 500 feet above the general level. On reaching Goose or Herkyelthtie Lake,—half way from Quesnel to Blackwater Bridge,—this range breaks down, and an irregularly hilly and rolling country stretches westward. The lake is about 1,050 feet above the Fraser. Beyond Goose Lake a rather extensive gently undulating terrace-plateau, with an average elevation of 1,012 feet above Quesnel, or 2,706* above the sea, was noted. The material of this plateau and that covering the surface of the country generally is boulder clay of the type above described, which, though implying water deposit, is in some places so much broken into mounds and ridges as to suggest moraines. In a few miles the range to the west again becomes pretty well defined, and with the same height as at first, runs parallel with the trail at an average distance of about three miles, but separated from it by a broad valley which holds a chain of small lakes, with wide swampy meadows. From the northern brink of the Blackwater Valley a very extensive view is gained, showing the north-western continuation of this,—the Telegraph Range,—and the lower country toward Fort George.

Effect of forest fires.

Fires have passed extensively and often over the country between Quesnel and Blackwater, destroying the original thick growth of western scrub pine (*P. contorta*), and Douglas fir (*Abies Douglasii*), and in some places, over considerable areas, almost completely removing the wind-fall. Small alders, aspens and scattered scrub-pines come up on these burnt areas, with grass which, though sometimes wiry and "sour," is often of good quality and mixed with wild pea and vetch. It is evident

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* The height of the flat on which Quesnel is built being, by a simultaneous series of barometer observations there, and on an instrumentally levelled line 1,694 feet.

that the destruction of the forest has led to the desiccation of the soil, some places which it had been necessary to corduruoy when the trail was originally made, being now quite hard. The vegetation on the plateau is appreciably behind that at Quesnel, the difference being most apparent when elevations above 2,000 feet are reached. The only land fit for cultivation is within a few miles of Quesnel, and that lying beyond the immediate valley of the Fraser is very limited in area.

Height of Blackwater River.

The valley of the Blackwater near the bridge, with its wonderfully terraced sides, has been described in a former report (1875-76, p. 244.) The height of the river itself above the sea, brought down by barometer from the nearest bench-mark on Mr. Bell's location line of 1875, is 2,170 feet.

Bella Coola Trail.

Blackwater Bridge to Eu-chen-i-ko River, &c.—On the northern brink of the Blackwater Valley, the so-called Bella Coola Trail leaves the well-beaten Telegraph Trail, and following the Blackwater River and its tributaries till those of the Salmon River are reached, leads eventually to the Salmon House near the head of Dean Channel, and the Indian villages on the Bella Coola River, discharging into Bentinck Arm. This trail appears, from the markings on the trees and other circumstances, to be a very old one, and indeed, we know from Sir A. Mackenzie's narrative of his journey to the Pacific Ocean, that it was in constant use at the time of his visit (1793). He speaks of it as a well-beaten path, and it has probably been for a long time one of the great trading roads between the coast and inland tribes. Like all the other Indian trails in the northern part of British Columbia, since the great reduction of the Indian population by small pox, it has become in many places much encumbered with windfall.

Eu-chen-i-ko and Na-tan-i-ko.

Five miles from Blackwater Bridge, the trail leaves the river bank, and continuing westward, crosses the Telegraph Range north of the Upper Cañon, and at about twenty miles from the Bridge reaches the Na-tan-i-ko and Is-cul-taes-li or Eu-chen-i-ko Rivers near their junction, four miles from the Blackwater, which here bends far to the south. This part of the route has been already described in my report for 1875.

From the western slope of the Telegraph Range, an extensive view is obtained up the low valley of the Eu-chen-i-ko, and a belt of low country, which, I believe, extends north-westward to the Nechacco. About the junction of these two streams a wide sandy flat occurs, with an average elevation of about 2,750 feet. The Eu-chen-i-ko, when in flood, is a stream about sixty feet wide, and where rapid can not be forded; the Na-tan-i-ko may carry about one-third as much water. These streams do not depend for their supply on melting snow, and consequently, even when full, are clear, though the water has a brownish tint. They rise early in the season, and like all the streams supplied by swamps and lakes, fall to their summer level, while those with sources in the mountains are still carrying their maximum amount of water. The Eu-chen-i-ko Valley holds many small lakes and lake-like expansions, some of which open into the river or form a part of its course, while others are steep-sided and separated from the stream by flat-topped mounds. Three large lakes occur as expansions of the river in the part of its length which has been explored. The first I have not seen; the second, Tas-un-tlat, eighteen miles up the river from its junction with the Blackwater, is about six miles in length, with an elevation of about 2,970 feet, and holds many long islands produced by gravel ridges like those above mentioned, but not distinctly flat-topped. The ridges in both cases appear probably to be moraines, but at the lower levels must have been somewhat modified by nearly contemporaneous water action. Five miles beyond Tas-un-tlat is Klun-chat-is tli Lake, a mile and three-quarters long, with an elevation of 3,070 feet. Near the west end of this lake, Tai-uk Brook joins the Eu-chen-i-ko from the south-west; a stream, which on the sixth of June, with a very rapid current, had a width of about ten feet, with a depth of twelve inches. This stream we were obliged to follow in our exploration, the river valley continuing with much the same aspect that it had heretofore presented, with a general bearing of N. 42° W. The Indians described to me as existing in the valley, at the distance of about a day's journey beyond this point, some remarkably coloured rocks, from which steam or smoke ascends in winter. This may very probably be a case of the spontaneous combustion of a lignite bed, like that described in the Report for 1875 as occurring at Quesnel.

Lakes on Eu-chen-i-ko.

Probable existence of lignite.

The portion of the Eu-chen-i-ko Valley followed, has a general course of N. 65° W. To the north it is bounded by rising and hilly ground, forming part of, or flanking the Telegraph Range. Hills appear on its southern side within a few miles of its junction with the Na-tan-i-ko, and continue to increase in height and width north-westward. In some places they may rise from 1,000 to 1,500 feet above the river. The valley is wide and flat-bottomed, and while its southern side is thickly timbered, except in certain spots where fires have run, the northern, with a considerable portion of the flat ground along the river, is generally open, and presents a very attractive appearance, being covered with bunch-grass, with patches of wild onions and occasional tufts of sage (*Arte-*

Character of Eu-chen-i-ko Valley.

misia frigida.) There is little arable land in the valley, but a considerable area fitted for stock ranges. On the 5th of June the young grass was showing well above the dead tops of the old, while small patches which had been burnt over were vivid green. An Indian who is in the habit of wintering a few horses here, cuts a stack of hay for their use in the autumn, and does not trouble himself further about them till the spring.

Vegetation.

Where sandy beaches occur, the scrub pine invariably forms groves, in which many of the trees were here observed to be dead and dying from the effect of the parasitic *Arcuthobium*, which hangs upon them in masses. The river is generally fringed with dark groves of tall symmetrical black spruces (*Abies Englemanni*), while small poplars characterize the slopes. This valley may be taken as a type of many which intersect the northern part of the interior plateau, of which most are probably yet unknown, but which must in the aggregate represent a great area capable of feeding cattle and horses. On ascending to the higher plateaus or low hills bordering the valley, the surface is found to be composed of the boulder clay, generally stony, and either covered with thick forests of the scrub pine, with windfall, or the young growth succeeding fires. Where the timber has been pretty thoroughly burnt over, by the passage of a fire, killing the original forest, followed by the uprooting of the dead trees by wind, and then by one or more subsequent fires among the prostrate timber, fair grazing is frequently found, and in many places grass, with pea, vetch and other nutritious plants come up in great abundance.

Tai-uk stream.

Following the Tai-uk stream for eight miles, its source is found in Choo-tan-li Lake, at an elevation of 3,600 feet. The valley of the stream is narrow, and slopes upward more rapidly than the general surface of the country gains in elevation, so that on reaching the lake one appears to be at about the level of the plateau. The Kuy-a-Kuz Mountains, rising to the west, showed large patches of snow on their summits at this date (June 7th).

It is on the north-western continuation of this range that Fawnie or Toot-i-ai Mountain is developed.

Terraces.

Terraces are well displayed in the Eu-chen-i-ko Valley, at heights estimated near Tas-un-tlat Lake at forty, 100, and 250 feet above the stream. The highest of these would have an elevation of about 3,280 feet above the sea. Near the Tai-uk stream terraces 3,400 to 3,500 feet above the sea are found.

In travelling from Choo-tan-li Lake southward to the Blackwater River, a part of the very obscure and almost disused Indian trail, from

Country between Choo-tan-li and Blackwater.

To-tuk Lake towards Cluscus was followed. The country passed over is a succession of ridges, running more or less regularly in east and west bearings, separated by hollows with swamps and lakes. Their elevation varies from 4,200 to about 4,500 feet, and their northern slopes are densely covered with forests of tall straight black spruce, mingled with balsam spruce (*Abies lesiocarpa*) resting on a peaty and mossy soil, on which patches of snow were found lying in the deep shade of the trees on the seventh of June. The southern slopes are more openly wooded, but here tangled and almost impenetrable windfalls occur. On this high country the rock is seldom seen, there being apparently a great thickness of drift. Very large boulders are scattered over the surface in many places.

The Blackwater Valley.

Valley of the Blackwater north of the Cluscus Lakes.—This part of the Blackwater Valley, like most of its length between this place and the bridge at the Lower Cañon, has much resemblance to that of the Eu-chen-i-ko above described, but is on a larger scale. The north slope is generally bare, or but lightly tree-clad, with bunch-grass, wild onions, bearberry, vetch, strawberry and *Galium boreale*, while thickets of willows and dwarf-birch (*Betula glandulosa*) fringe the stream. The south bank presents a somewhat similar assemblage of plants, but is much more thickly timbered, with scrub pine and poplar, and occasional groves of black spruce. The appearance of the river valley is pleasing, and there is abundance of good grazing for animals, which the winter snows can not be deep enough entirely to cover, as the Indians of Cluscus Lake own a number of horses which are allowed to live as best they can at all seasons. The sloping sides of the valley are generally steep, but show little rock, being covered with terraced drift material. At this place, a very conspicuous bench may be traced, running for miles along the valley at an elevation (at Cush-ya, sometimes called Upper Euchinico Lake) of 296 feet above the river, or 3,476 feet above the sea. The river itself flows rather rapidly between the long lake-like expansions, which here characterize it, and add greatly to the beauty of the landscape. Whether these lakes are held in by rocky barriers or dammed merely by drift material, I have been unable to satisfy myself.

Waterfall.

About one mile above Cush-ya Lake, the whole volume of the river descends at a leap about fifteen feet over a bed of grey columnar basalt. The waterfall is symmetrical and curtain-like, with dark amber-coloured water.

Kuy-a-Kuz Lake.

Two miles north of Cush-ya Lake, at an elevation, according to the railway maps, of 500 feet above it, is Kuy-a-kuz Lake, lying nearly east and west, like the Blackwater Valley, but discharging its waters northward into the Nechacco. It is remarkable, that with the exception of the Eu-chen-i-ko—which flows in a nearly parallel valley—the Blackwater receives no important tributaries from the north, the surface of the plateau seeming, on the whole, to slope northward from the brink of its valley. This is specially noticeable in the lower part of its course, where streams eventually joining the Chilacco may be found almost within gunshot of its northern edge. The northern and north-eastern side of Kuy-a-kuz Lake is bounded by the mountains of the Kuy-a-kuz Range, while the gently rolling plateau with sandy and stony soil, which separates it from the Blackwater, has an average altitude of about 3,700 feet.

Remarkable position of watershed.

Blackwater Crossing.

Country in the vicinity of the Trail and Location Line, westward by the Cluscus Lakes and Salmon River Valley to the Iltasyouco River.—The Blackwater is crossed at several places by the Indians when on the way to Cluscus Lakes, but of these the best known is at the junction of the Cluscus stream. At high water the river can only be crossed in this vicinity by rafting, but this is easily effected. The Cluscus stream was estimated on June 15th to have a width of twenty feet by two feet in depth and slope of about one in ten. Its water had a temperature of 61·5°, that of the Blackwater being 53·5°. The trail follows the stream southward for about half-a-mile, and then turns westward along the northern border of the lakes. The lower lake has an estimated total length of about six miles, with a width of less than half-a-mile at its upper end, and quite narrow and river-like at its lower. It is separated by a stream of about a mile and a-half in length from the upper lake, which, with a length of scarcely three miles, has a width of about three-quarters of a mile at its upper end, and holds two small islands. The water feeding these lakes must enter the upper on its southern side, and from its high temperature, is probably derived from other shallow lakes or extensive swamps. The country along the north side of the first lake is of very pleasing appearance, sloping gently with an undulating surface to the water, and dotted with groves of aspen and spruce, where not covered with luxuriant grass. The northern slope of the upper lake is similar but steeper, and showing a smaller area of grazing land. The lower lake stands about forty feet higher than the Blackwater River. A terrace, estimated at 100 feet to 120 feet above it is visible, and a second near its lower end, at an elevation of about 300 feet. The valley which contains the lake is seen to continue eastward beyond its outflow. At the west end of the first lake an Indian house is situated, and this has for a long time been

Cluscus Lakes.

Terraces.

a rendezvous for the natives, the site of an old establishment of the Hudson Bay Company being visible near at hand. The trail now described was that followed by Sir Alexander Mackenzie when on his way to the sea, the name obtained by him for the natives of the locality being *Sloua-cuss-Dinais.* There were at the time of his visit two houses at the upper end of the first lake, which, as he says,* "occupied a most delightful situation."

Upper part of Blackwater River.

On leaving the upper end of the second lake the country is found to change for the worse. Broken fragments of basalt strew the surface in many places, and dry sandy and stony soil alternates with swamps. In three miles, the Cush-ya River of the maps (Tsan-tsed-a-ko of the Indians) is reached. On June 16th it was estimated to average fifteen feet in width by two feet deep, with a swift current. To the south, at a short distance, the northern front of the basaltic plateau appears as a low broken cliff of columnar basalt; it runs south-westward for some distance from this point, and was noted by Sir A. Mackenzie as a "high, rocky ridge" † stretching along on the left. The country traversed by the trail from this place to the Third Crossing of the Blackwater, may, in fact, be considered as a region forming the broken and more or less denuded border intervening between the northern edge of the volcanic plateau and the Blackwater River. Older rocks are, however, seen at the surface in a few places. The trail follows, for about three miles, the south shore of Tsa-cha ‡ Lake, crossing three streams. The first and largest of these had an estimated volume of ten feet by two feet, with a slope of about one in ten. Here the old C. P. R. Survey trail to Chizicut Lake turns off, and about a mile up the stream rocks of the Tertiary lignite formation are seen below the basalts, though without any visible lignite coal. The north side of Tsa-cha Lake, which is one of the expansions in the Blackwater River, is partly open and grassed, with light groves of poplar, spruce and pine, rising at a short distance into broken rocky hills.

Lakes.

Eight miles further on is Tse-tzi Lake, nearly a mile long, and with low basaltic cliffs on its south-eastern side; and a short distance further on Klootch-oot-a Lake, nearly a mile and a-half long, and discharging into the former, is reached. Between the two lakes, the Indian trail to Bella Coola or Bentinck Arm turns off, and will subsequently be noticed. Here again are a few Indian houses, and some swampy meadows of considerable

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* "Voyages from Montreal on the River St. Laurence, through the Continent of America, to the Frozen and Pacific Oceans." London: 1801. Page 298. † Op. cit., page 300.

‡ The name meaning great stone, or mountain, and referring to the rocky hill on its north bank, is changed to Thracha on some maps.

size. About a mile beyond the last named lake, Tsil-be-kuz Lake, (Kultus Coolie of the maps) is approached at its east end. It discharges westward into the Blackwater, which here makes a hook-shaped bend, enclosing this and the two other lakes before referred to. At its third crossing, north of Tsil-be-kuz Lake, the Blackwater, instead of flowing in a deep valley as before, is found nearly at the general level of the plateau, and though easily fordable in the middle of summer, was a rapid and difficult stream to raft and swim horses across in June.

Ancient volcanic mountains.

From the north bank a good view is obtained of a snowy range of mountains, of which the higher parts are included between S. 37·5° W. and S. 5° W. The surface of the country slopes up gradually towards its base, while the higher portions are more or less covered with snow on the shady exposures the whole summer. The peaks probably attain an elevation of 7,000 feet above the sea, or almost 3,500 feet above the point of view. This is the central of three isolated snowy ranges which lie east of the Coast Mountains, between the main valleys of the Blackwater and Salmon River to the north, and that of the Bella Coola and its tributaries to the south. It is called Il-ga-chuz by the Indians, while that lying between it and the Coast Ranges is known as Tsi-tsutl, and that to the east is named It-cha. Between Il-ga-chuz and Tsi-tsutl, a remarkable isolated mountain called Beece, or Anahim's Peak, is situated, and stands on the west side of the southern part of the Salmon River. These mountains were at first supposed, from their appearance, to be formed of beds like those of the vicinity of Tatlayoco Lake, tilted at low angles on the flanks of metamorphic rocks. They were, however, subsequently found to consist entirely of volcanic materials, and to mark the sites of three great vents, from which in Tertiary times a large part of the basalt which has flooded all this region, must have been derived.

Eliguck or Uhl-ghak Lake.

In continuing westward for about ten and a-half miles, the valley of the Uhl-gha-ko, an important tributary of the Blackwater, is followed, and Eliguck Lake (more correctly Uhl-ghak) is reached. The country is flat, or gently rolling, with sandy or stony soil more or less densely timbered with small pines, and, with the exception of a few spots of limited extent, not even affording grazing for animals. Where it issues from the lake, the brook was estimated to have a width of fifteen feet, with a depth of two feet, and a sluggish current. At the lake is a meadow of fine grass, with an Indian house belonging to a man of some consequence called Smi-you, and a few Indian graves. This I believe to be the place described on page 304 of Mackenzie's narrative. Uhl-ghak

Lake is about three miles in length, and has a rather prominent rocky hill on its north bank.

Gatcho Lake.

About sixteen miles west-south-west of Uhl-ghak, the Salmon River is first reached, the head-waters of the south-western sources of the Nechacco being crossed in the intervening region. The country between Uhl-ghak and Gatcho (more correctly Ilgatcheo) Lakes is broken and hilly, though with no elevations of great height, the higher parts of the surface being remnants of basaltic and other rocks of the volcanic plateau, while older beds appear in the lower ground. The surface of the uplands is stony, dry and barren, alternating with mossy swamps, in which *Abies Engelmanni* sometimes attains a diameter of three feet, with dense forests of the western scrub pine, growing to a great height, and reaching in many places a diameter of over eighteen inches. At Gatcho Lake is another Indian house and some graves, the house being the best built of any I have seen in the interior, and, though repaired for a great *potlatch* this summer, bearing marks of very considerable antiquity. I have little doubt that this is the house mentioned by Mackenzie on p. 307, and that the "river" he crossed (p. 308) was the Gatcho Lake stream, which flows to the Nechacco.

Indian house.

Between Gatcho Lake and the Salmon River the aspect of the country is very similar, but in some places, where the dense forest of scrub pine had been partly destroyed by fire, a rank growth of fine grass was noticed. Some of the swamps are grassy, though most are covered with moss and thickets of willows and dwarf birch.

Salmon River.

Where the Salmon River is first seen, the Indian trail to the Salmon House, and Bella Coola River crosses it, while a new trail made to accompany the Railway Location Line continues down the stream on its north bank. The former will be subsequently described.

Moraines.

The Salmon River is here a stream with only a moderately rapid current, and not much depressed below the general level of the plateau, the surface sloping down gently towards it. There are many moraine ridges and mounds, some nearly parallel—while others are nearly transverse to the direction of the valley, causing a multiplicity of small pools and swamps. For more than ten miles down the north bank of the river, from this point, the woods have been almost entirely killed by fire, but have not yet fallen. When a gale of wind visits this region it will cause an almost impassable wind-fall. There are a few pretty meadows of limited size along the river, and in some places many tall aspens were observed growing among the coniferous trees, a sign of good soil and more congenial climate. The flowering plants were also noticed to be

Vegetation.

considerably in advance of any seen lately. *Aquilegia Canadensis* and *Cornus Canadensis* were in full flower on June 23rd, while the lupin (*Lupinus Nootkatensis*) also appeared for the first time, and *Thalictrum dioicum* and *Smilacina stellata* were common on grassy banks.

Further down the Salmon River, with continued evidence of greater rain-fall, the forest is found unburnt, and consisting in great part of the scrub pine in tall dark groves. One or two small patches of snow were observed in the densely shady parts of the woods. A corresponding change takes place in the undergrowth, *Lycopodium complanatum* becoming abundant, while the beautiful *Calypso borealis* covers large patches of the mossy soil, and *Viola sarmentosa* and *Pachystima myrsinites* appear. About six miles above the mouth of the Iltasyouco River (known to the Indians as the Pun-chi-as-ko), the Salmon River makes its first great leap, in a fall about eighty feet in height, descending by several steps. The water does not pause at the foot of the fall, but continues onward as a foaming rapid as far as it can be seen, and here leaving the general level of the plateau enters its cañon, and in a distance of forty-five miles reaches the sea after accomplishing a descent of nearly 3,000 feet. The Iltasyouco River falling into the Salmon River from the north, is about seven miles in length between its exit from Si-gut-lat or Tse-houts Lake, and junction with the Salmon River. The bluish colour of its water contrasts with the amber tint of the Salmon River. In June it appeared to carry from one-half to two-thirds as much water as the latter. The river valley is at least 300 feet below the average elevation of the country, and is trough-shaped, with a wide rounded bottom. There are low terraces at several levels near the stream, and one,—best marked near Si-gut-lat Lake—at an elevation of about 200 feet above it, consisting of rolled gravel and sand. The river itself, though often bounded on one side or other by steep banks, can never be said to flow through a cañon. A mile above its mouth, it forms a very picturesque waterfall, over rocks of the mesozoic volcanic series, which characterize this valley. The first leap of the fall is made in a broad curtain-like sheet of water, over the edges of hard bluish feldspathic rock, which dips in a direction opposite to that of the stream. After this descent of about twenty-five feet, the water boils and foams in a wide rocky basin, till jostled together by the narrowing rocks into the throat of a very narrow chasm, it falls a similar height between perpendicular rocky walls, a mass of seething foam.

Salmon River Fall.

Iltasyouco River.

A considerable change in the character of the vegetation is noticed in this valley. The forest is of a more mixed character, pines and spruces

Appearance of coast plants.

being commingled with occasional aspens. The balsam spruce (*Abies lesiocarpa*) appears abundantly, while the scrub pine attains a greater size than it has elsewhere been observed to do, and *Abies Engelmanni* often surpasses three feet in diameter, and reaches a great height. Another species of pine (*Pinus albicaulis,*) was noticed, though rarely. The hemlock (*Abies Mertensiana*) appears, and at the fall shrubby representatives of the giant cedar (*Thuja gigantea*). Among the plants constituting the undergrowth, the elder (*Sambucus pubens*) and devil's club (*Echinopanax horrida*) were new features, the whole probably indicating not so much a milder as a damper climate.

From Salmon River Crossing to the Salmon House, northern edge of Bella Coola Valley and Na-coont-loon.—Returning now to the Indian crossing of the Salmon River, mentioned on a former page, I shall describe the country from that place to the Salmon House, and next that southward to the Bella Coola Valley.

Scanty Indian population.

On arriving at the crossing place on July 7th, we found all the Indians of this part of the country collected there, on their way down to their annual fishery at the Salmon House. They may have been from fifty to sixty in number, this representing the population of a tract extending beyond Lake Tschich northward, and nearly to Cluscus Lakes eastward; or about 2,500 square miles of surface. Here I parted from Mr. Cambie, who continued eastward on his way to Quesnel, my own party now consisting, besides myself, of A. Bowman, assistant, one Mexican packer, and one Lillooet Indian packer and cook. Some of the Indians were engaged to assist in building a raft, which was speedily accomplished, and before dark our camp equipage and provisions were ferried over, the animals crossing a short distance below in a small rapid, without losing bottom. The Indians were not slow to take advantage of the raft which they had been paid to make, and following us to the south bank, made their camp much closer to ours than might have been wished.

Cross Salmon River.

July 8.—Travel by the trail south-westward to Tanyabunkut Lake (more correctly Tai-a-taisli-bun-kut). Heavy rain in the afternoon and bad trail, the mules miring down several times, and there being two bridges to repair before they could be crossed. Passed the Indians on the march, every man, woman and child, and even the dogs, with packs of appropriate size. All appear to be in good spirits, and on the way to their great annual holiday-making, the Salmon fishery, the whole scene much resembling that described by Sir A. Mackenzie, who travelled part of this very road with the Indians on the way to their fishery, on the 15th July, 1793.

Character of the country.

The country passed over to-day is stony and barren, and the greater part of the woods have been removed by fire. The first few miles after leaving Salmon River Crossing, are over rocks of the basaltic series, but near Hatty Lake of the map, the surface becomes broken, resembling the country in the angle between the Iltasyouco and Salmon Rivers, and is, like it, based on older rocks. There are, however, occasional broad swampy meadows, affording good feed for animals, but unfit for agriculture. Near the north end of Tanyabunkut gravelly moraines are passed over, and its south-eastern side is bordered for a short distance by very high basaltic columns.

Vegetation on burnt ground.

The greatly more advanced state of the vegetation where the country has been cleared by fire, is quite remarkable. The following plants were noticed in open ground to-day:—*Lonicera involucrata*, in flower; *Pyrola rotundifolia*, showing colour; *Fragaria Virginiana*, still in flower, and *Anemone multifida*, *Rubus arcticus*, and *Castilleia pallida*, in flower; *Achillea millefolium*, beginning to flower; *Linnæa borealis*, in bud; *Ledum latifolium*, flowering in warm situations; *Sedum* ——? in flower; *Epilobium angustifolium*, not yet in flower.

Tanyabunkut Lake.

July 9.—Morning fine; thunder storms with heavy rain in the afternoon. Waited to take some photographs of the lakes and mountains, and then travelled on down the north-west side of the lake, camping about five miles beyond its lower end. Tanyabunkut Lake is about five miles long, narrow, and with steep rocky banks, composed of Tertiary volcanic materials, which are cut into by the valley. At its lower end the valley widens, a high basaltic cliff bounding it to the north.

July 10.—Followed the trail south-westward about seven miles, making in the last mile a descent of several hundred feet. The trail runs midway between the Salmon River on the right, and the Tai-a-taesli on the left, the latter stream draining Tanyabunkut Lake, described yesterday. The first part of the path is over moraine mounds and ridges, which, though at first almost entirely composed of granite blocks, soon showed a preponderance of dioritic, and greyish or greenish porphyritic rocks, like those of the older volcanic series. After making the descent above referred to, we found a small pond and grassy meadow. Not wishing to take the heavy packs further, they were here left with the pack mules in charge of the Indian, Johnny. Riding on for three and a-half miles, by a very blind trail, much blocked by recent windfall, we suddenly emerged on the open brow of a hill, from which the Salmon House, and a considerable length of the Salmon River Valley, were visible. The valley of the Tahyesco River,—of which the Tai-a-taesli is a branch

Moraines.

The Salmon House.

PHOTO. LITH. BY THE BURLAND DESBARATS CO MONTREAL

From Photo. July 9th, 1876.

BASALTIC SLOPES OF TSI-TSUTL RANGE.

CHIL-A-THLUM-DINKY, COAST RANGE.

LOOKING DOWN TANYABUNKUT LAKE.

—here enters the Salmon River from the east, an area of comparatively low ground, in shape nearly an equilateral triangle, lying at the junction of the streams. The apex of the triangle, pointing down stream, is occupied by a little rocky hill, while the remainder, elevated about 100 feet above Salmon River, is a gravelly flat, descending by several rough steps on the Tahyesco side. Making the descent of about 500 feet by a very steep and critical trail, forming a succession of sharp zig-zags, we reached the flat by four o'clock.

The rocks of this vicinity are chiefly very hard felsites, and porphyrites, of the Mesozoic volcanic series, tilted to a vertical attitude, and traversed by dykes of granite. The river is exceedingly rapid and turbulent, and is hemmed in by rugged cliffs, which, however, do not form a cañon of great depth. From the edges of the cliffs the mountains rise in rough slopes of greater or less inclination to a height of probably 3,000 feet.

Indian salmon fishery.

There are two Indian houses here, one on each side of the Salmon River, opposite a small waterfall, at which the natives make their annual fishery. A precarious bridge of poles and sticks is constructed across the torrent, and a series of baskets arranged along the front of the fall, into which, in trying to leap up, the salmon drop. Two Indians, who had attached themselves to us so far, appeared much disappointed at the height of the water and consequent absence of fish. They told me that long ago the bridge used to remain always, but now that the rock in the middle of the stream, on which it is partly founded, had become so much reduced in size, that the structure is washed away every winter.

Re-appearance of Douglas fir.

At the Salmon House the Douglas fir, which does not appear east of this over a considerable tract of country, is again seen as a large tree. There are a few modern Indian graves on the flats, and three small heaps of stones, probably also sepulchral, to which superstitious stories attach, and an offering of a twig is made by each passer-by.

Old trail to Na-coont-loon.

July 11.—Took three photographs and then hurried back to the place where we had left the mules. Got them packed, and returned by the trail to the lower end of Tanyabunkut Lake. Here we found the tribe of Indians, waiting till a favorable report should be received from the Salmon House. I had learned by cross-questioning the Indians, that a trail, which was sometimes travelled, existed from this place to Na-coont-loon Lake, south of the Salmon River. This I was anxious to examine, but found it very difficult to procure a guide, partly from reluctance to hard work among the Indians, and partly also, I think, from the fact that few of them had been over the trail I wished to follow. By giving the chief a small present of tobacco, however, and after much talk, a man was finally induced to promise to go.

" Fire stone."

July 12--Started on foot to examine a locality which I had learnt from the Indians yielded "fire stone." Followed the trail towards Bella Coola, crossing the Tai-a-taesli, where it leaves the lake, a stream twenty feet wide by two deep, with slow current; the Tsul-tel-a-ko, a stream of forty feet by two feet, with a slope of about one in ten, shortly after leaving camp; and the Ko-has-gan-ko, sixty feet wide by two feet deep, with a similar steep inclination. The two last named streams flow from the flanks of the Tsi-tsutl range, and are fed chiefly at this season by the melting snows, being much larger in the afternoon than in the morning, after the cold of the night. On the Ko-has-gan-ko, five miles from camp, the "fire-stone" was found, and proved to be lignite of good quality, which, with its associated rocks dips below the volcanic accumulations, forming the Tsi-tsutl Mountains.

July 13.—Set out with our Indian guide, following the trail walked over yesterday to the Ko-has-gan-ko, and continued southward beyond it for about six miles. The Indians had led us to expect a bad trail, which was quite borne out by the facts. We crossed one other considerable brook, ten feet wide by six deep, with rapid current, and continued ascending diagonally over the north-western flank of the range. Gravel mounds and ridges apparently morainic, and densely timbered, alternate with swamps, in which the mules were constantly miring. Camped near dark at a height of 3,700 feet in a notch holding a swamp with some grass, and separating a rocky knoll from the main slope of the Tsi-tsutl Mountain. From this knoll a magnificent view is obtained over the whole surrounding country. Westward, the serried and snow-clad peaks of the inner ranges of the Coast Mountains are seen across lower rounded hills, and the valley of the Tahyesco. Through these the hollow of the Salmon River valley was indicated by a blue haze, with which it was filled, while the river itself is entirely concealed by the high intervening land. Northward, a portion of Si-gut-lat Lake appears up the valley of the Iltasyouco, while very distant snowy mountains—probably the Quanchus Range—rise above the horizon in one place. Tanyabunkut Lake lies too deep to be seen, but the broad hollow by which the trail reaches it from the Salmon River crossing is apparent. From the south-east side of the lake the whole surface gradually rises toward the peaks of the Tsi-tsutl range, here and there, however, showing only broken remnants of a surface which has at one time been a continuous

Fine view from Tsi-tsutl Mountain.

slope of volcanic materials. At the western end of the range, nearest to the point of view, the basalt flows simulate terraces, in their flat tops and broken and abrupt fronts. One of the mules died this evening from accidental injuries received during the day's march.

Alpine meadows.

Depth of snow in winter.

July 14.—Travelled almost directly southward, descending for about a mile and a-half, when a stream forty feet wide and six inches deep, flowing rapidly westward to the Tahyesco, is crossed. From this a gradual ascent is again made, and the trail then passes southward for some miles through a remarkably straight notch-like valley, separated by low hills from the Tahyesco on the west. A narrow grassy meadow follows the valley, and slopes northward and southward from its highest portion, the whole surface being saturated with moisture and indented with little hollows filled with clear water. The grasses and carices are at this date green and well grown, and very nutritious pasture could, no doubt, be obtained here during the summer months. After crossing two other streams—the first ten feet wide by six inches deep, with rapid current; the second, fifteen feet six inches, with slope of one in ten, reached the Tahyesco—and camped on its bank among burnt woods, at an elevation of about 3,690 feet, having made eleven miles in the day's march. The depth of the snow in the woods of this high region in winter must be very great, judging from the height at which branches have been broken down by it, and of the stumps of trees which have been cut at that season by the Indians. The line above which large patches of snow are seen during the summer months on this Tsi-tsutl Range is much lower than that on the Il-ga-chuz Range, to the east, of which the climatic circumstances must otherwise be much the same. A drenching thunderstorm this afternoon and steady rain in the evening.

Upper part of Tahyesco.

July 15—After crossing a branch of the Tahyesco twenty feet wide by one foot deep, with rapid current, we travelled eastward near the main stream, which was estimated at thirty feet wide by one deep, ascending gradually into a quite alpine region over 4,000 feet above the sea level, and beyond the limit of thick forest growth. The valley of the branch of the Tahyesco here followed is sometimes a mile in width, and runs southward between two ranges of hills; that on the west being the higher, and showing through its gaps more elevated peaks of the Coast Range. About two miles from camp, the main stream of the Tahyesco enters the valley up which the trail passes, from the right, forming a fine waterfall. The trees, which still continue to grow in clumps where heavy drifts of hard snow encumber much of the surface, belong to three species:—*Pinus contorta*, *Pinus albicaulis*, and *Abies lasiocarpa*—all

Alpine plants.

more or less stunted. The first named thrives moderately well, but often forks upward, departing in this respect from its habit in the lower regions. The second is not so common; and the last appears to be most hardy, growing stout, and with many low wide branches sweeping the ground. The smaller plants are of quite arctic appearance, and are seen in many places springing up in successive crops along the retreating edges of the snow. A peculiar white *Caltha*, (*C. leptosepala*), a *Ranunculus* (*R. macranthus*) with *Kalmia glauca* (var. *microphylla*), and occasionally *Spiranthes* and *Ledum latifolium*, thrive; in warmer situations a species of heath-like *Menziesia* (*M. empetriformis*) with *Andromeda cupressina*, were abundant.

Bella Coola Valley.

The trail was here scarcely visible, but our Indian guide knowing the country, led confidently on, and brought us at length to the northern brink of the great gorge of the Bella Coola Valley. Here he stopped, and told us it was utterly impossible to descend into the Bella Coola Valley with animals, or to follow the trail along its bottom to Na-coont-loon as I had hoped to do. He had apparently mistaken my intention in coming this way, thinking I wished merely to see the Bella Coola Valley and return as we had come. This being the case, it was decided to return some miles down the Tahyesco, and then strike off directly toward Na-coont-loon south of the Tsi-tsutl Range, the Indians having before told me that the country there was practicable. We crossed the rocky ridge on the east side of the valley, travelling often for considerable distances over old snow banks, hard enough to support the mules, and in some places ruddy from the growth of *Protococcus nivalis*, and camped at an elevation of about 4,357 feet, near a small lake called Ta-ba-tas-kun by the Indians. About one-tenth of the surface was here covered with snow. A very remarkable peak, (Mackenzie's "stupendous mountain," p. 316) towers above the Bella Coola Valley on the southern side. Its Indian name is Chil-a-thlum-dinky.

Turn toward Na-coont-loon.

Si-ka-ta-pa Lake.

July 16.—Travelled eastward near the junction of igneous flows of the Tsi-tsutl Range, with the older underlying rocks, making nearly eleven miles in the day's march. A mile and a-half from our morning camp came to a small lake called Si-ka-ta-pa, where our guide hoped to find a trail leading to Na-coont-loon, and where the "saghalie" trail from Tanyabunkut descends the southern slope of the Tsi-tsutl Mountains, in its course to Bella Coola. This "saghalie" or mountain trail I had originally intended our guide to follow. It is evidently that by which Sir Alexander Mackenzie reached the Bella Coola Valley, and Si-ka-ta-pa is probably the lake he describes on p. 316 of his narrative, which was passed by him eighty-four years ago, just one day later in the month of July than the date of our visit.

The country to the south of our route is broken, with rocky hills, and one remarkable snowy range, rising probably 700 feet above the general level, forms the northern brink of the Bella Coola Valley. To the north the surface rises in steps—marking the various basalt flows—to the higher peaks and broken remnants of plateaus, which form the summits of the Tsi-tsutl Range.

Character of country.

The country travelled over is lightly timbered with groves of the species mentioned yesterday, and though very stony in places, shows some grass on the slopes, and occasional fine meadows. Camped in a wide valley with flats covered with beautiful grass, through which the Tsed-a-kul-ko River (Cheddakulk of Palmer's Survey of the Bella Coola Valley) flows.

Streams flowing to Bella Coola

We nearly lost, in a stony torrent to-day, one of the pack mules, carrying camera and collection of plants besides part of food. The larger streams met with were as follows:—Branches of the Ne-ti-kun-as-ko:—torrent fifteen feet by two feet; stream fifteen feet by one foot; slope, one in twenty-five; main branch on issuing from Si-ka-ta-pa Lake, with the addition of the last named, thirty feet by five feet, torrent. Brook joining upper part of main stream, twelve feet by two feet; slope, one in ten; main stream, near its source, six feet by six inches, swift. Branches of the Tsed-a-kul-ko:—west branch (Tsan-tsal-ko), twenty-five feet by two feet, slope, one in twenty; main stream, forty feet by two feet, one in ten. All these streams are now full of water from the melting snows of the higher portions of the range.

Descend toward Na-coont-loon.

July 17.—Made about fourteen miles eastward, most of the way through open country like that before described, with many swamps and lakes of small size. On gradually descending from the south-eastern flank of the Tsi-tsutl Range, the timber becomes thicker. *Pinus contorta* and *Abies Engelmanni* preponderating, though at first rather scrubby. Swamps and meadows with much good grass still, however, occur abundantly. Camped on the bank of a large brook or small river called the Tus-ul-ko, here thirty feet by three feet, with gentle current, a tributary of the Salmon River, at an elevation of about 4,234 feet. Saw little snow to-day, even when travelling at a high altitude in the morning, a fact showing that the influence of the coast range in causing great precipitation diminishes very rapidly eastward. This we afterwards found still more markedly on the Il-ga-chuz Range, where the limit of sturdy growth of trees is considerably higher, and the vegetation

Causes of great snow-fall.

not so arctic. The immense snowfall on and immediately east of the Coast Range, by retarding the advance of summer, succeeds in reversing the effects which the vicinity of the sea might be expected to produce. It is also very probable, though no accurate observations have been made on this point, that the mountains about Dean Inlet, receiving the westerly and south-westerly winds from the Pacific, without the intermediation of any high islands, have in consequence a greater rain and snow fall than is usual even in this range. Our guide now confesses that he has not been in this region since he was a very little fellow, and the trail which we are supposed to be following is a very dim one, the appearances being that this part of the country has been almost abandoned by the Indians. Jim has a good eye for country, however, and seems almost by instinct to pick out the right way.

Na-coont-loon country.

July 18.—After travelling a few miles, struck the old Indian trail, which, though somewhat overgrown, saved us much trouble in chopping. Followed the valley of the Tus-ul-ko pretty closely till we reached the main Salmon River, a short distance above its junction with this stream, and at the lower end of A-bun-tlut, the most northern of the Na-coont-loon lakes; The country descends gradually toward the Salmon River, but appears nearly flat. The soil is generally sandy and gravelly, dry and poor; but swampy meadows, with good grass abound. Many moraine-like heaps and ridges, running east and west, occur. Rocks of the Tertiary volcanic series underlie the country. The Salmon River is here at an elevation of 3,440 feet, and flows north-westward in a wide valley, from which the gently sloping bases of the Tsi-tsutl and Il-ga-chuz Ranges rise, on the west and east sides respectively. Southward and south-eastward, the whole surface of the country appears low and flat, with a level sea-like horizon, but is probably at too great an elevation to render agriculture possible. Soon after our arrival two Indians, father and son, came into camp and informed us that several families were living for the summer at Na-coont-loon Lake. We had been previously told that all the Indians from this part of the country had moved down to the Chilcoten River, under the priests' directions.

Salmon River.

Na-coont-loon Lake.

July 19.—Bowman went south-eastward on foot, under the guidance of one of our new friends, to Na-coont-loon Lake. Beyond A-bun-tlut is a small lake called Nat-se-den-la, and at about seven miles from camp the Salmon River issues from the north end of Na-coont-loon Lake proper, which is a wide sheet of water, probably over five miles long, though the upper end, turning westward, was not seen.

July 20.—Ferried our stuff over the river on a raft, which we had built yesterday, the mules crossing easily, without loosing bottom or miring. Made about eleven miles east-north-eastward, under the guidance of the elder of the Na-coont-loon Indians, who showed us a disused Indian trail, part of which was still in fair order, but which, in many places, was much encumbered with fallen timber, rendering long detours necessary. Camped at 5.30, having lost the trail, among windfall, and in a perfect storm of mosquitoes. We are now on the so-called Bella Coola Trail, which leads from the Bella Coola Valley, *via* Na-coont-loon, to Tse-tsi Lake, mentioned previously. On leaving the flats about Salmon River, it gradually ascends the long southern slope of the Il-ga-chuz Range, and eventually passes over its eastern flank.

Il-ga-chuz Range.

July 21—Recovered the trail this morning, bade adieu to our Na-coont-loon friend, and continued gradually ascending as we advanced, till after a few miles we found ourselves on a broken plateau, with only scattered clumps of trees, and on the upper parts nearly bare, resembling the high open country of the Tsi-tsutl Range. The surface is dotted with small ponds and lakelets, and many little streams filled with snow water are crossed. The vegetation is quite alpine, but more varied than on the Tsi-tsutl Mountains. The following additional species, among others, were collected, *Sedum Rhodiola*, *Aster salsuginosus*, *Pedicularis euphrasoides*, *Pedicularis Grœnlandica* var. *surrecta*, *Menziesia glandulifera*, *Dryas octopetala*, *Campanula lasiocarpa*, *Gentiana glauca*. Several caribou were seen during the day's march, this high country being their favourite summer haunt. Camped in a sheltered nook on the north-eastern angle of the Il-ga-chuz Mountains, at an elevation of 5,200 feet. Good feed for the animals; but though large snow banks all around, mosquitoes very troublesome. The higher peaks of the range, perfectly bare of vegetation, rise to the west. We were much tempted to stay a day and ascend them, but our provisions being low, and not knowing exactly how far we might have to go to reach the Y. Division of the Railway Survey, thought it hardly safe to do so. Even from this elevation, however, a very extensive view is obtained. Eastward the eye is carried over a continuation of the broad high-level plateau, which we have travelled on, to the base of the It-cha, the furthest east snowy volcanic range, which is seen from here to have originally had a broad dome-like form, such as volcanic materials falling into water might be expected to assume. Broken and flat-topped remnants of its uniform surface, now, however, only remain on the flanks, while the central region shows irregular shattered peaks, without a trace of the original form.

Vegetation of the range.

Extensive view.

The upland plateau surrounding the three volcanic ranges, and connecting together the two eastern, will some day be of value in affording alpine summer pasturage of the most nutritious kind. This may probably be available during at least three months, after which animals would require to be driven down to a lower level.

Terrace at 5,270 feet.

July 22—On leaving camp, found ourselves at about the general level of an extensive, though somewhat broken and denuded flat, which stretches along the northern flank of the Il-ga-chuz Range. The material of this terrace is rolled and water-worn, and while chiefly derived from the volcanic rocks of the vicinity, travelled fragments not represented among these, also occur. It evidently marks an old water line, probably of the sea, but is higher than I have ever before seen. (See Plate II.)

Descend to the Blackwater.

Travelled northward, finding the Indian trail again soon after starting. The country gradually slopes down to the lower levels, the woods at the same time becoming thicker, with great areas of *brulé* and wind-fall, with swamps in which the animals more than once mired down. Crossed first several small streams running north-eastward, and then a large one with a width of forty feet, depth of six inches, and slope of one in fifty, derived from the central portion of the range. After crossing this little river twice more, in its windings, we left it, and shortly afterwards came very unexpectedly to the main stream of the Blackwater, running *westward*, with a strong steady current, about forty-five feet wide, and average depth of two feet. Camped on its north bank, having travelled about thirteen miles. The Blackwater River here appears to come from a south-easterly direction, from the It-cha Range and plateau country between this and that from which we had descended, where its sources may be said to be.

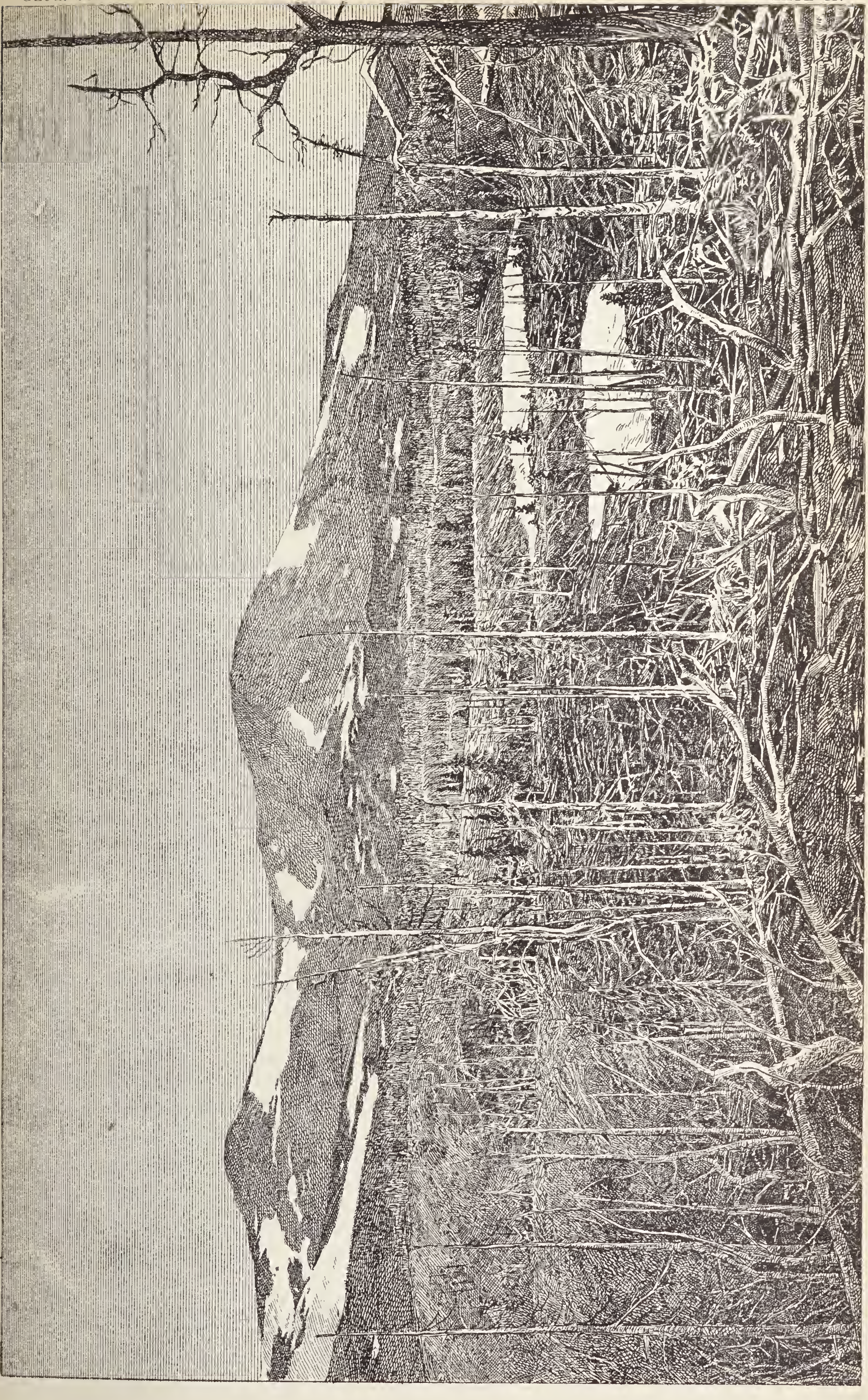
Reach Tse-tsi Lake.

July 23—After making four and a-half miles north-eastward, through densely wooded country with small lakes, reached Tse-tsi Lake, and the main Blackwater and Salmon River Trail. Found a small cache of provisions, and a mail, left for us by Mr. C. Seymour on his way from Quesnel to the Salmon House with supplies.

Qualcho Lake.

Qualcho Lake and thence to Fraser Lake.—From this point we travelled westward again to Gatcho Lake by the trail which has already been described; and from that place, north-westward seven miles, by an Indian trail to Qualcho Lake, where we found Mr. Hunter, in charge of Y party of the C. P. R. Survey. Qualcho Lake discharges westward into Si-gut-lat Lake, is about five miles in length, with clear water and pebbly beach, chiefly composed of rocks of the Porphyrite series, many of them glaciated. The banks rise somewhat abruptly from the lake shore to heights of 100 to 150 feet, and the whole surrounding country is thickly

PLATE II.



From Photo. July 21st, 1876.

LOOKING ACROSS WORN TERRACE-FLAT AT ELEVATION OF 5,270 FEET, TOWARD HIGHER PEAKS OF IL-GA-CHUZ RANGE.

PHOTO LITH. BY THE BURLAND DESBARATS CO. MONTREAL.

wooded, save where fires have passed, or the soil is too sandy and poor to support a rank growth.

Country about Qualcho and Gatcho Lakes.

Four miles east of Qualcho Lake, without intervening high country, the Gatcho Lake stream—already mentioned as the south-eastern source of the Nechacco in this direction—is found. The general elevation of the country in this vicinity is about 3,300 feet. It seems to be based on wide-spread, though somewhat irregular benches, forming plateaus differing a little in elevation. The stream-valleys are hollowed out in this, generally without reaching solid rock; and low mounds and ranges of hills project in some places above it. The material of the benches is sand, gravel, and small boulders, in various proportions, but chiefly derived from the Porphyrite series. The soil is almost invariably poor, and only occasional hay meadows are found. No marked features intervene between this region and the Coast Range, which bounds the view westward. On July 30, the fire-weed (*Epilobium angustifolium*) was beginning to flower, *Linnœa borealis* was in full flower, and wild strawberries were ripe, and in some places abundant.

Journey to Fort Fraser

From Y Division Camp on Gatcho Lake stream, I set out towards Fort Fraser, on August 7th, re-inforced by two axemen from Mr. Hunter's party, and some additional pack animals. It will be unnecessary to enter into the daily routine of this part of the summer's work; it will suffice to state, that after twenty-five days of severe labour in a country terribly encumbered by forest and wind-fall, we reached the Telegraph trail near Ta-chick Lake. A brief description of the route will, however, be given.

Gatcho stream.

Following near the Gatcho stream north-eastward twelve miles, Eu-ti-a-kwe-ta-chick Lake, into which it flows, is reached. In the intervening distance, several small lakes and ponds, formed by expansions of the stream, are seen, and at the lower end of the longest of these—six miles from the lake above named—it is joined by a much larger stream, the estimated dimensions of which, on the 8th of August, were: width fifty feet, depth six inches, slope one in one hundred. The upper part of the valley of this brook, as far as it can be seen from the vicinity of its mouth, bears S. 44° E., and it must drain a wide area lying west of the south-eastern extension of the Toot-i-ai Mountains and the northern bank of the Uhl-ghak stream and Blackwater. The surface of the country still preserves an appearance much like that last described, the streams, however, as they are followed down, cutting more deeply into the plateau surface. The appearance of the vegetation leads to the belief that the rainfall of the region is inconsiderable; and where the soil is poor, and fire has removed the covering of scrub pines, it often scarcely tends to reclothe itself. In the river valleys, however, and along some of the lakes and ponds, very beautiful meadows of natural grasses appear, of which, the area, though quite small when compared with the whole country, must in the aggregate be considerable. In sheltered valleys, and on the southern slopes of the lakes, Engelmann's spruce is found attaining a fair size. The Douglas fir does not occur.

Eu-ti-a-kwe-ta-chick Lake.

Eu-ti-a-kwe-ta-chick Lake, eight miles in length, and averaging about half a-mile in width, lying north-east and south-west, is a fine sheet of water. The banks are bold, the country attaining its full height of 150 to 200 feet near the lake. The north-western side is somewhat lower and more broken than the south-eastern, which is the more heavily timbered. At the lower end of the lake, the valley is continued by a flat marshy strip of country of equal width with the lake, and not much above its level. Through this, the issuing stream, now called the Kes-la-chick, pursues a very winding course for three miles, when low banks of gravel and drift-material appear, and making a right angle, it turns abruptly to the left into a narrow rocky chasm, with walls nearly 300 feet high. A short distance further on the stream again returns to the main valley. The diversion appears to have been caused by a barrier of drift accumulated during the glacial period, which must have been much higher and more complete at the time the change first took place.

Kes-la-chick River.

From this point to Na-tal-kuz Lake, the river, though flowing on the whole in a direct north-eastward course, is very tortuous in many places in detail. The sides of its valley become steep, and on approaching the high country surrounding the base of Toot-i-ai Mountain become absolutely perpendicular and cañon-like in places, and from one hundred to nearly 200 feet in height. There is generally a little flat ground a few feet above the water level, but the stream running at intervals into the foot of the steep banks renders it necessary to cross and recross in the endeavour to follow it. The largest stream observed to join the river in this part of its course, was fifteen feet wide by six inches deep, with a slope of about one in twenty. Before entering Na-tal-kuz Lake the river has a breadth of about fifty feet, with an average depth of two feet where it runs rapidly. The plateau above the river valley is densely timbered, though generally with small trees, and scarcely affords any pasturage. The soil throughout is poor, sandy or stony, and quite unfit for agriculture, even if at a much lower level.

Toot-i-ai or Fawnie's Mountain.

Toot-i-ai, Toodeeney, or Fawnie's Mountain, near the north-western base of which the Kes-la-chick passes, is the most prominent peak in this part of the country. It has already been referred to as being on the

Photo Lith. by the Burland Desbarats Co. Montreal.

From Photo. Aug. 18th, 1876.

TOOT-I-AI OR FAWNIE'S MT. FROM HILLS NEAR EAST END NA-TAL-KUZ LAKE.

continuation of the mountainous belt of Kuy-a-kuz Lake. Its summit must be about 6,000 feet above the sea, and is quite remarkable from its symmetrical form. Seen from all points of view its outline is much the same,—a broad sloping base, like an overturned basin, with a small roughly conical peak in its centre. It is detached nearly to its base on all sides, and only approached by mountains of lower height on the south-east. Seen from the north-east, the central peak shows three distinct, though somewhat irregular horizontal lines, while lower down on the flanks are step-like prominences showing against the sky, and dim lines across its front; all suspiciously like old water marks, represented either by the remnants of gravel benches or by erosion of the rocks. In the gap immediately east of Toot-i-ai, distinct flat-topped terraces are seen at an elevation estimated as 800 feet above Na-tal-kuz Lake, or 3,460 feet above the sea. (See Plate III.)

Na-tal-kuz Lake

Na-tal-kuz Lake, lying north of Toot-i-ai Mountain, is Y-shaped, the two branches running westward, while the stem narrows to the place at which the main Nechacco River flows out, and points directly eastward. The distance from the eastern end to the head of the southern branch is nearly six miles, and from the same place to the head of the northern, eleven miles (by Mr. Cambie's survey). The extreme width, measured just before the divergence of the branches, is about two and a-half miles. The southern arm receives the drainage of Tetachuck Lake and the Kes-la-chick River, while the northern is continued by a great series of lakes and rivers, surveyed by Mr. Cambie after the time of my visit. From a prominent rocky hill, about 300 feet above the general level, a good view of the lake and its surroundings was obtained, and a topographical sketch made. The south side of the lake and of its south arm, rises pretty steeply to a height of 100 to 200 feet, and the surface then only slightly gains in elevation as it runs back toward Toot-i-ai. Some meadows and hill sides with fair grass occur, but the greater part of this bank is densely timbered with tall straight trees of scrub-pine, birch, and poplar. The valley of the south arm is continued westward by low country, and through it, at a great distance, the mountains of the Coast Range are visible. The point between the north and south arms slopes also rather steeply from the water to a flat or slightly rounded summit. Beyond it, blue hills at a distance of twenty to thirty miles close the view. The valley of the north arm turns northward, and from this point of view appears closed by a rather remarkable square-topped mountain, which must rise more than 1,000 feet above the water level. The north bank of the lake, east of the point of union of the two arms,

View of Coast Range.

rises rather abruptly, at first in well marked terraces to a height of probably 200 feet, and then in irregular undulations to the summits of a range of hills, which appears to attain a height of 800 to 1,000 feet above the lake, at a distance of a mile or two from it. Somewhat east of these, and beyond them, another and higher range is seen, at a distance of eight or ten miles. To the north-east, the low distant mountains of the Telegraph Range appear, with the valley of the Nechacco running towards them. The eastern edge of the Toöt-i-ai Mountains is rather indefinite, sloping gradually down towards low country.

Nechacco River.

The Nechacco, where it issues from the eastern end of Na-tal-kuz Lake, is a noble stream, nearly 200 feet wide, deep, with strong steady current, and filled with clear blue water. The lake is pretty evidently dammed by moraine matter, through which the river has since cut its way. The moraines are more perfectly preserved here than I have elsewhere seen them, forming long sharp-topped and slightly sinuous ridges, which sweep round in broad curves, nearly parallel to the river valley for some miles. They are separated by narrow, deep, V-shaped valleys, and are probably in some instances over 200 feet in height. The slopes of these peculiar ridges are covered with bunch grass, and occasionally with sage, (*Artemisia frigida*), while in many places service berries abound, and were found quite ripe on the 18th of August.

Well-preserved moraines.

Ched-a-kuz-ko.

About four miles beyond the outlet of Na-tal-kuz Lake, the river receives an important affluent from the south. This stream is called by the Indians Ched-a-kuz-ko, and carries the waters of Kuy-a-kuz and Ta-tel-kuz Lakes, mentioned in a former connection. On August 18th it was estimated to be forty feet wide, by about eight inches deep, with a rapid current. Its valley near the Nechacco is wide and flat-bottomed, with pretty meadows through which it pursues a tortuous course. From a knoll in the vicinity it can be seen to continue as a wide depression for at least eight miles, with a bearing of S. 19° E.

Character of the country.

East of the Ched-a-kuz-ko the morainic character of the superficial deposits is not nearly so well marked, the ridges showing a tendency to become flat-topped, and eventually blending with broad sandy flats, at a small elevation above the river, which are covered sparcely with pine trees. From this point to its first great bend—eleven miles—the Nechacco flows in broad curves, in a wide valley, with broad flats on alternate sides. The current, as far as could be seen from our trail, appears throughout steady, and the water deep. The higher slopes of the valley and country beyond continue densely wooded, with few prairie patches even on the northern bank. Terraces are in some places well developed, in many instances at elevations of 200 to 300 feet above the river. A large stream twenty-five feet by six inches, slope one in 200, enters the river at its angle, flowing from the east. Up its valley, at a distance of three or four miles, is a remarkable step-shaped mountain, which can be seen from Na-tal-kuz Lake. It forms a portion of the broken country of the western ridges of the Telegraph Range, which running athwart the course of the Nechacco at this place, with a nearly north and south direction, causes it to double back on itself.

Nechacco canon.

Beyond the first great bend, the river becomes swifter and more contracted, with rapids at intervals, the sound of some of which was heard while travelling through the thickly wooded country above. Six miles lower, where the bank was again approached, the stream was found plunging onward over rocks and between small rocky islands, with cliffs about 100 feet high at its sides. These are composed of thick beds of basaltic and other igneous rocks, inclined at low angles, and underlaid by softer Tertiary beds near the water line. A terrace still continues to appear at a height of about 200 feet above the water. (See Plate IV.)

The windfall in this part of the river valley became so impenetrable that we were obliged to leave it and strike north-eastward across the plateau above, which was found to be not much better. A north and south valley here runs some miles east of that of the main stream, bearing much the same relation to it as the string to a bow, and holding a small stream, with wide marshy beaver-meadows and remains of beaver dams. This runs northward, and has been followed at one time by an Indian trail, of which traces remain, but which has evidently been abandoned for a long time. The surface of the plateau is broken and rugged, with small outlying hills of basaltic rocks. There is, however, good feed for animals along the creek, though the general surface of the plateau offers little grazing even in the swamps, and is quite unfit for agriculture. I subsequently wrote to Mr. Hunter, mentioning the existence of the valley of this stream, which was named Cut-off Brook, and suggesting it as a possible means of avoiding the bend and bad work on this part of the Nechacco, in the railway line. It was, I believe, afterwards surveyed.

Benches of white silt.

Beyond the mouth of Cut-off Brook, the Nechacco valley continues for about eight miles in a north-eastward course in a moderately broad valley, with benches at 200 to 300 feet above the water level. These are now found to be composed of fine greyish arenaceous clay, pretty hard when dry, but evidently subject to extensive slides during the wet season. It is an extension of the white silt deposit, afterwards found so largely developed in the basin of the lower Nechacco. With the change in the appearance of the surface material, the soil becomes much more fertile and supports heavy timber. On the lower benches, Engelmann's spruce frequently surpasses three feet in diameter, and the aspen attains a diameter of two feet and grows tall and straight. Occasional large cottonwoods (*Populus balsamifera*) also occur, and clusters of well grown and tall birches. The alder and high-bush cranberry abound as an undergrowth. On the higher terraces, spruce and aspen characterize the damper and more sheltered localities, while elsewhere, the scrub pine, tall and straight, forms the forest.

Second great bend of Nechacco.

The river from this point, making a second considerable bend, turns almost directly northward. At its angle it is joined by a brook about twenty feet wide by nine inches deep, with a rapid current through the valley of which the railway location line was carried. The Nechacco then, for about five miles, flows through a broken hilly region, forming a spur of the Telegraph Range, in a deep, heavily wooded valley with steep sides. The hill slopes have been in many places thoroughly burnt over, and are now partly open and covered with wild pea and vetch, raspberry bushes and a varied herbaceous growth. The river is bordered by clay, sand, and gravel bluffs.

On emerging from the hilly country, the Nechacco continues northward to the vicinity of Fraser Lake in a low, level region, which for the most part appears to be thickly timbered along the borders. According to Mr. Bowman, who examined this part of the river by canoe, its current is uniform and tranquil, with the exception of two small rapids, each of which was estimated to equal a descent of about two feet. The banks show frequent exposures of the white silts.

Reach Ta-chick Lake.

Leaving the river with our trail, while still involved in the hilly country, we steered north-eastward in the direction in which Ta-chick Lake was believed to be, and reached the Telegraph Trail on its south-eastern border on the 31st August, short of provisions, and with the pack animals nearly useless from the privations through which they had gone. The country intervening between the nearest part of Ta-chick Lake and the Nechacco River, to the west, is low, but slopes gradually up to the south. It has been for the most part pretty well cleared of heavy timber by fire, but still shows occasional patches of bad windfall. The higher ground is rather light and sandy, and forms undulating ridges; but on approaching the lake it became nearly level, and slopes gently down to the fertile land bordering it.

The country in the vicinity of Ta-chick and Nool-ki Lakes, stretching

PHOTO LITH. BY THE BURLAND DESBARATS CO. MONTREAL.

From Photo. Aug. 22nd, 1876.

RAPID ON UPPER NECHACCO, SOUTH OF FORT FRASER.
(*Tertiary Igneous and Sedimentary Rocks.*)

Appearance of country about Ta-chick Lake.

westward to Frazer Lake and eastward down the Nechacco, is generally level, or but gently undulating, and more fertile in appearance than any land before seen on the line of route followed. It is based on the very fertile white silts of the Lower Nechacco basin, with only occasional low ridges with gravel and boulders, which may belong to the underlying boulder-clay. Open groves and scattered park-like clumps of aspen poplars, with occasional areas of thicker woods, formed of scrub pine, alternate with meadows and open land, which is covered with a fine growth of natural grasses, wild pea and vetch. (See Plate V.) The slopes bear thickets of the service berry (*Amalanchier Canadensis*), which were covered with fine fruit in great profusion. On our way to Fort Fraser by the old Telegraph Trail, we found numerous families of Indians at work harvesting the berries, which we were told were more than usually abundant this year. They were fully ripe at the end of August. Near Fort Fraser, the choke-cherry (*Prunus Virginiana*) appears in some places on sunny northern banks, with the service berry; and it may here be mentioned that it was also found in similar localities on François Lake, and near Fort St. James on Stuart Lake.

Arrangements for expedition to François Lake.

On arriving at Fort Fraser I found myself, owing to the time occupied in the difficult country between Gatcho Lake and that point, too late to keep my appointment with Mr. Cambie, who had left some days before. Through the kindness of Mr. Alexander, in charge of the Hudson Bay Post, I was able, however, to obtain a re-supply of the more necessary provisions—there being, fortunately, sufficient flour and tea in the store—the loan of a fish-net, and a suitable dug-out canoe, with two Indians. Hiring an Indian boy to assist the packer, I sent him back for supplies to Blackwater Depot with such of the animals as were fit to travel, while we set out by water to examine Fraser and François Lakes in which, fourteen days were occupied. A general description of these lakes and the country in their vicinity will be given.

Valley of François and Fraser Lakes.

Broadly viewed, François and Fraser Lakes occupy the western portion of a depression, nearly coinciding with the fifty-fourth parallel of latitude. The upper part of the Nechacco—which we had followed in our former journey—reaching this depression from the south, immediately adopts it as its course, and receiving at its angle the stream from the two great lakes, flows almost directly eastward to the Fraser River at Fort George. The original cause, or mode of formation of this depression, I have not been able to determine, but it is paralleled by others of a similar character making important features in the topography of the country.

Fraser Lake (Nau-tley of the Indians) is about twelve miles in

Fraser Lake.

length, shallow at both ends, but apparently deep in its central portion. Its elevation is about 2,225 feet. It discharges eastward, over low ground forming a continuation of the trough in which it lies, on a part of which Fort Fraser is situated. The country about its west end is also low, and in part swampy. Near Fort Fraser, is the Indian village of Naul-tey, and at the other end that of Stella: each inhabited by a few families, the remnants of a once more numerous tribe, who appear to live in comparative comfort, and cultivate small garden patches, but are neither industrious nor cleanly.

The lake is bordered to the north and south by rather bold and broken hills, some of which, probably, rise from 600 to 800 feet above it, and are of Tertiary volcanic rocks. There are, however, in some places, patches of flat terrace country of considerable size, suitable for agriculture, where the bays of a former larger lake have been filled with sediment.

Terraces.

Benches are distinguishable on the higher slopes to a height estimated at over 200 feet above the lake, or 2,450 feet above the sea. The hills on the north side show a general tendency to form ranges, which run from the lake in a north-westward direction, with steep bluffy fronts south-westward, and longer slopes to the north-east.

The Douglas fir again appears in some abundance on the hills about Fraser Lake, though not observed in any part of the upper Nechacco country.

Stellako River.

The Stellako River, uniting François and Fraser Lakes, is wide and still at its mouth, on the south side of which the Indian village lies. On its north side it is joined by a stream called the En-da-ko, coming from a direction a little north of west, and navigable for canoes, one day's journey, to a lake which is described as not being very large. The Stellako soon becomes more rapid when followed up, and for the greater part of its course may be described as a succession of rapids, difficult for canoes, in consequence of their shallowness and the number of boulders and stones with which they are encumbered. In one place a fall of nearly five feet occurs, rendering a portage unavoidable, and in several other rapids it is necessary at most stages of water to lighten canoes before tracking them up.

The working time occupied in ascending by this river from Fraser to François Lake was ten hours twenty-five minutes. It is very tortuous, but in a straight line the distance is not more than six miles. The river is bordered in some places by terraces of rolled gravel and coarse sand, which from their number and arrangement show that it must have cut down by degrees to its present level. Granite cliffs, forty to fifty feet

Photo Lith. by the Burland Desbarats Co. Montreal.

From Photo. Sept. 1st, 1876.

VIEW AT FORT FRASER CROSSING OF NECHACCO RIVER.

high, occur in some places. The aspect of the country to the south is pleasing, being in great part open woodland, with some wide grassy meadows, and apparently a very fertile soil.

François Lake.

François Lake—more correctly called Lac de Francais, a translation of the Indian name Ne-to-bun-kut—has a length, according to my track survey, which was carefully checked by micrometer measurements, of fifty-seven and three-quarter miles, with an average width of about a mile and a-half, and an elevation of about 2,375 feet. It lies, in the main, nearly east and west, but is slightly sinuous, and shows a decided tendency to narrow at its western end. It resembles the valley of an ancient river, which from change in relative elevation of its lower end, or blocking of its outflow in some other way, had been converted into a lake. The two sides maintain a remarkable parallelism, following each other in their flexures so as to preserve the width of the lake nearly uniform, but there is a marked departure from the appearance usually seen in river valleys in one respect. The wider reaches of the lake appear rather to lie in the mountainous parts of its length than in those comparatively flat and low. On a larger scale François Lake repeats in most particulars the peculiarities of Tatla Lake, further south, which also bears a very similar relation to the mountains of the Coast Range. The depth of François Lake must, in most parts of its length, be great, the shores often sloping steeply down from the base of the high land surrounding it. Owing, no doubt, to its depth, it does not freeze readily in winter. The Indians say it remains open long after the snow covers the surrounding country, and in some mild winters does not freeze across at all. Generally, however, ice is formed and remains a short time, and in severe winters covers it for four months, but even then goes away much earlier than that of other neighbouring lakes. Fraser Lake, for instance, is said to be covered with ice every winter for about five months. The only other lake known to the Indians which behaves like François Lake, is Na-to-bun-kut or Babine Lake. The highest water-mark on the rocks was about four feet above the water level in September last. From the accounts of the Indians it nearly touched this mark early in the summer. The principal terrace on the lake was estimated to be about 100 feet above it, which, allowing for the difference of level of the two lakes, is about on the same horizon as that before noticed on Fraser Lake, and must have been produced at a time when the waters were united. On Tah-cho Mountain, terraces appear faintly marked, to a height probably 300 feet above the lake.

Terrace.

Outlet of the lake.

The outlet of François Lake is not situated at its extreme eastern end, which forms a *cul de sac*, the Stellako breaking out across its north-eastern side more than a mile from the bottom of the bay. The valley of the lake is continued in a direction S. 59° E. by a wide depression, which has much the appearance of having been at one time its draining valley. Near the east end of the lake stands a prominent hill called Tah-cho by the Indians, which may rise about 800 feet above its level. The north shore of the lake, for about twenty miles, with the exception of a few rocky hills of small height, is low, and in many places after rising pretty steeply a height of fifty to 100 feet, runs back a long way before attaining a much greater elevation. One little range of hills, occurring about midway in this distance, reaches a height of 800 feet above the lake, but rises very gradually from it. The soil appears to be fertile. The south shore is much rougher and more abrupt in its character, attaining a height of 300 to 400 or 500 feet above the lake, within a mile of the shore, and in some places showing rugged and rocky slopes. It is also in general pretty heavily timbered, contrasting with the partly open character of the opposite side. Low, sandy and gravelly flats, running out as points into the lake, and fringed along the shore with white-barked cottonwood trees, are not uncommon in all parts of the lake, and add greatly to its beauty. Un-cha Brook, coming from a lake of the same name to the south, enters François Lake at the distance above named, from its lower end. The Indians leave their canoes here, and proceed overland to Un-cha Lake, which appears to be a place of some importance among them, probably from the abundance of fish. About twenty-two miles up the lake, rather prominent mountains rise on either side, that to the north being called Ta-tzan-ta-cho-nun, that to the south Hun-cha-yuz. The first named was estimated to have a height of over 800 feet, and rises steeply for a mile or more along the shore of the lake, with bare, grassy and stony slopes. It falls gradually northward to lower country, which was not seen. Hun-cha-yuz, probably over 1,000 feet in height, forms a prominent landmark from many parts of the lake; its highest summit, which is rounded, lies some distance south of the lake, its greatest length being nearly transverse to that of the lake.

Tah-cho Mountain.

Un-cha Brook.

Mountains bordering on the lake.

Fine country.

The south shore continues generally low from this point to the upper end of the lake, a distance of about thirty-two miles, seldom rising more than 100 feet above it. The steep slope actually bordering the lake is usually thickly wooded, but the country beyond, as seen from a height, is much less densely tree clad, poplar and pine woods alternating with much open grassy country. The surface, though occasionally rising in hills 300 to nearly 800 feet above the lake, is in the main gently undulating, and of a fertile and attractive appearance.

Ches-nun Mountain.

The north shore, for about eight miles beyond the hills of the Ta-tzan-ta-cho nun range, is low and resembles that just described. The next eight miles is more broken, the disturbance finally culminating in Ches-nun Mountain. This is formed at its summit of basaltic rock, which stands out in a salient point toward the lake, with a perpendicular cliff about eighty feet high, which forms the crest of a steep and stony slope rising from the lake shore. Its height is 800 feet, and it affords a magnificent view, embracing nearly the whole valley of François Lake, with many peaks of the distant Coast Range and its eastern outlyers, Toot-i-ai Mountain to the south, and many other ranges. The summit of Ches-nun stretches northward some distance from the lake without falling much in elevation, and the high land connected with it runs north-westward, forming the north-eastern boundary of an extensive area of flat low land, which borders on the lake for ten miles westward. This, like the low country already described, is partly open, the woodland being chiefly of aspen poplar. The service berry is abundant, and the rank growth of grass, mingled with tall fire weed (*Epilobium angustifolium*) cow parsnip (*Heracleum lanatum*) and tangled masses of wild pea and vetch, evidence the great fertility of the soil. Rounded pebbles of rocks, differing from those of the mountain itself, are found on the summit of Ches-nun.

Fertile land.

Na-di-na-ko.

Five miles from the west end of the lake is a prominent hill, of which I did not learn the name, surrounded by broken country. A low sandy beach about half a mile in length, with flat country behind it, forms the upper end of the lake. No streams of importance enter the lake from either its southern or northern sides. The Na-di-na-ko, flowing in from the valley which continues westward from the head of the lake, is wide and still at the mouth, but on following it up is soon found to become shallow and very tortuous, with a rapid current in places. Three miles from its mouth it was only thirty feet wide by nine inches deep on the 12th of September, and here we found it necessary to turn back with our heavily laden canoe. It must rise in the vicinity of Na-di-na Mountain, from its Indian name, which simply means Nadina River, and is no doubt appropriate. At certain seasons it must be very greatly increased in volume by the melting snow, to judge by the large trees which it has brought down and which now lie stranded at its mouth. These also show that fine timber must exist in its upper valley. Na-di-na Mountain is a bold peak, situated, by rough triangulation, fourteen mi'es west-

Na-di-na Mountain.

north-west of the end of François Lake. Its elevation above the lake—ascertained in terms of the distance by the micrometer telescope—is 2,880 feet, or above the sea 5,255 feet. It is symmetrical in form, blunt topped, and rises conspicuously in a low country. The view from its summit must be very fine, embracing the region between the west end of François Lake and the Coast Range, in which a tributary of the Skeena is reported to rise. My Indians were, unfortunately, found to be quite ignorant of this part of the country, not knowing whether any trail existed to the vicinity of the mountain or not, and, with the limited time at command, it was thought best to abandon the idea of visiting it.

Islands.

In François Lake there are in all eight islands. The largest, Noo-cho, with two smaller ones—one of those a mere rock—is situated near the north shore, five miles from the upper end of the lake. Two very small gravelly islets occur near the south shore, thirteen miles from the head of the lake, and Tat-gaz-noo Island, also near the south shore, twenty miles from the same place. Eight miles from the east end of the lake are two more small but high islands.

Forest trees.

The foliage of the country around François Lake is much more varied than usual. Engelmann's spruce is pretty abundant, especially on the shaded southern banks, the Douglas fir common in the hilly country, *Abies lasiocarpa*, is rare. The scrub pine occurs, though rather sparingly. A juniper (*J. Virginiana*) was noticed in some places becoming arboreal, attaining a height of twenty feet, with a diameter of trunk of fourteen inches, and rough ropy bark like the cedar. Aspen poplar abounds, and fine trees of the balsam poplar occur along the shores. White and black birch occur, while alders and willows attain a tree-like growth on low alluvial points. The service-berry reaches in some places a height of twelve feet, the choke-cherry grows as a shrub on sunny slopes, and thickets of the high-bush cranberry, heavy with fruit, were found in shady localities. On September 16th the poplars were beginning to turn sensibly yellow.

Possibility of agriculture.

A very considerable area of the low undulating country near François Lake lies beneath the three thousand foot contour line, a great part of it having, perhaps, a mean altitude of 2,500 feet. If severe summer frosts do not occur, this region should be useful agriculturally, and, judging from the flora alone, I think there can be little doubt that most of it would be suited at least to the growth of barley, oats, and the hardier root crops. The soil is very fertile, and the country in general, like that about Fraser Lake, well suited to the support of stock. The area of the lower undulating and level country in the neighbourhood of François Lake may be estimated, very roughly, at about 200 square miles.

Reach Fort Fraser.

We reached Fort Fraser on our return, on the afternoon of September 20, and after making the necessary arrangements with regard to supplies and payment of Indians, I set out on the 23rd by the trail to Stuart Lake, sending Mr. Bowman in a canoe to examine a part of the Nechacco south of Fort Fraser, where coal was reported to exist. The trail from Fort Fraser to Stuart Lake is used by the Hudson Bay Company, and is not in very bad order. According to my track-survey, a line drawn from Fort Fraser to Fort St. James on Stuart Lake, runs about thirty degrees east of true north, giving the lakes a relative position very different from that which they are made to occupy on the published maps. The distance between the two places I estimate at about thirty miles in a straight line. By following a north-eastward course from Fort Fraser, and then turning north, a route between the two forts could be made over low ground, but the trail running directly northward from Fort Fraser gradually rises, skirting for a few miles a low range of hills on the west, and then ascending more rapidly the southern slope of a high ridge which runs nearly east and west. A remarkable notch or gap in the crest of this ridge, called the Porte d'Enfer, conducts the trail across it, at an elevation of 3,790 feet. A descent is then made to the valley of a brook which runs westward, and a second broad-topped ridge next passed over at a height of 4,910 feet. Both these are covered with material resembling the boulder clay of my report of last year, and holding rolled and travelled stones. Gradually descending again to flat country, Whool-tan or Kwa Lake, and a small sheet of water known as Chaz-kan are passed, and the shore of Stuart Lake reached at the mouth of Sowchee Brook, a rapid stream about ten feet wide by six inches deep. *Abies lasiocarpa* is quite abundant on the two high ridges, while well grown Douglas firs, over three feet in diameter, and tall straight aspens occur near Stuart Lake. Its southern shore is bordered by tiers of moraine mounds. Little land suited to agriculture occurs on this route, but the low country to the east is seen to be very extensive, and appears to have a fertile soil.

Trail between Fraser and Stuart Lakes.

Boulder clay at high levels.

Moraines.

Crops at Fort St. James.

At Fort St. James we found in Mr. Gavin Hamilton's garden fine cabbages, cauliflowers, turnips, beets, carrots and onions, grown from seed in the open air without forcing. Barley and potatoes are grown on a larger scale, for use in the fort. In his flower garden, notwithstanding the rather severe frost of the evening of September 26th, a species of mallow, mignonnette, a mesembryanthemum, portulaca and sweet-pea were still flourishing. On the evening of September 23rd, a light flurry of snow was experienced on the high ridges above mentioned, but fell in the form of rain at lower levels.

The vicinity of Stuart Lake is described more fully by yourself in the report for 1875-76.

Descend the Nechacco.

On the 2nd of October, I left Fort Fraser with two Fraser Lake Indians—Ja-sen and Be-ni-ta—to descend the Lower Nechacco in a canoe to Fort George, sending the pack animals by the trail to the same place. This portion of the river flows, for the most part, through a low fertile country, no high hills being visible in any direction. It offers some geological features of interest, which will be referred to elsewhere, but need not occupy much time in its general description.

Fertile land.

Rapids.

About a mile below the junction of the Fraser Lake stream, a rather troublesome stony rapid occurs, with low cliffs of basalt at the sides. Low fertile-looking land borders the river for six miles from the same point, when the stream becomes contracted and rapid, and, suddenly turning northward, breaks through some low rocky hills. Three miles further on occurs a second rapid, with small rocky islets, and from this point to the junction of the Stuart River—a distance of thirty-one miles in a straight line—the river, though making a few abrupt turns, in the main pursues a pretty direct course through a fertile country generally wooded with poplar, which seldom rises fifty feet above the water level on the upper part of the stream, but as the river descends, eventually appears to stand about 100 feet above it. Below the mouth of Sin-kut Creek, however, a few rounded hills, a little over 100 feet in height, occur on the south side.

Confluence of Stuart and Nechacco.

Isle de Pierre Rapid.

White-mud Rapid.

The confluence of the Stuart and Nechacco Rivers is known to the Indians as Chin-lak. For nine and a-half miles below this, the ordinary flat country borders the stream on both sides, several lower benches extending between the river and the general level of the plain, generally with rather sandy soil. The river here turns northward, and describes a semi-circle in passing through a low range of rocky hills, on the east side of which is the Isle de Pierre Rapid, one of the worst in the river. From this place to the mouth of the Chilacco—a distance of twelve miles in a direct course—the river is rather crooked, and is depressed from 150 to 200 feet below the general level of the surface of the country. A mile above the Chilacco the Na-tsen-kuz or White-mud Rapid is formed by a projecting bed of basalt, underlain by soft Tertiary clays. From the mouth of the Chilacco to Fort George, at the confluence of the Nechacco and Fraser—ten miles—the river makes double this distance, in a great loop, with many minor convolutions. It is rapid throughout, and in many places shallow.

White silts and shingle beds.

On the upper part of the Lower Nechacco many sections of the fine white silts, already referred to, occur. Below the mouth of the Chilacco these do not continue to appear, but seem to blend with thick beds of rounded shingle, which are shown in numerous cliffs at the convex bends of the river, and in one place, near Fort George, form the great gravel cliff, 200 feet in height, known to the Indians as Uz-us-ki-whal-kla, which is mentioned in last year's report. With this change in the character of the deposit, the soil appears to become less uniformly fertile.

Agriculture at Fort George.

At Fort George, wheat and grain of all sorts can be grown successfully. Very fine and large potatoes were being dug at the time of my visit, and on October 10th the stalks were frost-killed, with the exception of the lower leaves.

Chilacco Valley.

Having paid off my two Indians, I waited at Fort George several days for the pack-train, which finally arriving, we set out by the trail down the Chilacco River for Blackwater Depôt and Quesnel. The lower part of the valley of the Chilacco is wide and flat-bottomed, probably averaging about a mile from rim to rim. It forms a great trough in the generally level surface of the country, and is margined by abrupt slopes, with occasional bare bluffs of the white silts. Some parts of the bottom-land are heavily timbered with Douglas fir, Engelmann's spruce, and *Abies lasiocarpa*, tall and straight; the two former often reaching a diameter of three feet. There are a good many extensive patches of open grassy land, elevated from five to ten feet above the river, and covered with a heavy growth of grass, from four to five feet high in places, and mixed with the *Heracleum* and other rank weeds. These flats seem to be more or less subject to flood, but the soil must be very fertile. At occasional intervals, fine groves of cottonwood are found, the trees often of great height, and sometimes five feet in diameter. Further up, the valley becomes more contracted, especially near the base of the Double-headed Mountain, there averaging probably not more than half a mile in width. The surface of the plateau or plain above is formed of the disintegrated material of the white silts, and which bears a good growth of timber, where fire has not passed.

Double-headed Mountain.

Southern edge of white silts.

Above the Double-headed Mountain, the river valley again opens out, forming, eventually, a wide shallow depression, which slopes gradually up towards the high country, near the north bank of the Blackwater. The white silt deposits are here lost, the stony boulder clay, with its usual appearance, again coming to the surface.

On October 12th the poplars were here quite bare, and heavy frosts occurred at night. The Devil's Club (*Echinopanax horrida*) was found in several places in the Chilacco Valley, indicating a greater rainfall than usual in this part of the interior.

Return to Quesnel.

We arrived at Quesnel on October 19th, when, after having made the necessary arrangements with regard to the storing of our tents and equipment, I made a short visit to Cariboo with Mr. Bowman, returning to Quesnel on the 28th. A few days in November—from the first to the seventh—were occupied in a hurried examination of the Kamloops and Nicola valleys, and on November 11th Victoria was again reached.

Geological Observations.

Boundaries and area of region examined.

It will be observed that the region to which most attention was devoted last season lies between latitudes 52° 30′ and 54° 10′; longitudes 122° 50′ and 126° 40′; the object being to acquire at least an approximate knowledge of the structure of some 15,000 square miles of surface. The explorations, while leading to some important results in regard to the mutual relations of the rocks of the mainland of British Columbia, have introduced some new elements of uncertainty, which the country examined, from its wooded and difficult character, was not suited to explain. It may now, however, be affirmed with considerable certainty, that the rocks called the Porphyrite series in last year's report, underlie, probably conformably, the fossiliferous series of Tatlayoco Lake; and, consequently, bear the same relation to the Jackass Mountain beds of the preliminary classification. This inference is chiefly based on the fossils discovered on the Iltasyouco River, described by Mr. Whiteaves in an appended Note. A second point of interest is the discovery of *Fusulina* in the Lower Cache Creek limestones of Stuart's Lake, fixing a horizon of great importance in the rock series of the country, and correlating these with the wide-spread *Fusulina* limestones of other parts of the West.

Characteristic fossils discovered.

Method pursued in describing rocks.

These and other points, will, however, be more fully noticed in the following pages, in which the rocks observed will be grouped, as far as possible, under the classification already adopted, it being better to avoid change in nomenclature till many points yet in doubt have been settled. It should also be premised that, in some instances, considerable doubt may obtain in regard to the relations of the rocks of isolated exposures; but in all cases, while classing such rocks provisionally, it will be endeavoured to retain the identity of the locality; so that such changes as future study may necessitate may be made without their re-examination.

No new facts of importance were obtained, in the region examined, regarding the rocks classed as the Cascade Crystalline series.

Lower Cache Creek series.

Lower Cache Creek Series.—An excursion from Fort Fraser to Stuart Lake, with the special object of ascertaining the relation of these beds with the Mesozoic series to the west, was unsuccessful in this respect, as immediately on leaving Fraser Lake the surface was found to be occupied by Tertiary volcanic rocks, which continue to within a few miles of Stuart Lake. Three miles from Stuart Lake by the trail, and on the bank of Sow-che Brook, occurs a small but prominent exposure, referable with little doubt to this formation. The rock is a dark, greenish-black. indurated clay-slate, with rusty joints. This is the nearest exposure to the north-eastern edge of the basalts in this place ; but the drift for some miles southward is largely composed of fragments of rocks of the same series, which also characterise the beach of the south shore of Stuart Lake.

Limestones of Stuart Lake.

On crossing to Fort St. James, on the north-east side of the lake, near its outlet, the massive limestones described in your report for 1875–76, (p. 78) are met with. These, from the south shore. appear to form the entire mass of the mountains along the north-east border of the lake, including that called Pope's Cradle, which rises 2,600 feet above it. This mountain is known to the Indians as Na-katl, and strikingly resembles, in its form and general freedom from forest covering, some of the limestone peaks of the Rocky Mountains. From the mouth of Sow-che Brook, the furthest summits of the limestone range of which this forms a part, bear N. 33° W., at an estimated distance of about forty miles; and if the map, in its present very imperfect form, is to be at all trusted, should lie between Tremble or Cross Lake, and Tacla Lake.

The rocks near Fort St. James are chiefly limestones, of varied, and in some cases very peculiar appearance, but these are interstratified with cherty siliceous bands, exactly resembling the characteristic quartzites of this series elsewhere. The general strike is N. 48° W., and the beds are on edge, or very nearly so. The limestone, when weathered, is generally pale-grey to nearly white, and presents rough surfaces from the prominence of its silicified portions. The silicification has in some places affected bands following the stratification, several feet in thickness, which are often bounded above and below by sharp lines of division from the more calcareous beds. Some of the silicified layers appear originally to have been sandstones, in which silica, penetrating in solution, has replaced all calcareous portions and filled the interstices. Such seldom show traces of fossils. Other layers, while still in the main siliceous, become roughly

Silicified layers.

Mode of preservation of fossils.

porous on weathering, from the removal of calcareous matter, which here constitutes the substance of the organic fragments. In the limestone proper, the organisms are usually themselves silicified, projecting above the surface on weathering; and so clear in many instances is the line between the calcareous and siliceous belts, that the finger may actually be laid on the surface so as to rest at one side on calcareous fossils in a silicious matrix; on the other, on silicified fossils, in a matrix of limestone. In some parts of the limestone siliceous blotches also appear irregularly.

Brecciated limestone.

In certain layers the limestone itself is brecciated, a granular calcareous material filling the crevices between more compact fragments of varied texture. The brecciation has probably occurred almost contemporaneously with the deposition of the rock, and long anterior to the solfataric action which appears to have caused the deposit of silica, and which has resulted in the infiltration with this material, over great areas, of thick masses of the slaty and arenaceous beds of the formation; and the production in these and in the limestones of innumerable seams of quartz. The quartz veins traversing the rocks, however, seem to contain little or no gold, for in some parts of the shore of Stuart Lake, in great measure formed of quartz fragments, not even a "colour" of gold could be found on washing.

Fusulinæ.

The most interesting, and at the same time the most abundant fossils contained in the limestone are the *Fusulinæ*, already referred to. The best preserved specimens of this fossil agree closely with those from Shasta County, California, called *Fusulina robusta* by Meek. Its form is about the same, but it shows transitions towards the typical *F. cylindrica*. The length of the largest specimens is nearly the same as that given as the maximum of *F. robusta*, but the breadth of these best developed examples is less in proportion. Following Dr. C. A. White, however, it may be best to refer all these forms to *F. cylindrica*, as varieties, in which Fusulina may have been as prolific as most modern Foraminifera.

Fusuline limestone of the West.

The fusuline limestone is probably the most certainly fixed palæontological horizon of the west, and has been recognised from the Mississippi to the Pacific, the Arctic coast to California. The nearest known localities of the fossil to that of Stuart Lake, are those in the Rocky Mountains described by Dr. Hector. The genus Fusulina is characteristically Carboniferous, but according to Lyell, reaches in some places to the Permian formation.

Great numbers of discs of encrinal columns also occur in the Stuart

Lake limestones with imperfect specimens of a coral like *Alveolites.* A microscopical examination led to the discovery of no smaller foraminiferal organisms, but showed, that notwithstanding the perfect preservation of the outward forms of the Fusulinæ, their more minute internal characters have for the most part disappeared. At the junction of the calcareous and siliceous bands, the crystalline, transparent siliceous matter is seen under the microscope in irregularly scattered blotches in the less transparent calcareous matrix.

Quartzites and slates on Lower Neehaceo.

Seven miles below the junction of the Fraser Lake stream with the Nechacco, rocks referable to the Lower Cache Creek series again appear from below the Tertiary volcanic products. They are first seen at a small rapid in the river, as hard greenish and greyish-green quartzites, with blackish slaty beds; the former spotted and streaked persistently with darker colours, which for the most part follow irregular crack and jointage lines. The strike is here N. 23° W., the strata being vertical or very nearly so. Four miles further down the river are several exposures of dark, banded quartzites, with schistose beds, softer, and containing enough anthracitic carbon to render them bright. These, and the associated quartzites, very much resemble the rocks near Blackwater Bridge, described in last year's report. (p. 249) The beds are all nearly vertical, with strike varying from N. 3° W., to N. 18° W.; the latter being the most general. No further exposures of rocks of this age occur on the Lower Nechacco, and the region in which the thick limestones of Stuart Lake would be expected to appear, is covered with Tertiary and Drift deposits.

Fraser between Fort George and Quesnel.

The Fraser River, from the mouth of the Nechacco to Quesnel—seventy miles—though examined with yourself in the autumn of 1875, has not yet been reported on; and as the rocks seen on the Nechacco run across the intervening country and reappear on the Fraser, it may be well to describe briefly the exposures on the latter.

At the great bend, eleven miles above the mouth of the Blackwater, beds of the Nechacco series, shortly to be described, are found A short distance lower down, these are complicated by the appearance of a great mass of diorite of uncertain origin; beyond which rocks of the Nechacco series again appear, and are then succeeded about six miles above the Blackwater, by blackish and bluish-black glistening shists, more metamorphosed than the rocks previously seen, but not differing very much in texture from them. The nature of the junction of the two series was not observed, but the strikes are parallel. In descending the stream, similar thin-bedded rocks ,more or less silky and occasionally talcose, continue to near the head of Cottonwood Cañon, eight miles below the Blackwater. At the lower end of the cañon the rocks are thin-bedded, flinty quartzites and schists, much contorted and weathering yellow, alternating with darker, often bluish-black layers. These rocks are evidently of the Lower Cache Creek series, but agree in their strike with those last described. They are seen in several other places between the cañon and Quesnel, and at the latter place, below Tertiary beds. The silky and chloritic schists resemble the gold rocks of Cariboo, and probably represent them, but seem to adhere to the Cache Creek beds so closely that they have been united on the map under a single colour.

Porphyrite series.

Porphyrite Series.—The most interesting and typical sections of these rocks examined last summer are those in the vicinity of the Iltasyouco, and Islaho or Salmon Rivers. The rocks here seen represent those described last year on Tatlayoco Lake, and though they have not been again observed in contact with the upper arenaceous and conglomerate beds of the Tatlayoco Lake sections, the discovery of fossils on the Iltasyouco River of a horizon close to, though probably lower than that of the Jackass Mountain group, together with additional evidence tending to show the blending of the ordinary aqueous sediments of the upper part of the Jackass Mountain series with the igneous products of the Porphyrite series, leaves little room for doubt that the latter is the downward continuation of the former, and that the whole constitutes a formation, bridging to some extent the gap ordinarily found between the Cretaceous and Jurassic. During the past season, doleritic and somewhat basic rocks have been found to occupy a more prominent place in some parts of the Porphyrite series than previously observed, but as representing its most marked characteristic the name Porphyrite may still be retained, till more complete knowledge of the extent and relations of the beds are obtained. It appears safer, in the necessarily somewhat disconnected examination of an extensive territory like British Columbia, to apply local names where convenient, even at the risk of appearing to complicate the subject, rather than to attempt at first to formulate the rocks too rigidly under a few classes. The gradual elimination of these from ordinary use will follow, as facts by which a complete palæontological classification can be formed, are accumulated.

Nomenclature of formations.

On passing, in the vicinity of the Salmon and Iltasyouco Rivers, from the region underlaid by basalt, with its generally plateau-like character, to that of the older volcanic rocks of the Porphyrite series, the surface is found to assume a "lumpy" and irregular appearance, locally characteristic of these rocks. The district is, for the most part densely forest-clad, but little knolls or abrupt rocky hills of rock very frequently project through the vegetable mould and mossy covering. These continue to increase in importance on approaching the eastern base of the Cascade or Coast Range, and eventually rise to form the rugged and rocky hills which here form its flanking ridges.

Section of the Porphyrite series.

The best section of the Porphyrite series obtained, was measured in the forest north of the Salmon River Fall, described on page 28. The rocks are not continuously exposed, but are generally seen at frequent intervals. The lowest observed, is a rough feldspathic breccia, of which the paste is greyish, and holds angular and irregular fragments of compact feldspathic rock, generally of pale tints, and sometimes several inches in diameter. Occasional small rounded pieces were also seen, which, when freshly exposed, are almost as soft as wax, but eventually become somewhat harder. Some of the more compact felsitic fragments are marked with fine twisted lamination surfaces, in a peculiar manner. Above this is a considerable thickness of dark, blackish-grey hornblende-porphyrite, with pale-grey, imperfectly-formed feldspar crystals, and black hornblende. These, together, constitute a thickness of about 180 feet. Next in order is a dark purplish porphyritic rock, which must have been a volcanic ash of fine grain, but is now very compact. Above this is a grey-green porphyrite, with rather large glimmering crystals scarcely distinguishable in tint from the matrix. This is overlaid by a fine-grained grey rock, resembling a diorite, but probably a diabase—of a type common in these rocks, and more fully described on a subsequent page—above which is another bed of breccia, probably near 200 feet in thickness, the lower part resembling that already described, while above, in some layers, the fragments become more or less perfectly rounded, as if by water action, and the matrix shows green cupreous stains. Overlying the last, 235 feet of the section is represented by porphyrites, seen in a few places only, but varying from grey to purple; those of the latter tint forming a hard, finely granular rock, in which feldspar crystals are often scarcely distinguishable. The next 240 feet shows in two places dolerite, or diabase, of the usual character; over which comes greyish compact felsite, with some hornblendic blotches, succeeded by a blackish diorite. Above the last, a thickness of 950 feet is built up—as far as the exposures allow the composition to be ascertained—of dark porphyrites and felsites, sometimes very fine-grained, with one bed, near the top, of a rather remarkable character. This appears to be a tuff, of a kind not uncommon in the Tertiary

Altered tuff.

series, but here much altered. The mass, which is yellowish-grey in colour, and still somewhat porous, is traversed in all directions by irregular blackish streaks, and holds occasional compact feldspathic fragments, with small scattered pinkish feldspar crystals.

Thickness of beds shown.

The total thickness of the rocks included in this section is about 2,290 feet. No beds like ordinary aqueous sediments were observed, and scarcely any evidence of water action, greater than that required to spread out those materials which must originally have been volcanic ashes or tuffs. Nearly all are more or less calcareous. The rocks of this series seen at other places on this part of the Salmon River, are very similar in character. Seven miles below the crossing of the Indian trail, the rock is seen in several places near the river, with a general dip of S. 61° W. < 35°. The beds are greenish and greyish-green porphyrites and breccias. Five miles further down the river, and not far from the base of the measured section, the lowest rock seen (station 3,483, C. P. R. S.) has a pale, reddish feldspathic base, speckled,—apparently by the decomposition of particles of pyrites—blotched with larger crystals of yellowish feldspar, and containing scattered quartz crystals, which differ from those of ordinary granites, and resemble those of quartz-porphyry in having developed their crystalline form irrespective of the minerals of the matrix. There are also a few small scales of talc imbedded in a similar manner. Whether this rock forms an intrusion, or is an altered material, I was unable satisfactorily to determine; but resting on it, at the foot of a little rapid, is a very compact, dull-red feldspathic rock, with small white feldspar crystals porphyritically imbedded, which dips S. 46° W. < 30°, and is followed in ascending order by a considerable thickness of porphyrites of varied tints, and feldspathic breccias. In one of the latter was found a small black cherty fragment, resembling the quartzite of the Lower Cache Creek group, and distinctly rounded by water action.

Lowest rock seen.

Rocks at mouth of Iltasyouco.

At the Salmon River Fall, the rock is a homogeneous grey-green porphyrite, with glimmering feldspar crystals, scarcely distinguishable from the base except in certain lights. The dip is N. 34° W. < 70°.

The narrow point at the junction of the Iltasyouco and Salmon Rivers, at the water's edge is composed of a rock, which, though containing no quartz crystals, otherwise much resembles that described above as elsewhere forming one of the lowest in the section. The matrix as before. is a feldspar of a dull pale-pink tint, and is minutely speckled with a dark mineral, which may be hornblende. Scattered through it are large pale-greenish crystals, which show the striation characteristic of triclinic feldspars, and are associated with, and sometimes penetrated by, smaller dark-green crystals, probably hornblende. The rock is laminated, the planes appearing to represent the true dip, and agreeing very nearly in direction with that of the neighbouring exposures, which distinctly belong to the Porphyrite series. I am in doubt whether to look upon this rock as forming a part of the Porphyrite series, or of an inferior group of rocks, or possibly representing an intrusion. As a similar material, however, is associated with the porphyrites in other localities, without showing any additional reason for accepting either of the following alternatives; and as rocks apparently transitional in character between this and the less-altered sediments and flows of other parts of the region occur, I am inclined to believe that it has been produced by the exceptionally perfect crystallization of a bed, perhaps suited by its composition for easy metamorphism.

Overlying this rock, apparently on all sides, are dull purple porphyrites resembling those already described in several localities, but here holding little masses of white calcite, which have probably originally filled amygdaloidal cavities, but are now shapeless.

Rocks at Iltasyouco Fall

A mile and a-half from the mouth of the Iltasyouco, is the fall already described, at which is a fine exposure of close-grained bluish felsites, generally rather thick-bedded, and seldom showing much porphyritic structure. The total thickness of beds of this character here exposed must be over 150 feet. In one place only, near the top of the section, is a little fine breccia seen. These beds, though considerably disturbed a short distance above the fall, are very regular in its vicinity, with a dip N. 6° E. $<$ 18°; and are probably much higher in the series than those last described. Below the first leap of the fall, a broad even stratification-surface, sloping at the above angle, is exposed. It is indented in many places with little pits, nearly circular in outline, and from half an inch to an inch in depth, almost resembling the borings of a lithodomous mollusc, but probably caused by the weathering out of softer concretions, —perhaps calcareons. Fossils also occur, though quite sparingly. A fine impression of an ammonite was seen, but so imbedded as to be impossible to break out; also casts of *Belemnites*, a *Pinna*, and an *Inoceramus*. The lithological character of these rocks is more minutely described on a following page.

Fossils.

No good exposures occur near the river, for about three miles above the fall, when the rocks are again well shown for some distance. They were here minutely observed, and measured, and were found in certain bands to be highly fossiliferous. The beds, as a whole, may be

Description of section, including fossils.

described as compact, bluish and greenish-grey felstones, often porphyritic with small imbedded crystals, and all apparently composed of volcanic material, which must, however, have been a very fine mud in some cases. A bed of fine-grained diabase is the highest in the series, and overlies by a few feet only, the bed in which fossils were first discovered. The rocks are all more or less calcareous, including the diabase, and some bands are so highly charged with lime that they might almost be called impure limestone. In most cases, however, the calcareous matter fills small irregular cavities, which form minute pits and holes on weathered surfaces. The bedding is generally very perfect, though the beds are often thick; but some layers are only a few inches in thickness, and occasionally even shaly. Where large bedding-surfaces are exposed, the uniform character of the deposit is apparent, and in at least one case, the surface is so shaped as to imply the action of flowing water, though the rippling has no determinate direction. One of the beds holds large nodular masses, which blend at the edges with the porphyritic matrix, but are much more calcareous, and include well preserved fossils. The lithological transition from these rocks, to those more distinctly crystalline and clearly volcanic in origin, is so complete, that there would be no reason to doubt that they belong to a single series, even without the evidence afforded by stratigraphy, though without such transition some of them might almost be called metamorphic clay-stones. Their resemblance to some rocks called blue quartzites in the Tatlayoco Lake section of last year is also close. The general direction of dip may be stated as N. 36° E., at an average angle of 35°, which would place these beds far above those at the Iltasyouco Fall. There can be little doubt but that this section is altogether higher in the series than that measured north of the Salmon River Fall, though what the extent of the gap may be, remains unknown. The two may, however, to give an idea of the alternation of beds in this formation, be arranged together in one scheme as follows. The upper section was measured with a tape, the lower by pacing. The beds follow in descending order.

The total thickness in both sections is nearly correct, though that assigned to each particular bed may not always be so, as the precise divisions were not often seen.

Measured section.

	FEET.
1. Fine-grained grey-green diabase, with an intercalated bed of blackish, shaly, feldspathic rock	35
2. Blackish hornblendic (?) porphyrite	64

	FEET.
3. Compact bluish porphyrite. Fossiliferous.	432
4. Compact bluish feldspathic rock. Fossiliferous.	
5. Compact bluish feldspathic rock. Surface ripple-marked.	
6. Finely spotted, bluish, feldspathic rock.	
7. Compact bluish rock. Fossiliferous.	
8. Greyish and pale greenish-grey feldspathic rock, with calcareous bands and nodules. Many fossils.	
9. Compact grey feldspathic rock.	
10. Dark greenish-grey feldspathic rock. A few fossils.	
	531
(Gap of unknown extent.)	
11. Dark porphyrites and felsites, with the altered tuff bed	280
12. Porphyrites, and concealed	670
13. Blackish diorite (?)	55
14. Greyish felsite	100
15. Dolerites or diabases (in part concealed)	240
16. Purplish porphyrite (in part concealed)	235
17. Breccia	200
18. Diorite (?)	30
19. Grey, and purplish porphyrites	300
20. Hornblende porphyrite	130
21. Breccia	50
	2,290

General distribution of rocks.

The general features of the distribution of these rocks about the junction of the Salmon and Iltasyouco appear pretty simple. The Salmon River, though somewhat tortuous, seems to follow the broken crest of an anticlinal which runs a little south of west. The Iltasyouco, on leaving Si-gut-lat Lake, flows almost due south to the Salmon River, joining it nearly at right angles. In the intervening angle the beds to the south dip away from the Salmon River anticlinal, and then bending northwestward, run obliquely across the Iltasyouco. Si-gut-lat Lake, to the north, lies in a valley parallel to that of the Salmon River, while the trough-like valley of the Iltasyouco unites them. At the spot already referred to, at the junction of the two rivers, very distinct crack or jointage lines traverse the rocks in two main directions—about N. 21° E., and S. 69° E. respectively. The latter appear to follow the anticlinal axis, while the former are part of a transverse series, which have defined the course of the Iltasyouco, and are again seen on a large scale, with exactly the same course, at the gorge of the fall.

Structure causing river valleys

The sections are not such as to allow the actual measurement of the series, as a whole, but taking all the local circumstances into account, Total thickness of series.

I scarcely hesitate to affirm that it must approach 10,000 feet in thickness.

The rocks forming hills on the north-west side of Si-gut-lat Lake, from their colour and appearance, no doubt belong to the Porphyrite series. Circumstances did not permit their examination, but I am indebted to Mr. W. B. Ross for several fossils found loose in this vicinity.

Rocks near Hatty Lake.

South of the Salmon River, on the Indian trail between Hatty and Tanyabunkut Lakes, rocks of this series again rise above the basaltic flows, forming broken hills about Hatty Lake, and a ridge which runs westward, and approaches Salmon River. The most prominent rock here is a volcanic breccia with a dip S. 41° W. $<$ 20°.

Intrusive granite.

The rocks about Tanyabunkut Lake are of the Tertiary volcanic series, but at its lower end is a group of low rounded hills, looking white from a distance, and composed of granite, which, on account of its association with the porphyrites, should be mentioned here. The mass is of considerable extent, and is evidently intrusive, not only from its mineralogical similarity with other similar rocks of which the relations are clearly seen, but also from the fact that it contains angular fragments of dioritic and feldspathic rocks probably derived from the Porphyrite series. The rock is a syenitic granite, of medium grain, and grey colour, with two species of feldspar—probably orthoclase and oligoclase—black hornblende, and occasional scales of dark mica. It would form a good building stone, but is probably too much jointed to be quarried in large blocks.

In continuing to approach the Salmon House by the trail, rock in place does not appear, but granite ceases to preponderate among the loose rock fragments, and is replaced by greyish, and greenish dioritic and feldspathic rocks, of the Porphyrite series. The next rock seen *in situ* is a fine-grained, dark porphyrite, perhaps containing enough hornblende to allow it to be classed as a diorite.

Much-altered Porphyrites.

About a mile and a-half further on, considerable exposures of reddish granite-like rocks, are seen. On closer examination, however, one variety of these rocks is found to resemble that described from the mouth of the Iltasyouco in every respect, save its generally reddish tint. In a second variety, closely allied to the last, the base is more coarsely crystalline and of flesh-red colour, while the porphyritically imbedded feldspar crystals are pale yellowish-red. These rocks have no apparent stratification, but, I am inclined to believe, are closely connected with the Porphyrite series, and even probably a more altered portion of it.

Rocks near the Salmon House.

No rocks are seen between this place and the steep hill above the Salmon House—about two miles. In the neighbourhood of the Salmon House, and on the Tahyesco, near its confluence with the Salmon River, though situated well within the eastern border of the Coast Range, all the rocks appear to be referable to the Porphyrite series, the contact of which with the Cascade Crystalline rocks proper, must lie further down the Salmon River, and was not observed; the hills and mountains, as far off as their characters are distinguishable, appear to be of similar rocks. They consist, broadly, of greyish to greyish-red porphyrites, with compact felstones, passing over through intermediate varieties into diabases and probably also dolerites and diorites, which are sometimes porphyritic, and occasionally spotted and blotched in such style as to point to concretionary action, or original amygdaloidal structure. On the Tahyesco, near the Indian bridge, these rocks are vertical, with a strike of S. 36° W., and are beautifully shown where worn smooth by the river. Across the stream, and further up it, they form cliffs several hundred feet in height, and from the vertical position of the beds, combined with jointage structure, present sometimes an almost columnar appearance, at a distance simulating basalts. The beds are generally from about a foot to six or ten feet thick, and show a tendency to irregularity in this respect, sometimes thinning out abruptly in one direction. They seem to have been for the most part, or entirely, igneous flows, and have not been water-bedded. In fine contrast to these dark rocks are irregular masses and dykes of bright-red granite, generally lenticular, and often including evident fragments of the surrounding rocks. The granite is composed of flesh-red feldspar and white quartz in nearly equal proportion, with sparsely-scattered irregular mica crystals. An intrusive rock, with compact grey felsitic base, and isolated perfectly formed pink feldspar crystals, occurs in thinner dykes, and may be a material similar to the granite, but cooled under different conditions. In the immediate vicinity of the building called by the Indians the Salmon House or Yeltas, the rocks are broken and complicated by a granitic intrusive mass, the existence of which, no doubt, has to do with the fall which here occurs in the river, and is utilised by the Indians in their salmon fishery.

Rocks on Tahyesco.

Granite dykes.

Junction of Tertiary and Porphyrite rocks.

In following the Indian trail southward from Tanyabunkut Lake toward the Bella Coola Valley, and then turning westward, (as described in a previous page under date July 13, 14, 15,) one travels in a wide valley between the Tsi-tsutl Range and eastern flanks of the Coast Range, nearly following the line of junction of the Tertiary volcanic rocks of the former, and older rocks, which may all belong to the Porphyrite series. In some places, however, these older beds are so much altered and schistose as to cause some doubt as to whether a portion should not be referred to the Cascade Crystalline series, but no line can be drawn between these and the more typical rocks of the Porphyrite formation. All the rocks are much disturbed, though preserving, as a whole, northerly and southerly strikes. Granitic intrusions are common, and in some places important. The rock is generally pale-reddish in colour, very often hornblendic, and sometimes scarcely contains any mica. Along the southern slope of the Tsi-tsutl Range, the line between the basaltic and other Tertiary flows, rising in successive terrace-like steps, and the more rugged and broken surface of the porphyrites, is very clearly marked, and the most distant view of the mountains enables one to distinguish between the two formations. The older volcanic series consists of more or less compact, greyish, greenish and purplish felsites and porphyrites, with occasional beds which are either fine-grained diorites or dolerites. In one locality, a considerable thickness of brecciated material was observed, but in most cases it is almost impossible now to tell which beds have been originally molten, and which composed of ashy fragments or tuffs. These beds, with general north-westward and south-eastward strikes, are tilted at high angles, in some places exceeding fifty degrees. The mountains to the northern rim of the Bella Coola Valley are composed of similar rocks, which, no doubt, also appear in the sides of that wonderful depression

Granitic intrusions.

Lithological character of Porphyrite rocks.

The following is a detail of the more minute characters of some typical rocks of the Porphyrite series, as ascertained microscopically and before the blowpipe.

Iltasyouco Fall and River.

Iltasyouco Fall.—Fine bluish felsite, with conchoidal fracture, holding scattered cubes of pyrites a line in diameter. Holds fossils, as before described; is bedded, and probably represents a fine-grained ash rock. Fuses under the blowpipe to a grey porous glass. Base finely granular, clouded, rather opaque, with scattered transparent feldspar crystals, which are brought out more clearly, together with many before invisible by the polariscope. Small grains of magnetite. Feldspar crystals evidently formed during metamorphism and not mechanically included.

Iltasyouco River.—(No. 9 in section.)—Material forming roughly lenticular nodules, in beds of indurated volcanic ash (porphyrite). Highly calcareous; fuses readily before blowpipe. Base resembles the last and next described, but with a large proportion of calcareous matter, rendering the whole more transparent. Small fragments of shells and other organisms, including chambers of foraminifera and perhaps crinoids.

Si-gut-lat Lake.

Si-gut-lat Lake.—Grey porphyrite, holding fossils as above described. An ash rock. Fuses on the edges to a grey glass. Brownish opaque granular base, with large feldspar crystals, and masses, not evidently crystalline. Many of the crystals have been broken and imbedded as they are now found. Part, at least, of orthoclase feldspar.

Tahyesco River.

Tahyesco River, near Salmon House.—A grey porphyrite; probably altered trap. With the blowpipe fuses easily. Base granular, but differing from that of those above described as altered ash rocks, in being somewhat coarser, and its granules evidently little crystals not mechanically imbedded. Small scattered octahedrons of magnetite. Porphyritic, with large whitish, rather opaque, and apparently somewhat altered feldspar crystals. Smaller crystals of pyroxene also porphyritically imbedded, and in most cases surrounded by masses of chloritic material formed by their decomposition.

Tahyesco River, near Salmon House.—Probably altered trap. Green-grey spotted rock. A confused crystalline aggregate of feldspar crystals, somewhat decomposed and opaque. Many grains of magnetite. Fine acicular crystals of apatite (?) and large patches of a chloritic mineral. Probably a diabase.

Tahyesco River, near Bella Coola.—Rock spotted with different colours, and probably a volcanic breccia or agglomerate of fine grain. The fragments have been flattened parallel to cleavage or bedding planes by subsequent pressure. Before the blowpipe, fuses. Base laminated, with very indefinite lenticular outlines indicating the original fragments, which are sometimes darker, at others more transparent than the matrix. Grains of magnetite. More highly magnified the whole is found to be granular, and probably in great part feldspathic.

Having now described the rocks of the more typical exposures of the Porphyrite series met with last season in the vicinity of the Salmon, Bella Coola and Iltasyouco Rivers, the age of which is fixed with some certainty by the fossils found at the last-named locality, it will be necessary to mention more briefly those other localities—in none of which distinctive fossils were found—in regard to the reference of some of which doubt may obtain.

Mesozoic rocks on Tai-uk.

Near the mouth of the Tai-uk stream, joining the Eu-chen-i-ko River just above Klun-chat-is-tli Lake, a considerable area of older rocks rises from below the basalts. They dip N. 48° E., at an angle of about 70°, where best seen; and running south-eastward, appear to form the high ground south of the Eu-chen-i-ko.

Circumstances admitted only a hurried examination of these beds, and most of the specimens collected were afterwards lost. Conglomerates and sandstones, however, occur, with some volcanic rocks, and the whole may not improbably represent some part of the Jackass Mountain series. After passing over a considerable width of basalt, south of Choo-tan-li and Ky-na-bun-kut Lakes, rocks not dissimiliar in aspect to the last are again found, rising in a few places, as rounded bosses in the woods. Coarse sandstone, with imperfectly rounded grains,—chiefly of feldspar and feldspathic rocks—is here, however, in association with a volcanic breccia containing large sub-angular masses occasionally over a foot in diameter, the whole being of a greenish tint. The strike, in one place was observed to be N. 24° W. Rocks of this series probably occupy a pretty extensive tract about here. Mr. McMillan reports granitic rocks westward, near the upper end of Choo-tan-li Lake, which, from a hand specimen, appear to be pale grey syenitic granite, and are probably intrusive in rocks like the porphyrites. In travelling southward to Cush-ya Lake on the Blackwater River, few exposures occur, but all appear to belong to the older volcanic horizon, with the possible exception of some rocks seen near the northern rim of the Blackwater valley, which may be of Tertiary age. The hills between Cush-ya and Kuy-a-kuz Lakes also appear to be composed of rocks of the Porphyrite series. Between the upper and lower Cluscus Lakes, a rock which I find called a hornblende-porphyrite in my notes, but of which the specimens have unfortunately been lost, occurs, with a dip of N. 51° E., $<$ 50°. The bedding is quite distinct in some places, and the rock appears to alternate with softer layers, of which the character was not ascertained. This is probably a spur from the mountains near Kuy-a-kuz Lake, and hills seen southward in the direction of the strike are probably composed of similar beds.

Rocks near Cush-ya and Cluscus Lake.

Tsa-cha Lake.

At the west end of Tsa-cha Lake, on the Blackwater, are several exposures of white-weathering, spotted dioritic rocks, unlike those of the Tertiary. At a distance, a heavy bed was noticed on the north side of the Blackwater, dipping westward at an angle of about fifteen degrees. Tsa-cha mountain, and the associated broken and hilly country north of the lakes, are probably also of these older rocks. On the north bank of Klootch-oot-a Lake, an isolated exposure of pale, yellowish-grey feldspathic rock of slaty structure is seen. It is so much tumbled as to give no true indication of its attitude, but much resembles some of the beds

Klootch-oot-a Lake.

described last year as occurring in Battle Mountain, on the Chilcotin River.

Uhl-ghak Lake and vicinity.

Near Uhl-ghak Lake, another island of older rocks rises above the horizontal Tertiary basalts. A short distance below the lower end of the lake, a rock with no visible strike or dip is seen; it is greenish-grey in colour, and fine grained, and may be a diorite or diabase. It holds occasional larger blade-like crystals of a plagioclose feldspar, is calcareous, and resembles an altered amygdaloid in showing irregularly scattered blebs of crystalline calcite. On the north-west side of the lake, where a hill running down to the water forms a steep bluff, a dark blackish-green compact feldspathic rock, somewhat calcareous, with veinlets of pale green epidote and quartz, appears. Between Uhl-ghak and Basalt Lakes —about a mile and a-half—several other exposures of rocks, probably belonging to the same series, are found. Near the former, is a close-grained, grey, calcareous, dioritic material, which may be intrusive, but in a short distance is replaced by greenish and bluish-grey volcanic breccias, in some places much altered and compressed, and like some of the rocks seen on the western flanks of Tsi-tsutl. There must be a considerable thickness of these, but the strike and angle of dip are both irregular.

Intrusive granite.

Near Lilly Lake, half way from Gatcho to the Salmon River Crossing, an area of greyish dioritic granite occurs. This rock, though probably here, as elsewhere, intrusive was seen only in isolated hillocks in the forest.

Drift specimens of Porphyrites.

Following the course of the Gatcho Lake stream and Kes-la-chick River to Na-tal-kuz Lake, the first rocks in place clearly older than the ordinary Tertiary volcanic series, appear about three miles below Eu-ti-a-kwe-ta-chick Lake. Near the lake, however, many of the stones of the drift are of the rocks of the Porphyrite series, and, from analogy, it may be supposed that some pretty extensive area of these occurs not far off. The fragments seen differ a little from the rocks of the Iltasyouco and its vicinity, in the larger proportion which conglomeratic and brecciated materials attain, and in the fact that in many of these the fragments show evidence, from their rounded forms, of considerable water action, some, indeed, containing comparatively little purely volcanic material. These rocks pretty closely resemble those seen on the Tai-uk Brook One fragment, well water-worn, with a dense feldspathic matrix, held many fragments of calcareous fossils. At the place first indicated in the preceding sentence, a peculiar, laminated, yellowish-grey feldspathic trap, which I believe is of Tertiary age, rests on granitic rocks like those so often found in association with the porphyrites elsewhere. These occupy the river valley for about five miles, and are generally syenitic granite, with pale-red, and dull-white feldspar, and little quartz. In most places they appear to be very much cut up by jointage planes, but below the surface might be found to be compact enough to be quarried in large blocks for building stone, and in any case would yield good material for masonry in which large sized stones are not essential.

Granite.

Building stone.

North of the granitic area, near the river, after a short interval of concealment, the first rock seen is a compact, pale speckled felsite, scarcely porphyritic in texture, but not resembling the Tertiary rocks. Beyond this a considerable width of country—about a mile and a-half—is underlain by a peculiar whitish rock, which forms cliffs along the river, in which it appears to dip sometimes in one direction, sometimes in another.

Purplish ash-beds on Kes-la-chick.

About half-way from the base of Toot-i-ai to Na-tal-kuz Lake, a steep anticlinical crosses the river in a direction N. 14° W., bringing purplish ash beds to the surface at an angle of about 70°. These appear in cliffs 100 to 150 feet high for a few hundred yards, when the white beds above referred to again replace them, and appear to continue nearly to the lake shore. The white rock seems to have originated as a fine trachytic tuff, like some of those still found in a little altered condition in the Tertiary series, but is here much hardened. When seen well exposed, it is found to be distinctly bedded, the beds differing more in colour than in texture, but being occasionally brecciated. The most ordinary variety is yellowish-white in colour, with a granular structure throughout, but no visible crystallisation. Splinters scratch glass easily, and some forms are so compact as to ring under the hammer. Quartz occurs sparingly in rather irregular minute blotches, and small cubical pyrites crystals have weathered out of some specimens, leaving brown stains. From the same cause, the whole rock, for an inch or more from the surface, is weathered brown. Not having had opportunity to trace out the individual beds, I can not affirm that they pass by greater alteration to the materials next to be described, but they are certainly associated with them. These are more distinctly crystalline rocks, the crystals being of glassy feldspar, and separated by a little white amorphous matter, and with more abundant spots of quartz. By further alteration these again seem to change to a material still more evidently crystalline, with dull, pale-red feldspar, distinct, more or less perfectly formed crystals of quartz, and black specks which may be hornblende; the

Metamorphosed tuffs.

Photo Lith. by the Burland Desbarats Co Montreal

From Photo. Aug. 17th, 1876.

CANON ON KES-LA-CHICK, NEAR TOOT-I-AI MOUNTAIN

(*Cliffs of Purplish Ash and Agglomerate Rocks.*)

whole breaking with a rough fracture and the general appearance of granite, and being, in fact, a trachyte or quartz porphyry.

The underlying rock, of general purplish colour, is evidently brecciated, but has also had in it small angular cavities, now filled with some silicious mineral. The fragments and the including mass are so much alike in colour that it is somewhat difficult to distinguish them; but the former have, on the whole, a darker purple tint. White feldspar crystals are porphyritically imbedded in both fragments and matrix, though in the latter they appear to have suffered somewhat from attrition.

Rocks near Na-tal-kuz Lake.

Rock in place was seen in only two spots near the south shore of Na-tal-kuz Lake; the first about half-way from the mouth of the Kes-la-chick River to the lower end and outlet of the lake, and the second, near the outlet, in a little hill called View Knoll. In both cases it is a compact, grey, feldspathic material of no particular interest.

Rocks of Fawnie's Mountain.

Toot-i-ai or Fawnie's Mountain, and associated ranges, from the strike of the rocks observed on the river, should be composed of similar beds; a supposition confirmed by the great quantity of fragments of this class of rocks, mingled with some of granite, brought down by streams from its base. Lines apparently indicating thick stratified beds, with a probable strike of S. 31° W., are seen near the summit.

The Ched-a-kuz-ko River, joining the Nechacco below Na-tal-kuz Lake, shows rolled pebbles of porphyrites and allied rocks of many different kinds, almost to the exclusion of any other materials, leading to the belief that these rocks are largely represented in the lower part of its basin.

Shales with *Estheria.*

In continuing to follow the Nechacco, on leaving the last described exposures, rocks of the Tertiary volcanic series are passed over for some distance, but at the first great bend of the river, fourteen miles below Na-tal-kuz Lake, older beds again come to the surface. These were seen in small exposures in two places—one to the north, the other to the south of the mouth of the brook which here enters. In the southern locality, the most important beds are black calcareous shales, quite different from any previously seen on this river. They are associated with other rocks, however, some of which are evidently fragmental, and in part probably volcanic in origin. The surface of rock seen is near the water's edge and not extensive, but the beds are nearly on edge, with a strike of S. 44° E., and appear to form the crest of a sharp anticlinal fold. They are all calcareous, and in a loose fragment of the shale, which, though its exact position in the exposure could not be found, must have come from it, contained many specimens of a species of *Estheria*. The greater part of the second exposure is composed of a rusty porphyritic rock, with some clay shale, but the whole much disturbed and broken. These rocks are probably associated with, and perhaps form a part of the porphyritic series, though the nature of their relation was not ascertained. The high broken hills which cause the river here to turn from its course, are, in all probability, formed of similar beds.

Calcified pumice

A black, nodular mass, associated with the *Estheria* shales, being highly calcareous, was sliced for microscopic examination, in the hope that other fossils might be found. It proved, however, to be really a calcified fragment of pumice, or vesicular trachytic material. In section a reticulated glassy mass, of pale yellowish tint and not showing any sign of crystallisation with the polariscope, encloses crystalline calcite, which often in many adjacent chambers, conforms to a single axis of crystallisation.

Porphyrites south of Fraser Lake.

About twenty-two miles south of Fraser Lake, older rocks again appear on the river, and are seen in many places for about seven miles northward. They are chiefly purplish porphyrites and feldspathic rocks of varying texture, in places brecciated and very generally much broken and silicified, and otherwise altered by subsequent hydrothermal action. They appear to pass in some cases into coarsely crystalline grey or whitish syenitic granites, some of which, however, are evidently intrusive among the darker-coloured feldspathic rocks. Where bedding can be detected, it is found to change in direction and dip at short intervals. These rocks probably belong to the Porphyrite series, and are on the strike of those afterwards examined near François Lake. They are overlain, in the higher parts of the hills on the east bank of the river, by Tertiary volcanic beds, not far from horizontal.

Nechacco series.

Nechacco Series.—It is proposed to include under this name a series of beds, of which the best display was observed on the Nechacco, between the mouth of the Stuart River and Fort George. There can be little doubt that these rest unconformably on the Lower Cache Creek rocks, and though their relation to the porphyrites could not be ascertained either palæontologically or stratigraphically, they may, with great probability, be assumed to represent them in whole or in part.

Clay shales and sandstones.

Nine miles below the confluence of the Stuart River, a peculiar dark dolerite or diorite appears, which may either form a contemporaneous mass in the formation, or be intrusive. It is soon succeeded, however, by clay-slates or shales, locally much hardened, probably by dykes. To these follow in ascending order, clay-shales, black and comparatively soft, with interbedded sandstone-like rocks, which pass in some cases into conglomorates, holding fragments of cherty silicious rocks like the Lower Cache Creek quartzites. The shales are often very perfectly stratified, in layers from a few inches to a few lines in thickness, the beds maintaining their width with the utmost regularity for long distances. They dip from S. 81° W. to S. 84° W., at angles of 40 to 45 degrees.

After a small gap in the section, rocks are again well exposed near Isle de Pierre Rapid, but are here much disturbed. and traversed by dykes and veins in such a manner as to render it uncertain whether they should be classed with the series now under consideration, or with the Tertiary volcanic rocks. They are certainly of volcanic origin, and while some beds are of a dark hornblendic or augitic material, the greater part are made up of brecciated volcanic fragments, the whole soft and crumbling when weathered. A mile and a-half below the rapid, several exposures of a brownish-red sandstone are seen, and six miles further down blackish clay shales of the usual character are interstratified with a grey feldspathic sandstone, more fully described below. In the shales, plant remains occur. These are not determinable, but have been little chips and ligneous fragments, probably water-worn before their inclusion in the sediment, and are now converted into coaly matter. These beds dip S. 47° W., < 70°, conformably with the brown sandstone above mentioned.

Fragmentary plant remains.

Two miles further down the river, beds dipping S. 77° W., < 50°, are exposed, consisting again of the sandstone-like rock, with black shales. Underlying these, at a point three miles above the mouth of the Chilacco, a steep bank and cliff borders for about 2,000 feet the left bank of the river. This forms a remarkable feature, resembling at a distance a great exposure of the lignite-bearing beds, but was found on inspection to be formed of clay shales of the formation above described, curiously altered by solfataric action. The rocks are traversed by small faults and cracks, and generally lie at low angles. The alteration has followed in some places nearly vertical, in others horizontal lines, but has more or less affected the whole bank, changing the original dark colour of the rocks to white and various rusty reddish and yellowish tints, and rendering them comparatively soft and crumbling. A short distance below this place the Tertiary rocks appear, and the older formation is not again seen.

Cliff of bleached shales.

The rocks above referred to as feldspathic sandstones are seen in many places in these sections, and seem to present all characters between true water-formed—though not very purely siliceous—sandstones, and others for which the material has been given in a comminuted form by volcanic

Feldspathic sandstones.

vents, and imbedded with little alteration. Those of the the latter class being easily altered, form hard rocks, and are often scarcely distinguishable from true grey porphyrites. Like many other rocks of the series they are more or less calcareous. A microscopical examination of one of the intermediate forms of this rock, showed it to consist chiefly of angular and broken fragments of plagioclase feldspar, with some orthoclase, the crystals being transparent and little altered. It fuses easily before the blowpipe.

Contemporaneous volcanic action indicated.

It thus appears certain, that whether the volcanic masses seen near the rapid belong to the series or not, volcanic action must have been in progress when the beds were deposited. This, with the character of the volcanic material, would seem to assimilate these rocks to the Porphyrites, while some of the clay shales are not unlike those holding *Estheria* on the Upper Nechacco. The resemblance of many of the beds to those of the Jackass Mountain series near Tatlayoco Lake, must also be pointed out.

Thickness of series.

In thickness the series here exposed must almost certainly surpass 6,000 feet, and may be considerably greater. Some of the sandstone-like beds, which conform very regularly to the stratification of the shales, and the layers of which are often only a few feet in thickness, would yield fair building stone; the best to be found, I believe, on this part of the Nechacco.

Nechacco rocks on Upper Fraser,

The strike of these rocks would carry them south-eastward to the Fraser River, and here, accordingly, we find them exposed at intervals from Fort George Cañon—fourteen miles below Fort George—to the northern edge of the Lower Cache Creek and associated gold rocks, already described. At the cañon, the most abundant rocks are blackish, hard shales, sometimes thick-bedded, and passing over into quartzite-like sandstones, which are probably feldspathic like those of the Nechacco. They appear to be underlain by a thick contemporaneous greenstone. Plant remains of exactly the character of those above described were found, but no other fossils. Further down the river similar rocks appear in many places, and in some of the exposures are much broken, and traversed by dioritic and compact feldspathic dykes, which weather to a pale dun colour. In one place, a massive conglomerate was observed, in which pebbles of diorite formed the chief ingredient, but were mingled with others apparently derived from the Lower Cache Creek series.

The older rocks found on François and Fraser Lakes will be described separately, in connection with these localities.

Tertiary rocks.

Tertiary Series.—Sections examined during last summer's exploration enable the rocks treated of separately in last year's report, under the heads of Lignite and Basaltic series, to be united in one group, which, on the evidence of the fossil plants, corresponds with the Miocene Tertiary of Alaska and Greenland. The basaltic and other igneous flows form the later part of this formation, but are now known to blend with the underlying sedimentary beds, and form an integral portion of the whole. No trace has yet been discovered of rocks due to volcanic action subsequent to the glacial period; all being covered by the drift deposits, and frequently still grooved and glacier-polished when circumstances have favoured the preservation of the marks. It will be unnecessary to enter into any detail with regard to all the very numerous localities in which the Tertiary volcanic rocks are seen. A few general facts bearing on their distribution may be stated, and some description of several of the more important and interesting localities then given.

Lignite and basaltic series united.

Tertiary area defined.

From the western side of the hills called the Telegraph Range, to a certain line following parallel to the eastern base of the Coast Range, basalts, and other similar igneous rocks of the Tertiary period, in horizontal, or now slightly inclined sheets, cover fully three-fourths of the surface and lap round the bases of the older rocks which here and there project above them. The western line, above referred to, may be drawn roughly, from near the eastern end of Tatla Lake, through the eastern sources of the Bella Coola River, as they appear on the map, thence northward, with many flexures, and then north-westward between the western end of François Lake and the mountains, beyond the limits of the country explored. The sources of these immense flows of molten matter, have, I believe, been numerous; for, besides the many dykes found traversing the older rocks, which may at one time have been fissures giving exit to lava streams, beds characterised by a roughly brecciated character appear in many places, and can scarcely have been formed far from the mouths of larger or smaller vents capable of ejecting fragments. Between the region of the upper waters of the Blackwater and Salmon Rivers, and the Bella Coola, however, three masses of broken mountains represent as many centres of former very great volcanic activity. These detached ranges are named from west to east, Tsi-tsutl, Il-ga-chuz, and It-cha, by the Indians. They stand on a great, gently-swelling area of high land, which forms a base uniting them all,—though cut through in one place by the Salmon River—and stretches away towards the sources of the Nazco River in the form of a plateau, from which streams fall to the north and south. The higher peaks of these mountains reach a height of fully

Sources of igneous matter.

7,000 feet, and in their general shape they still show traces of their formation by volcanic eruptions, which have probably been in part subaqueous. The Tsi-tsutl, or western of the three volcanic centres, has already been described to some extent on a previous page. Viewed from the vicinity of Hatty Lake, it is seen to rise very gradually and uniformly from the nearly horizontal basaltic country at its base, the successive basalt flows, in some places taking on a step-like arrangement. The central and higher peaks are for the most part gently sloping plateau-like remnants of a grand flattened dome, which the range in its perfect shape must have formed. The Tsi-tsutl Range, measuring from the extreme edges of its long slopes, must be at least thirty miles in length from west to east, by about twenty from north to south. The broken central peaks and ridges occupy an oval area about fifteen miles in length. They rise bare and treeless, and often show the peculiar red colour which has given cause for the Indian name. In the valley of Tanyabunkut Lake, and part of that continuing it westward, we have a section of a portion of the broad base of the range, showing successive overlapping lava flows, built up in some places to a height of over 500 feet, and resting on the mass of intrusive granite described on a former page. Some beds are perfectly columnar basalts, while others form an imperfect obsidian with irregular jointed structure.

Tse-tsutl vent.

On the Ko-has-gan-ko stream, south of Tanyabunkut Lake, the ordinary clays and arenaceous-clays of the Tertiary appear from below the igneous material. The line of junction is marked by a series of peculiar rocks, evidently produced by the flow of molten matter on soft wet clays, perhaps under water. The basalts and dolerites, which in the upper part of the section are blackish or greyish in colour, and compact in texture, become dull, whitish, opaque-wacke, or tuff-like materials, sometimes still showing vesicles like those of some of the overlying beds, but often confused and structureless. In the upper compact beds, zones are characterised by numerous, hardened, and in some cases almost porcelainised fragments of the lower slaty clays. Some of the vesicles, in both the compact and earthy basaltic rocks, contain minutely crystallised zeolitic minerals. From thirty to forty feet below the lowest basalt, occurs a bed of lignite, which appears to be of excellent quality. About four feet in thickness was visible at the time of our visit, the base being covered by the high water. This measurement, however, includes a few shaly partings. In one place, a remarkable, brown, almost greasy clay, is seen, which appears to represent a hardened peaty material. The sedimentary beds holding the lignite, rest on the surface of the intrusive granitic mass

Ko-has-gan-ko.

Junction of clays and basalts.

Lignite coal.

already described (p. 64), which, where they have been lately removed by denudation, is rotten and decomposed to a considerable depth. The lignite bed and overlying basalts, dip S. 34° E., to S. 19° E., at angles of from 13° to 18°. The direction is toward the central region of the Tsi-tsutl Range, and shows slight folding subsequent to the close of the Tertiary volcanic period, or a subsidence toward the centre of volcanic emission.

Possible exten of the formation.

The exposures of the lignite-bearing beds are here quite small, and occur only in the banks of the brook. From the soft and crumbling character of these beds, and the tendency of the basalts, when bared in cliffs or escarpments, to break off in columnar or angular fragments which form a rough talus concealing all below, the actual appearance of the lignite-bearing portion of the formation is very rare, even though it may underlie a great area of country. The lignite bed in the Ko-has-gan-ko might easily be exposed with a little labour, at low water, in August, and the thickness and extent of the basin determined by boring through the basalt capping to the south. No beds seem to intervene between the Tertiary basalts and uncomformably underlying porphyrites, on the south side of the range.

Rocks of higher parts of Tsi-tsutl.

The higher peaks of the Tsi-tsutl Range were not visited, but in the material carried down from them in the brooks there is no evidence that porphyritic or other rocks much more acidic than ordinary basalts are there extensively developed. These frequently contain well-formed, more or less glassy feldspar crystals, and are sometimes at the same time vesicular. On the south-eastern slope of the range a grey porphyritic trap occurs in great abundance, in large scattered blocks, and is probably nearly in place.

Il-ga-chuz vent.

The central, or Il-ga-chuz Range, in its main characters resembles that just described. Rising from a similar broad base, its central peaks are probably higher and more rugged than those of the last. The form is, moreover, more nearly circular, and the region in which the summits rise above 5,000 feet in altitude being about ten miles in diameter. As with the last range, on ascending from the broad flows of basic material here covering the country, less basic rocks, of different appearance and probably greater age, are found to constitute the higher region. The most abundant rock in the region examined, in a grey, somewhat vesicular feldspathic base, holds well-formed glassy feldspar crystals. Another rock, with a dull yellowish-grey, minutely-speckled mass, shows stratification lines, or banding simulating them, and may be a water-bedded material. In turning it before the light, occasional obscure blade-like feldspar crystals are rendered evident by reflection from their cleavage planes. Large and small masses of obsidian strew some of the higher eastern slopes, though not actually observed *in situ*. It is of blackish-green colour, with scattered white feldspar crystals from one to two lines in length, and is marked with parallel planes of darker colour. Microscopically, the glassy base is found to be filled with minute acicular crystals, nearly all lying in one direction, with spindle-shaped gas-cavities, and occasional stout, rod-like, pale-green crystals. With the polariscope, numerous oblong feldspar crystals, also lying more or less nearly parallel to the other structures, flash out. The large feldspar crystals above mentioned contain gas cavities like those of the matrix, and fine glass-cavities. In one case, one of the rod-like crystals penetrates into a large feldspar crystal, carrying with it a glass-cavity. Round the edges of the large crystals the smaller ones of the mass are arranged, as though by flowing in an imperfectly fused menstruum in which the large feldspar crystals were already formed. Heated carefully before the blow-pipe, a thin splinter may be reduced to a transparent glass, in which the rod-like crystals still remain. They would appear, as they penetrate the large feldspar crystals, to have been formed before them and to be capable of enduring a higher temperature on re-fusion than any of the others. When a splinter is partly fused on one edge, and then examined, the spindle-shaped gas cavities can be seen in every stage of expansion, till they form in the portion completely fused large round vesicles many times the volume of the original. Granting that the obsidian now fuses at about the same temperature at which it formerly solidified, it would thus appear that it must have hardened under great pressure. It must have cooled quickly, however, or its glassy structure would not have been preserved, and may therefore be supposed to have penetrated some already cold rock as a dyke.

Obsidian.

Microscopic structure.

Sequence of formation of minerals.

No distinct traces of a former volcanic crater were observed in either this or the Tsi-tsutl ranges. Denudation, and the action of ice during the Glacial period, appear to have completely removed all the higher and softer portions which may have surrounded the old vents.

It-cha vent.

The eastern or It-cha volcanic range is united to the central by a broad and high, rolling plateau. It was not visited, but as seen from the eastern flank of the Il-ga-chuz Mountains, shows, even better than they do, traces of its original symmetrical form, and slope from a centre. A line drawn from summit to summit of its broken plateaus would slope uniformly away from its central portion, which shows two or three

PHOTO LITH. BY THE BURLAND DESBARATS CO MONTREAL

OUTLINE OF IT-CHA VOLCANIC RANGE, FROM NORTH-EASTERN SLOPES OF IL-GA-CHUZ.

(*The dotted line indicates the probable original outline of the volcanic rocks now seen in broken plateaus.*)

rougher and less regular peaks, probably representing the hardened materials surrounding old crater plugs. (See Plate VII.)

On the west side of the southern bend of the Salmon River, between the Tsi-tsutl and Il-ga-chuz Mountains, is the remarkable isolated summit called Beece, or Anahim's Peak. Its sides are almost perpendicular, and it is surrounded by no sloping base, but rises abruptly to its full height. Though unable to afford time to visit this mountain, the examination of the surrounding country leaves no room to doubt that it is of volcanic origin,—a belief further confirmed by the fact that it has, before the arrival of the whites, been a place of great importance among the Indians, having yielded them their supplies of obsidian for knives and arrow-heads from time immemorial. It is now not frequented, and the Indians know of no distinct trail leading to it, though they occasionally visit it in their hunting excursions.

Anahim's Peak volcanic.

Source of supply of obsidian.

Near the western edge of the Tertiary volcanic rocks on the Salmon River, a conglomerate, with ferruginous and sandy cement, which contains rolled fragments of the granites, porphyrites and other rocks, but none of the newer volcanic series, is found. This, with little doubt, is a part of the lignite-bearing formation.

Tertiary conglomerate.

On the south side of Tsa-cha Lake, where the C. P. R. Trail turns off to Chizicut Lake, the delta at the mouth of a brook showed numerous fragments of shaly Tertiary clays, some with obscure plant impressions, leading to the inference that the basalts generally characterising the region were cut through in its bed. Mr. Bowman subsequently examined the brook-valley, and reports the existence of a section showing a considerable thickness of strata immediately underlying the basaltic flows. They consist of whitish arenaceous clays, interbedded with layers of mixed clayey and coarse sandy matter, which appear, from their want of regular arrangement, and the numerous little irregular cavities in them, to represent flows of rather thick mud. With these occur beds holding fragments of grey pumice, together with beds resembling very fine grey sand, harsh to the touch, which, on microscopical examination, proves to consist of triturated pumice. With the polariscope it behaves like a structureless glass, and in every respect precisely resembles pumice from the Azores, when that is reduced to a like degree of fineness. In the brook, is found a substance, which though not actually seen in place, must occur in the lower part of the section. This resembles a very fine white clay, but proves to be a diatomaceous earth, rich in *Gallionella*, *Cyclotella* and other fresh-water forms. It also holds occasional grains of coniferous pollen, which—probably aided

Blending of igneous and aqueous deposits.

Volcanic mud.

Pumice.

Diatomaceous clays.

by other organic fragments—causes it to blacken when heated to redness.

Mode of deposition.

We appear to have here a very distinct case of the interlocking of the ordinary sedimentary and volcanic products of the Tertiary. The slow accumulation of the diatomaceous frustules, must have occurred in some quiet lake or pool, of which we cannot define the extent, but in the vicinity of which, forests of coniferous trees, similiar to those elsewhere producing the lignite beds, must have existed, and added their pollen from time to time to the deposit. Closing this scene, came the showers of ashes and pumice, and streams of volcanic mud, initiating for this region the period of volcanic activity, and followed after a time by the great horizontal flows of basic volcanic rocks.

Blackwater.

From the mouth of the Nazco, and west end of the upper Blackwater Cañon, no rocks but those referable to the Tertiary volcanic series were met with in the vicinity of the trail or Blackwater River, till near Cush-ya and Kuy-a-kuz Lakes and the Cluscus Lakes. The materials are generally, if not altogether, balsaltic and doleritic, Westward, similar rocks continue to characterise the country, with the exception of certain small areas already described, till the western edge in this latitude is reached about Qualcho, Hatty, and Tanyabunkut Lakes.

Near Gatcho Lake, the basaltic material holds many large transparent feldspar crystals, porphyritically imbedded; and between Maliput and Gatcho Lakes, a white, porous, siliceous material occurs, which has apparently been deposited by thermal waters. About four miles north of Gatcho Lake a remarkable little hill rises about 250 feet above the general level of the undulating, plateau-like country, on the east side of the stream. It may be called Sinter Knoll from the material composing it, which is either a deposit formed directly from mineral waters, or in connection with a solfataric vent; or may be a silicified trap like those observed by Mr. Darwin in the Island of Ascension. The most common variety is yellowish-grey, or pale purple in colour, and is seen on transverse fracture to be composed of fine superposed laminæ, often scarcely thicker than paper. This occasionally shows minute specks of clear siliceous matter following the surfaces of lamination, but in some cases becomes quite uniform in colour, and massive. Other parts of the hill are made up of an extraordinary brecciated material, composed entirely of fragments of the rocks above described, from several inches in diameter to the size of grains of sand. These are tumbled confusedly together, and have been completely re-cemented by added material slightly different in colour. Some portions of the breccia are blotched

Sinter Knoll.

Remarkable siliceous deposit.

with white spots and streaks, from which the colour serving to indicate the fragmental character of the rock has been removed by the protracted passage of steam or acid waters. Other varieties contain in their crevices a yellow material, probably hydrated opal-like silica.

About two miles north of the Knoll, another similar little hill appears, but is composed of basalt, finely columnar, the columns being inclined.

Inclined beds of basalt.

Following the tributaries of the Nechacco towards Na-tal-kuz Lake, little rock is seen in place, but the Tertiary basalts probably preponderate. About midway between the mouth of the Ched-a-kuz-ko and the first great bend on the Nechacco, a wide-spread sheet of columnar basalt is seen sloping eastward, from the flanks of the hills on the north bank of the river, at an angle of ten or fifteen degrees. Whether it owes this slope to that originally possessed by the surface, or wholly or in part to subsequent flexure, which the Tertiary rocks of adjacent regions are seen to have undergone to some extent, was not determined. It rests, however, on pale beds of softer materials, which appear from a distance to rise in one place into the basalt in a dome-like form, while not far distant, the basalt seems to descend and fill a hollow in the underlying beds, showing apparently some unconformity. On the south bank of the river, a smaller exposure of similar deposits was more carefully examined. The following section gives the different materials as they alternate with each other, in descending order; the thicknesses stated being, however, only estimated :—

Section of basalts and tuff.

	FEET.	IN.
1. Basalt; the upper part fine-grained, dark yellowish-grey; the lower, compact, blackish-grey with conchoidal fracture (approaching obsidian). *At least*..........................	40	0
2. Rock peculiarly banded with red and black layers, probably feldspathic, in part at least fragmental..................	0	5
3. Greyish feldspar rock, imperfectly, but coarsely, crystalline....	2	0
4. Grey hard rock, with small black acicular and other crystals, and half-rounded grains of fragmental origin, but apparently fritted together afterward by heat.........................	0	6
5. Fine-grained, pale-grey, trachyte-tuff, with scattered, black, shining, crystalline points	1	0
6. Trachyte-tuff, scarcely crumbling between the fingers; with occasional small stony fragments, weathering to pillar-like masses. Bottom not seen. *At least*......................	30	0
	73	11

On the Cut-off Brook a remarkable hill occurs, rising to a height of about 150 feet, and nearly vertical on the north-west side. It is composed

Inclined basaltic columns.

of basalt, with porphyritic, glassy feldspar crystals, and shows columns, beautifully regular, and some of them at least 100 feet in length. They are not perfectly parallel, but spread out towards the base of the hill, in one place so abruptly, that a little slightly overhanging cliff shows their ends in section. Near this place some red and banded agates were found strewn on the surface of the ground, but most of them much broken and cracked.

Lignites below basalts on the Nechacco.

The Cheslata Lake stream joins the Nechacco from the west, not far below the first great bend, already mentioned. From this point, for some distance northward—as ascertained by Mr. Bowman, who ascended the river in a canoe—the basalts are underlain by an extensive sedimentary formation, including lignites, of which one bed of very good quality was found to be four feet in thickness. The rocks accompanying the lignites appear to be arenaceous clays of the usual character, but are associated with conglomerates in greater proportion than usual. These contain well-rounded fragments of silicified volcanic rocks, like those described on a former page, as probably representing the Mesozoic series on this part of the river. The basaltic and other later igneous rocks seem here, as in other instances, to have flowed out into pools and lakes containing the earlier Tertiary deposits; and are in consequence, in their lower parts vesicular, and sometimes earthy. No exposures occur in the reach of the Nechacco flowing due north toward Fraser Lake, but the underlying rocks are, in all probability, those of the Tertiary series.

Tertiary outcrops on Lower Nechacco.

In mapping the formations on the Lower Nechacco, an extensive area, reaching from that part of the river opposite the west end of Ta-chick Lake to a short distance below the mouth of the Stuart River, has been coloured as Tertiary. The rocks are seen in very few places, but from the character of the country, and absence of other exposures, it is supposed that they are here largely developed. The best section of these rocks seen in this region showed only about fifty feet in thickness, the beds dipping S. 42° E., < 12°, and consisting of rather hard sandy shales and soft yellowish sandstones, the former with scales of mica, and comminuted carbonaceous matter on their surfaces of bedding. The eroded edges of the beds are overlain by the white silts of the Lower Nechacco basin.

Below the Isle de Pierre Rapid, for about a mile and a-half beyond Ses-ti-noo Island, yellowish, and pale-greenish clays of the lignite formation are seen in several places along the north bank of the river, at low water. They appear to be more or less inclined, and to indicate an outlying patch of the Tertiary on older rocks. Further down the river, Rocks at White Mud Rapid.

at the White Mud Rapid, basalts, compact and vesicular, are found overlying white and yellowish clays, which show some purplish carbonaceous bands and fragments of lignite. The rocks are here somewhat disturbed, probably by the under-cutting of soft beds by the stream, and subsequent collapse of the upper layers. Occasional small outcrops of Tertiary clays occur for about a mile below the mouth of the Chilacco, beyond which point only Glacial or still later beds are found. Nearly opposite the mouth of the Chilacco is a prominent hill of basaltic rock, and, for about a mile and a-half up that river, Tertiary igneous rocks are seen at intervals. The lowest, forming at one place a little cliff on the river, is a pale greyish tuff, with fine-grained matrix, but including fragments of half-decayed yellowish pumice. It is overlain by a hard doleritic bed.

On the Fraser River, Tertiary rocks—but without any trace of the igneous portion of the series—appear in several places between Fort George and the first cañon below it. No older beds are seen on this part of the river.

Tertiary and Mesozoic rocks of Fraser and François Lakes.

Rocks of Fraser and François Lakes.—These two lakes, with the river connecting them, form a transverse section of the country nearly ninety miles in length, but were not found to yield as good a geological exhibition of its structure as had been expected. The rocks shown seem to belong entirely to the Porphyrite series or its representatives, and to the igneous rocks of the Tertiary; but on François Lake, their mutual relations are in some places exceedingly perplexing. It is with the view of avoiding the confusion which might be caused by placing some of these rocks somewhat arbitrarily in the series to which they are at present supposed to belong, that they are here separately described.

Syenite.

The flat land at the lower or east end of Fraser Lake, is underlain by syenite, passing in some places, by the addition of a little quartz, into syenitic granite. These rocks are seen on the north shore of the lake, forming the lower hills, and distinctly passing under the Tertiary volcanic rocks, for two and a-quarter miles from its outlet, when the overlying series comes down to the water's edge. Peninsula Bay, near the west end of the lake on the north side, marks here the western edge of the overlying rocks, the peninsula and shore of the west bay being again composed of syenitic granite. On the south shore, a point on which stands a prominent little hill opposite the peninsula, is composed of a similar material, which may also appear along this shore for some miles near the east end of the lake. This rock resembles a true diorite in some places, and in the last mentioned locality, is traversed by dioritic, or aphanitic dykes. The feldspar varies in colour from grey to red, and is sometimes quite coarsely crystalline. Near the outlet of the lake, on the north shore, the rock shows spots or blotches of a darker colour, sometimes over a foot in diameter; and occasionally almost resembles an altered breccia. No bedding planes are ever visible, however, and it is probable that these are not really fragments, but concretionary masses. Good blocks for building might be quarried here at the lake shore, but the material is very hard A prominent hill, a mile and a-half behind Fort Fraser, holds a little black mica in addition to the ordinary ingredients, and is spotted similarly to that last described. The spots are darker, and show grey feldspar crystals, porphyritically imbedded in a fine-grained, blackish-grey mass. These rocks resemble those elsewhere seen intrusive in the Porphyrite formation, and may be supposed to be of the same age.

Tertiary rocks.

A rampart-like hill, just south of Fort Fraser, appears to be composed, to the summit, of rocks of the basaltic series, but at the base probably overlies some soft tufaceous or clayey beds, from the abundance of fragments of such material strewing the shore. With the exception of the areas of older rock already mentioned, the Tertiary volcanic rocks seem to form the shores of the lake and hills surrounding it. In several places, these rocks were observed to dip at low angles in various directions, but most commonly toward the basin of the lake. On the north shore, a volcanic breccia, or agglomerate of basaltic and other similar fragments, is largely developed, and is seen to be overlain by a laminated basalt with flattened and drawn out vesicles. Near the entrance of Peninsula Bay, on the north side, the beds are dipping N. 67° E., or away from the syenitic mass of the peninsula, at angles of eight to ten degrees. The agglomerate is here particularly well shown, consisting of masses, which are sometimes very large, confusedly mingled with smaller fragments. The finer parts of the matrix are of a pale colour, with little irregular cavities, holding zeolitic minerals; the fragments are chiefly of a species of tachylite with a resinous fracture, and appear to have been the broken-up surface of a lava flow, still in some places showing very perfectly the original ropy flow-structure.

Agglomerate.

Traces of copper.

Minute veins, and fissures stained with copper, traverse some of the basaltic rocks west of the syenite of Peninsula Point.

Near the south bank of the Stellako River, at its mouth, a low hill is formed of a hard porphyrite of purplish-grey colour, but of which the attitude is not apparent. The base is finely granular, and through it are scattered large blade-like feldspar crystals, sometimes half an inch in length and of nearly the same colour with the matrix. From its lithogical similarity to the rocks at the west end of the Stellako, this rock is supposed to belong to the same series. In ascending the river, the next rock seen in place is granite, consisting chiefly of flesh-red feldspar and quartz, with little mica. This continues to appear in the river banks nearly to François Lake, and is usually much broken-up by jointage planes; most of which are nearly vertical, and run N. 7° E. The point between the south bank of the river and François Lake is chiefly composed of greyish feldspathic rocks of fine-grain, with scattered, larger, porphyritic, feldspar crystals. These alternate with granite like that just described, which, in one place, was observed to form an evident dyke about four inches wide among them, proving its more recent origin. The porphyrites are laminated or bedded, the direction of the structure being N. 62° E. These rocks not only resemble those at the mouth of the river, but are much like those of the Nechacco, twenty miles south of Fort Fraser.

Porphyrites of Stellako.

Granite dykes.

François Lake, or Ni-to-bun-kut, has already been described as to its general features. Geologically, its basin appears to be formed in rocks of the Porphyrite and Tertiary volcanic series, which it is in many cases difficult to separate. The Tertiary igneous rocks seem to rest, at least in some places, directly on the older series, and in others to lie on conglomerate beds of Tertiary age, and probably also on clays and sands, though these were not seen. The Tertiary formation, as a whole, appears to have been formed on an uneven surface of the older rocks, and to have afterwards been removed in many places by denudation. It is probable that the lake-valley was cut out, at least to some degree, in pre-Tertiary times; as the basaltic flows have been seen in several places to slope towards it as though poured out originally on an inclined surface. There can be no doubt that rocks of both series occur on the Lake, but with our present knowledge, their separation is often a matter in which it is almost impossible to feel perfect confidence. In view of this fact, and the difficulty of satisfactorily describing the distribution of the beds from the exposures seen, it is intended to give here merely a brief summary, the map showing the dividing lines as they are supposed to exist.

Igneous rocks of two periods on François Lake.

On the north shore, granite, seen in a few places, is supposed to extend for about six miles; beyond which, for six and a-half miles, rocks, clearly belonging to the Tertiary series, are found. They consist of basalts and purplish vesicular rocks, overlain at the west by heavy beds of conglomerate or breccia, composed of fragments for the most part

Granite.

resembling rocks of the Porphyrite series, with some of granite, similar to that seen in the eastern part of the lake. Rocks of the Porphyrite group then occupy the shore for some distance, forming broken rocky hills inland, and represented where examined, by a fine-grained, dull purple porphyrite. Igneous rocks of the Tertiary then again appear, and form the whole of the blunt point opposite Un-cha Brook; the prevalent material being a greyish-green amygdaloid, the cavities of which are filled with calcite. The south shore from East Bay, for nearly twelve miles, is occupied, as far as the water-side exposures enable its character to be determined, by rocks most closely resembling the Porphyrite series in their hardness and appearance of alteration, but differing somewhat mineralogically. They are chiefly hard, greyish and blackish traps, compact in texture, but sometimes vesicular; the cavities being filled with calcite. West of these, rocks evidently Tertiary, again appear. Opposite the conglomerate described on the north shore, a breccia, similar in character, but differing somewhat in colour, is found; beyond it, brownish basaltic rocks of the usual character continue to near Un-cha Brook.

Dark traps.

Reverting to the north shore, from the place last described, rocks of the older series appear from point to point for nearly fourteen miles. The beds seem for the most part to lie at angles of from twelve to twenty degrees. The chief varieties of rock observed in order from east to west, are as follows:—dark grey porphyrite with epidote in small veins. Compact rock with pale-purple feldspathic base, through which are scattered small quartz crystals, and dull white concretionary spherules with a radiating structure. A rock, which might perhaps be called a spherulitic perlite, consisting of a yellowish feldspathic base, through which concretions like large and small shot are thickly scattered. The concretions are much harder than the matrix, and give it a curious appearance on weathering. Beyond this the shore for some distance is characterised by an opaque, white, or grey feldspathic rock, through which little spots of quartz are scattered. This must have a thickness of several thousand feet. From Un-cha Brook, on the south shore, to the point of Hun-cha-yuz Mountain—four miles—the rocks differ in appearance from those elsewhere seen on the lake, consisting, apparently, of bedded diorites and black compact beds, with conglomerates, some of which appear to be made up largely of fragments of cherty rocks, like those of the Lower Cache Creek series. At Hun-cha-yuz Point the beds dip S. 27° W., at an angle of 15°. For the next ten miles exposures are few, but the white bed last mentioned, on the north shore, appears to

Concretionary perlite.

Conglomerates with siliceous fragments.

cross over, and compact greenish and purplish rocks in considerable thickness are seen to overlie it.

Tertiary conglomerate.

At the point now arrived at in the description of the lake westward, the Tertiary rocks again appear almost simultaneously on the north and south shores. The lowest bed seen is a brown-weathering conglomerate, holding films of coaly matter in places, formed evidently by the alteration of bitumen, which must have penetrated it. Westward, and overlying this, are volcanic rocks of different kinds, basalts, agglomerates and amygdaloids, which together constitute the mass of Ches-nun Mountain and the accompanying high land, with a total thickness of at least 1,000 feet. Near the foot of Ches-nun, a basaltic dyke fifteen feet in width is seen, cutting a volcanic agglomerate with some fragments three feet in diameter. The dyke is columnar at right angles to its walls, and was again seen at a distance of over two miles on the south shore of the lake. Beyond Ches-nun Mountain exposures are rare for a considerable distance, but it is probable that the Tertiary series occupies the lake shores for about seventeen miles from the point first mentioned in this paragraph. At the western extremity, a rock precisely resembling the conglomerate above described, and containing little fragments of lignite among the well-rounded pebbles, is again found. Notwithstanding some irregularity in the directions of dips obtained, I am inclined to think that this great area of Tertiary rocks constitutes a synclinal of which Ches-nun lies nearly in the centre.

Columnar dyke.

White trachyte-tuff.

From the western edge of the above Tertiary region to the west end of the lake, rocks of the older volcanic formation appear to continue. The most remarkable are those seen on and near Noo-cho Island on both sides of the lake. The rock is here a white trachyte-tuff, which appears from its finely laminated character to have been deposited in water, but may have been subsequently bleached or altered by acid vapours. It now forms a coherent, or even somewhat hard, finely porous mass, and must be at least several hundred feet in thickness. Microscopically, it is found to be very opaque, by reason of the many small pores in its substance. When rendered transparent, however, by saturation with balsam it appears as a clouded or streaky film, which, under the polariscope, breaks up into a congeries of glimmering feldspathic crystals, forming a reticulated mass. With the blow-pipe it fuses with difficulty on the edges, but becomes semi-transparent and hard, and would appear to be a very suitable material for the manufacture of porcelain, if properly selected and ground.

Microscopic character.

Ma-di-na Mountain, beyond the west end of the lake, seems to consist of heavy beds with a dip at an angle of about fifteen degrees. From their appearance at a distance, and from the nature of the stones in the Ma-di-na-ko River, it is probably of rocks of the Porphyrite series.

Ootsabunkut Lake.

From Ootsabunkut Lake, south of François Lake, Mr. Cambie has kindly brought some rock specimens. These for the most part resemble those attributed to the Porphyrite series on François Lake, but also indicate the presence of Tertiary igneous rocks. They have been of assistance in drawing the probable boundary of these rocks in that region.

General Conclusions and Comparison of the Rocks above described with those of other Localities.

Three periods of volcanic activity.

It is now certain that there are represented, in the rocks of British Columbia, at least three distinct periods of great volcanic activity, included respectively within the Palæozoic, Mesozoic and Tertiary eras of geological time. The rocks produced by volcanic action in many places seem to be the chief representatives of these periods in the geological scale, excluding to a great extent the ordinary aqueous sediments.

Cascade Crystalline and Vancouver rocks.

In the report for 1871-72 you provisionally united, under a single heading, the Cascade Mountain rocks with those of that part of Vancouver Island near Victoria. The progress of the investigation of the country appears to favour the correctness of this view, and to show a blending and interlocking of such characters of difference, as the typical and originally examined localities of the two series present. No fossils more characteristic than the encrinal columns, mentioned by Mr. Richardson in his report for the same year (p. 92), have yet been found, but many facts seem to show that it is at least highly probable, if not certain, that the rocks near Victoria represent a part of the series examined by Mr. Richardson between the head of Alberni Canal and the east coast of the Island, though in a more metamorphosed condition. These, with part of the series found in the Ballinac Islands, were pronounced by Mr. Billings, on Palæontological evidence, to be either Carboniferous or Permian, and most probably the former.* Volcanic action has played a large part in the building up of these rocks on Vancouver Island, and near Victoria probably nine-tenths of their entire thickness is made up of ash-beds, interleaved with lavas and other igneous rocks. These,

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* Report 1872-73, p. 54; 1873-74, p. 98.

from their composition, have yielded readily to metamorphism, and now lithologically resemble, as you have pointed out,* the rocks of the Huronian and altered Quebec groups of Eastern Canada. This likeness, with the fact that the rocks still preserve not alone the chemical, but also in some places the mechanical characters of volcanic rocks, will render them when worked out a most interesting study, and a valuable term of comparison in the discussion of the great series of older metamorphic and crystalline rocks of other parts of the continent.

Relations of Lower Cache Creek rocks.

In the country east of the granites and diorites of the Coast or Cascade Range, the Lower Cache Creek group, which from the fossils now obtained in its limestone, must in all probability represent a part, or the whole, of the rocks of Vancouver Island just noticed, is found largely developed, and though showing considerable intercalations of volcanic matter, it consists in great part of limestones, quartzites, and other beds of ordinary aqueous origin. The junction of these with the more crystalline rocks of the Coast Range has not been worked out, and little is known of their extension in the eastern part of the Province where they are widely spread, till we reach the main range of the Rocky Mountains, where we again find limestones of great thickness associated with sedimentary beds and holding *Fusulina* and other Carboniferous fossils, with, perhaps, in some places, a tendency toward Devonian facies. Dr. Hector has described these rocks as forming the great mass of the mountains for a considerable part of their length, but I know of no region in which contemporaneous volcanic action is indicated, but that which I have examined in the vicinity of the 49th parallel, where a wide-spread sheet of contemporaneous diorite forms an important member of the section.† The tendency of the evidence at present available, therefore, seems to be towards the conclusion that in Carboniferous times a great region of volcanic activity nearly coincided with the position at present occupied by the Cascade or Coast Range, and the parallel range of Vancouver Island, and that the great igneous accumulations there found may eventually be traced westward step by step, gradually losing their importance till they are replaced by the unbroken limestones underlying the plains.

Rocky Mountain and Coast regions contrasted.

Gold-bearing series.

The rocks of the gold-bearing series, were examined last summer only at Leech River, Vancouver Island, of which the features observed are elsewhere reported on, and connected with some general remarks on the auriferous rocks of the Province. It may suffice to state here, in the

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* Report 1871-72, p. 52.

† Geology and Resources of the Forty-ninth Parallel, p. 68.

absence of any definite information on the subject, that I believe the probabilities are in favour of the view that the auriferous rocks of Cariboo, Anderson River and Boston Bar, and Vancouver Island, are nearly on the same horizon, and will be found intermediate in age between the Carboniferous and Porphyrite series, though probably most closely attached to the former.

Porphyrite series.

As already observed, the evidence, palæontological and stratigraphical, seems to show a close connection between the Jackass Mountain beds, of the report for 1871-72, and the formation designated the Porphyrite group in 1875, and first found on Tatlayoco Lake. While the overlying Jackass Mountain series, equivalent to a part of the Shasta division of the Cretaceous of California, is composed of rocks not unlike those of ordinary aqueous origin, the Porphyrite group is built up almost exclusively of igneous products, chiefly porphyritic, but seldom showing quartz; interstratified with rocks which appear to be fine-grained diabases, with perhaps some diorites, and great masses of volcanic breccia or agglomerate. Many even of the finer grained rocks are of fragmental origin, having been volcanic ashes, lapilli and sands; but as these cannot be distinguished in most cases from those of the same chemical constitution which have originally been flows of molten matter, in their description, the same names have been applied to both indifferently. The thickness of this volcanic series must be very great. It has been roughly estimated in one locality—as above stated—at 10,000 feet. The most typical exposures of its rocks, yet studied, are in close relation to the eastern flanks of the Coast Range, but it is probable that other scattered centres of volcanic activity of this date also existed elsewhere.

Nechacco series.

The wide-spread Tertiary basalts have, in the region examined last summer, prevented the tracing of the connection of these and the Jackass Mountain rocks with those called above the Nechacco series, which probably represents them, at least in part. Volcanic products are still found among the Nechacco beds, but with a preponderance of those of ordinary aqueous origin. The stratigraphical connection of these with the Jurassic and Cretaceous rocks of the great plains, in which no evidence of contemporaneous volcanic action appears, yet remains to be established.

Comparison with Chilian volcanic rocks.

The resemblance of the Porphyrite formation of western British Columbia with that described by Mr. Darwin under the general name of the *Phorphyritic formation* in the Cordilleras of Chili, is so striking as to be worthy of mention, especially as it seems to obtain not only in lithological characters but also, to a great extent, in regard to age. The basal strata on the flanks of the outer lines of the Cordillera are described as having for their prevailing rock a purplish and greenish porphyritic claystone-conglomerate, or breccia, the imbedded fragments of which vary from mere particles to blocks six to eight inches in diameter. The basis is generally porphyritic, with perfect crystals of feldspar, and resembles that of a true injected claystone porphyry, though often of a mechanical or sedimentary aspect, and sometimes jaspery. The fragments are of many varieties of claystone porphyry, usually of nearly the same colour with the surrounding matrix. This description might almost apply word for word to the rocks of the corresponding series in many parts of British Columbia. Further on, the aspect and distribution of the formation is described in the following terms:—

Porphyritic formation of the Cordillera.

"The alternating strata of porphyries and porphyritic conglomerate, and with the occasionally included beds of feldspathic slate, together make a grand formation; in several places within the Cordillera I estimated its thickness at from 6,000 to 7,000 feet. It extends for many hundred miles, forming the western flank of the Chilian Cordillera, and even at Iquique, in Peru, 850 miles north of the southernmost point examined by me in Chili, the coast escarpment, which rises to a height of between 2,000 and 3,000 feet, is thus composed. In several parts of Northern Chili this formation extends much further towards the Pacific, over the Granitic and Metamorphic lower rocks, than it does in Central Chili; but the main Cordillera may be considered as its central line, and its breadth in an east and west direction is never great."

Mesozoic volcanic rocks of West Coast.

It would thus appear, that the general similarity of the formations of the Pacific Coast when traced in lines parallel to the axis of mountain elevation, obtains striking confirmation in this case, and that at about the same stage in the Mesozoic division of geological time, volcanoes were in active operation at points so distant in this old axis of disturbance as Chili and British Columbia. Nor are intermediate links quite wanting. Rémond, I believe, describes Cretaceous rocks as resting on porphyries and Carboniferous limestones in Northern Mexico; and, though I have not been able to find that rocks of the Mesozoic have been attributed to volcanic action in California, in studying Professor Whitney's report one is almost irresistibly led to the conclusion that in the Cretaceous, and perhaps also in some of the older rocks, a portion of the metamorphic beds, (which, in their distribution and rapid alternation with little changed sediments of ordinary aqueous origin, have been so puzzling) are really due to the inclusion, in different places, of easily crystallized and hardened volcanic products, whether ashes or lavas. The silicification of rocks, which has occurred extensively, is a species of metamorphism quite recognizable, and not likely to lead to the formation of trap-like or "dioritic" beds. The "red rock" or "imperfect serpentine" of the Cretaceous of the vicinity of San Francisco, resembles nothing so much as a slightly altered volcanic material.

Known representatives of the Mesozoic.

Uniting for the present the Jackass Mountain and Porphyrite Series, with the rocks of Tatlayoco Lake, and the Nechacco Series, as known representatives in British Columbia of the lower Mesozoic; we may add to them with certainty the coal-bearing rocks of the Queen Charlotte Islands and the Monotis beds which you have described on the Peace River, and with a considerable degree of probability, though on merely lithological evidence, the trappean and agglomerate series found south of the gold rocks near Sooke, and a part of the rocks seen on the Ballinac Islands, by Mr. Richardson. The coal bearing rocks of Vancouver Island appear to be higher in the scale than any of these.

Tertiary volcanic products.

The overlying Tertiary rocks rest quite unconformably on all the older formations, and appear to have suffered little flexure since their deposit. Their lithological appearance has already been described. The basalts often afford very fine displays of columns, which, in several instances, were observed to be curved. In many places basalts and allied rocks show a peculiar laminated structure, which appears to have been produced by the flow of a half liquid mass, or internal movement caused by lateral pressure in the case of intrusive masses. This often simulates bedding, but is only in some instances parallel to the surface of the sheet.

Difficulty of separating Tertiary and Mesozoic volcanic products.

As described in the report for last year, older rocks sometimes stand out above the basaltic flows as hills, and in other cases appear in valleys cut through them. When the lower rocks are of ordinary aqueous sediment, or have been much metamorposed, they are very easily distinguished from those of the Tertiary, but when the Porphyrite Series, with its great masses of volcanic material, appears in contact with the later rocks of similar origin, their separation is often a matter of extreme difficulty, especially where exposures are few and hidden by forest. Some of the intrusive porphyritic rocks of the later period are indistinguishable in hand specimens from the altered volcanic sediments of the Porphyrite series, and when we approach the region of a Tertiary vent, where the rocks are much broken and altered, and trachitic products abound, it is not always easy to prove that the rocks of changed character do not belong to the older series. The rocks near Toot-i-ai, for instance, though supposed to belong to the Porphyrite series, might, on lithological grounds, with equal probability, be explained as those characterizing a Tertiary vent, all other traces of which have been removed by denudation.

No crucial test.

No crucial test by which these two formations may be distinguished now remains, all those which have been proposed from time to time having broken down in one or more instances. Only by working out the stratigraphy and the organic remains, can certainty be arrived at in some instances. There are, however, certain criteria very useful in most parts of the region examined, the more important of which are are as follows.

Differences generally found.

The older series generally rests at higher angles, and is more disturbed and metamorphosed. Its most abundant rocks are acidic, while the most widely spread rocks of the Tertiary are basic; free silica seldom appears in the first, but scarcely ever in the second series. The older series shows no true basalts, and perhaps no unaltered dolerites. The cavities of its originally vesicular rocks, are almost invariably filled with infiltrated minerals, while those of the newer parts of the Tertiary series are most commonly open. In the older series, epidote is very frequently developed, generally in cracks and joints, but sometimes penetrating the compact rock. Olivine is never found. In the Tertiary rocks olivine abounds and epidote has not been met with. About eight-tenths of the Porphyrite rocks so far found, contain enough calcareous matter to effervesce slightly with an acid, while scarcely one-tenth of the newer series are calcareous. This fact is probably due to the very general, more or less complete decomposition of the feldspars of the older rocks.

Two classes of granitic rocks.

The rocks of Granitic texture, of the region examined last season, appear to fall into two classes. Of these one contains little quartz, though sometimes passing over into a rock resembling quartz porphyry. This has been described as occurring at the mouth of the Iltasyouco River, and at one place on the Salmon River, and may be the result of the greater metamorphism of the porphyrites themselves. The second is more commonly found. It cuts through the Porphyrite formation in intrusive masses, and frequently directly underlies considerable areas of the Tertiary igneous rocks. It may vary from a true Granite to a Syenite or diorite, and very probably, in some cases, represents the deep-seated products of the last period of volcanic activity. In other places, however, the older Tertiary sedimentary beds resting on denuded surfaces of rocks of this class, show that they had been formed long anterior to the Tertiary volcanic period. Evidence continues to accumulate to show that sedimentary Tertiary beds, laid down in lakes of fresh water, underlie very

Lignites abundant in Tertiary.

extensive areas of the later basalts. With these the lignites are associated, and it would appear that in almost every case where important exposures exist, lignites of greater or less thickness also occur. The same importance does not attach to lignite as a fuel, in a well timbered country like British Columbia, as on the treeless plains east of the Rocky Mountains; but all these deposits will no doubt eventually be of value, and the better qualities of lignite would probably even now be preferred to pine and spruce wood for raising steam, if these two classes of fuel only were available. Nodular clay ironstone has been found in one place—Tsa-cha Lake—in association with the lignite formation.

REPORT

OF A

RECONNAISSANCE OF LEECH RIVER AND VICINITY.

[*Made in April*, 1876]

BY

GEORGE. M. DAWSON, Assoc. R.S.M., F.G.S.

Discovery of gold at Leech River.

Leech River was discovered to be auriferous by Mr. R. Brown's Government exploring expedition, in the summer of 1868. It attracted much notice, and it is estimated that about $100,000 worth of gold was obtained from it in a comparatively short time. Houses and stores were erected, under the supposition that it would prove a permanent mining region, but it is now completely abandoned.

Road and trail Leech River.

Leech River joins the Sooke River from the west, about seven miles from the mouth of the latter at Sooke Inlet, and nearly twenty-one miles from Victoria. A waggon road extends from Victoria to Goldstream Brook, which it reaches at a point about two miles south of the end of Saanich Inlet, into which the brook flows. The remaining distance of eight miles, to the mouth of the Leech, is accomplished by a trail, cut out at the time of the mining excitement, and still, with the exception of the bridges, in fair order. This follows the Goldstream for about three miles and then crossing it continues westward, while the valley turns to the north. The highest point attained by the trail, which keeps to a comparatively low tract in a country generally mountainous, is about 1,300 feet above the sea. From this it descends to the valley of the Sooke, which, at its junction with the Leech, has an elevation of about 230 feet. Large patches of snow remained in the woods at the higher levels on the 19th of April, and in the sheltered Leech Valley, at the junction of the North Fork, snow several feet in depth lay on the ground, interfering much with geological observation.

Rocks at Goldstream Bridge.

At Goldstream Bridge, where the waggon road ends, the rocks are greenish-grey schists, or slates, more feldspathic than quartzose. Some beds are divided into thin regular layers; the surface being slightly lustrous and talcose; others are less regular, break with a rough fracture, and are traversed in all directions by rusty surfaces. At the bridge the division planes of the rock have a strike of N. 58° W., with a dip northward at an angle of about 80°. At another place, the altitude is vertical, with a strike of N. 38° W. These planes appear to be that of the bedding, but may represent cleavage only. In some places, many veins of quartz are intercalated, and much broken vein-stuff strews the surface. The quartz is generally somewhat cavernous; though even the rusty stain of the pyrites, which it may once have contained, has for the most part been removed by weathering. It looks unpromising as an auriferous material. A tunnel has been run into one of the banks of the Goldstream, near the bridge, on a quartz vein. The material obtained, has, however, been completely removed by the flood waters of the stream, but it is to be inferred that the result of the enterprise was not satisfactory. Little alluvial gold has been found in the Goldstream.

Similar rocks extend westward.

In continuing westward to the crossing of Goldstream by the trail, rocks somewhat lower in the series—supposing the observed dip to represent their normal attitude—are met with. These consist of soft, glistening blackish schists, undulated and crimped, and often showing minute wrinkles on their surfaces. In some places they hold many veins and lenticular masses of quartz; parallel to the strike, and at the last exposure before crossing the stream, were observed to be rather paler in colour. The following strikes were obtained at three places, from east to west:—S. 43° E., with dip northward about 70°; S. 58° E., with probable high dip northward; S. 53° E., with dip northward at an angle of 50°. The position of the beds, it will be noticed, is extremely uniform. The slopes and lower portion of the valley, are for the most part, formed of a hard clayey "cement," like that to be described in the valley of Leech River.

Volcanic rocks.

After crossing the brook, no rock is seen for about half a-mile, and then, a dark purplish-black, apparently feldspathic rock, appears, quite unlike any of those formerly seen, and evidently of volcanic origin. Its dip is S. 2° W., $< 50°$, or nearly opposite to that of the slaty series. It would seem that the trail passes beyond the southern edge of the slates at this place, and for about a mile and a-half outcrops of similar volcanic rocks are found, though their altitude could not again be ascertained. They are dark greenish-grey and purplish traps: in some places showing little amygdaloidial grains, and often strung through with seams of pale green epidote. A mile before reaching the junction of the Sooke and Leech

River, black schists, like those already described, are again found, and must constitute here the extreme southern edge of the belt. They hold much quartz in leaves and lenticular masses, and strike S. 83° E., with a northward dip < 60°.

The auriferous area.

At the junction of the Leech and Sooke Rivers, on a low bench called Kennedy Flat, was formerly situated Leech Town. The valley of the Sooke runs directly northward to Sooke Lake—nearly two miles distant—from which it takes its rise. That of the Leech continues due west for three and a-half miles, and then forks; a small stream, known as the South Fork, coming in from the west or south-west, while the valley of the North Fork runs directly northward. Very little gold has been found on the Sooke River above its junction with the Leech; while below, scales of gold occur on all the bars. On the east and west reach of Leech River the greater part of the gold was obtained, and in turning up the North Fork it rapidly diminished in quantity; nothing to pay being, I believe, found above a fall known as the Devil's Grip.

East and west reach of Leech River.

The east and west portion of the Leech takes its course along the strike of soft, blackish schists, like those already described, which as we have seen, appear to form the southern margin of the slaty belt, and to these dark rocks we must attribute the greater part of the gold. The valley is narrow, in places almost V-shaped, and rises very steeply on its southern side, which appears to be formed by hard trappean rocks. While the strike of the soft rocks explains the course of this part of the river, its northern branch, and the north and south direction of the Sooke, seem to be due to remarkable systems of parallel cracks, which have affected the rocks without causing much displacement, and are best exemplified at the cañon on Sooke River.

Position and run of gold rocks.

Although, as just stated, the southern portion of the belt of schists appears to be characterized by the preponderance of blackish beds, there are also considerable intercalated masses of greenish-gray rocks, like those of Goldstream Bridge, and the general appearance of the beds near Kennedy Flat is so precisely that of those of the Bridge and its vicinity that there seems no reason to doubt that the same horizon is represented in both places. At the mouth of Wolf Creek—joining the Sooke from the east nearly opposite Kennedy Flat—the compact trappean rocks are again found bordering the slaty belt to the south. The material is here a fine-grained felsitic trap or indurated volcanic ash, shot through with epidoic seams and stains. Its dip is N. 10° E. < 54°, being almost opposite in direction to that previously observed in these rocks near their junction with the slates. In following the auriferous belt to the North Fork the rocks were observed to have the following attitudes in order from east to west:—Dip N. 17° E. < 45°; dip N. 22° E. < 60°; dip N. 30° E.< 80° to vertical; dip N. 17° E.<80°; dip N. 22° E.<70°; dip N. 2° E. <80°; strike S. 58° W., vertical.

Relations of gold rocks with Victoria series to the north.

North-westward from Kennedy Flat, among the mountains, the rocks are frequently seen at the surface, and though no absolutely continuous section was discovered in the short time at my disposal, some facts bearing on the relations of the schistose belt to the north were obtained. In crossing the rocks obliquely to their strike, which continues similar to that noted on Leech River, they are found in some places to be as black and soft as anywhere seen, but are in general paler, and at times coarser, and gritty from the introduction of arenaceous matter. At a stream known as "Prospect Gulch,"—estimated to be nearly two miles from the southern edge of the belt at right angles to the strike—a considerable band of the blackish schists, penetrated by many quartz veins, is still found. They dip N. 27° E.<70°. Still further northward, on the base of a prominent mountain nearly opposite the lower end of Sooke Lake, paler tints again prevail, and the rocks there seem to change rather gradually into thin-bedded and schistose diorites of fine grain, greyish and blackish-grey colours, sometimes glistening over the surfaces of lamination and occasionally micaceous. They resemble very closely many of the beds seen near Victoria, and are in all probability a part of that series. Shortly after the change occurs, the dip, though still very high, becomes reversed in direction. This may not be a feature of much importance with beds so nearly vertical, but may indicate their slightly fan-shaped arrangement. The strike, though about here rather inconstant, agrees pretty well with that of the gold rocks, and there is little to suggest the existence of a fault separating the two classes of rocks.

Trappean rocks of Sooke River.

Down the Sooke River, from the mouth of the Leech to Sooke Inlet, the rocks are all referable to the trappean series. The exposures being poor, and the weather at the time of my visit unfavourable, the attitudes of the rocks along this line of section were not discovered. It is probable, however, that several folds occur within this distance—over six miles. The varieties of rock observed in order from north to south are as follows:—

1. Rock already described at Wolf Creek. 2. Grey-green compact felsite, with small obscure feldspathic spots. 3. Coarse black and white diorite, perhaps intrusive. 4. Compact grey-green feldspathic trap, with veins of epidote, like the rock at Wolf Creek. 5. Fine grained grey diorite, with small pale feldspar blotches. 6. Dark grey-green amygda-

loid, with small round amygdules. 7. Fine grained blackish dioritic trap. 8. Fine grained, almost aphanitic, blackish-grey diorite. 9. Like No. 5, but rather coarser veins of epidote. 10. Like No. 8.

Rocks on Sooke Road.

From Sooke Inlet, by the road, to its junction with the Metchosin road, many exposures of rocks of this series again occur, showing trappean rocks of various colours, compact, amygdaloidal or brecciated. The country based on them is extremely rugged and rocky, with little soil, and no leading valleys.

Quartz veins.

In all parts of the slaty belt quartz veins abound, and in the black schists of Leech River are especially numerous, though small. A band of slates is often characterized by small thin streaks of quartz and little lenticular bunches through all its layers, without showing any well marked large vein. The quartz holds little pyrites, though sometimes superficially rusty, and I cannot learn that gold has ever been found in any of the veins. Just north of Kennedy Flat is a broad quartz band, resembling a lode, but which, from its lamination and compact aspect, more probably represents a zone of the slaty rocks silicified. It contains no metallic minerals. The sides and bottom of the Leech River Valley are covered by a "cement" like that already mentioned as existing at Goldstream. It is a hard, yellowish-grey sandy clay, which has apparently been consolidated by great pressure, as no calcareous or other cementing material is recognizable. It is charged with small sub-angular rock fragments of very varied origin, and in its character and mode of occurrence appears to represent the bottom-moraine of a glacier; precisely resembling the material which has in some places been forced into rock crevices near Victoria during the glacial period. On exposure to the weather it crumbles down to a soft sandy and stony clay. Knolls of slaty rock project through this "cement," and stand out above the lower benches in many places, showing that the cover is nowhere deep.

"Cement" a glacial deposit.

River gravels and sands.

Kennedy Flat is composed of shingle, sand, and boulder beds, irregularly stratified, and of quite recent fluviatile origin. It is from fifteen to twenty feet above the river, and is bounded by a second low terrace, about thirty feet higher, which runs back and blends with the slopes of the hill. At the North Fork another small flat of a few acres in extent occurs. No very marked difference was observed between the material of the cement and that of the later detrital deposits, though the latter usually contain less clay, and a greater proportion of comminuted black schist. The sand of the river shore is in great part composed of small, blackish, slaty particles derived from the rocks of the valley itself. The larger pebbles and boulders of both deposits are often of rocks of the immediate neighbourhood, but mingled also with great quantities of foreign rocks of all the kinds elsewhere observed in the drift of the south-eastern part of Vancouver Island; including coarse-grained diorites, whitish hornblendic granites, conglomerates and sandstones from the Cretaceous.

Distribution of the gold.

Adding to the east and west reach of the Leech River about a mile and a-half of the North Fork, the total length of the stream on which gold in any quantity has been found is about five miles. As far as I can learn, all the good "pay" was obtained in cleaning up the bed of the river itself, and by "crevicing" in the pot-holes, pockets and fissures of the slates of the sides of the valley. This distribution of the gold seems to follow naturally from the steep sides of the valley and its small width, and I do not know that any rich finds were made on any of the terraces and banks far above the stream, though a good deal of prospecting work has been done on some of them. The greatest quantity of heavy gold appears to have been obtained near Bacon Bar, about half-way between the North Fork and Kennedy Flat. At the last named locality the gold was nearly all light and scaly.

Sources of the gold.

Judging from appearances, the gold of the Leech River rocks has been pretty generally diffused in small quartz seams through certain parts of the slaty rocks, of which a great mass has been worn down and removed during the excavation of the valley, leaving the heavy gold, by a natural process of concentration, in a narrow line in the bottom of the excavation. It may, therefore, very well be, that no veins exist suitable for mining operations, though the deposits of the valley have been so rich in some places. At the same time the finer particles of gold are very generally diffused through all the surface deposits, and one can generally find two or three "colours" to a pan of dirt taken either from the modern deposits near the river level or from the decomposed "cement" far up the slopes.

Its general dissemination.

Little pyrites is found in association with the gold, and no particles of galena were observed; while magnetic sand is also present in rather small quantity, especially on the lower part of the river near its junction with the Sooke. In quality the gold is remarkably good.

Prospects for future mining.

There is little doubt but that some rich spots yet exist in the neighbourhood of Leech River, but they must be comparatively quite limited in extent, and, from the nature of the country, difficult to find. I am told that in most cases the miners were content to go no lower in the bed of the Leech than the surface of the cement, which in some places passes completely under it. In this case it is highly probable that an auriferous horizon, at least equally rich with the upper, exists on the surface of the true bed rock. The steep-sided character of the valley precludes the possibility of the existence of extensive old channels, following different courses from the present stream; but, on the south side of the river, near its mouth, a gravel flat occurs, where, in the opinion of miners, the river at one time flowed. This opinion may very probably be well founded, and if the ground is not very difficult it might be worth testing it It is also not improbable, that by hydraulic work, a great part of the cement and benches near the river would be found remunerative. The possible existence of auriferous veins rich enough to pay for working in this part of the country, which in respect to its position has great advantages over the inland districts, should also be borne in mind, though nothing of a very encouraging nature can yet be said on this subject.

Altered volcanic rocks of Victoria series.

In regard to the general relations of the auriferous belt, it may be stated to intervene between the dioritic and feldspathic rocks of the Victoria series on the north, and the traps, amygdaloids and breccias of the Sooke series on the south, though its relations to either of these systems cannot yet be certainly stated. The Victoria series will be more fully described when the map, for which materials are now accumulating, is finished. They consist chiefly of much altered volcanic sediments and traps, but hold beds of limestone and bands of argillite in some places, and may probably be of Carboniferous age. I am inclined to believe, from the apparent blending of the rocks of the gold series with these north of Leech River, that it is more closely connected with the Victoria than the Sooke beds, and may even rest comformably on the former. Some circumstances would appear to suggest a faulted junction, but even if this occurs it may not be a dislocation of much importance, or interfere with the conclusion drawn from the apparent lithological passage. The Leech River schists certainly represent the continuation westward of those seen at Goldstream, which are probably continuous eastward below the low land about Langford Lake and reappear at the point forming the western side of the entrance to Esquimault Harbour. Still further east, the extension of these soft beds may account for the step-like gap in the coast and straight line of the shore between Esquimault and Victoria harbours and beyond. The rocks here, however, become complicated by the great intrusive mass of the peninsula between the two harbours. I do not know anything of the extension westward of the gold-bearing belt, beyond Leech River, but its course, if uninterrupted, would probably bring it again to the coast about the Jordon River or Port San Juan, and it is probable that the gold found at the first named locality has been derived from it. The slaty belt is not, however, equally auriferous

Definition of the slaty belt.

Gold not equally distributed.

throughout, a fact shown not only by local differences found in the east and west part of Leech River, but by the absence of rich deposits on the Goldstream, which seems in its relation to the slate belt to be as favourably situated as the Leech. Though thus rather irregularly distributed in the slaty belt, gold, in paying quantity, is probably confined to it; which renders its defininition, both on the map and in its relations to the neighboring rocks, a matter of some importance. It is quite possible that several parallel folds may occur within the width of the belt of gold rocks, and that variations in its width and character may depend partly on these. In only two places has the attitude of the rocks of the Sooke series been ascertained near their junction with the gold rocks. In one case they dip in a direction almost exactly opposite to them, and in the second dip with them, and might be supposed to pass under them conformably. Taking the section as it occurs on Leech and Sooke Rivers, it would almost seem that the Sooke rocks were the lowest and the Victoria rocks the highest in an ascending series. This is negatived, however—besides other considerations—by the appearance of the Sooke rocks, which are altogether newer looking and less affected by metamorphism than the Victoria beds. It must either be, then, that the Sooke rocks form the highest member in a consecutive but overturned section, that they rest unconformably upon the gold rocks in a similar section, or that they join them along a line of fault. With our present knowledge the second would appear the most probable solution, though faulting may also tend to complicate the junction in some places.

Junction of slaty with Sooke rocks.

Age of the Sooke rocks.

The mutual relations of these three series of rocks offer an interesting and important problem, which could no doubt be most satisfactorily worked out in coast sections; but if these do not offer, might, I think, be solved in the Leech River district by a careful survey during the summer months, when the streams are low. I have not examined the coast from Esquimault to Sooke, but specimens collected near Albert Head by Mr. Richardson are evidently referable to the Sooke division, and he has found the same series on the coast west of Sooke. The age of these beds must at present remain an open question, but many facts tend to show that they represent the Mesozoic volcanic series of the mainland, elsewhere described as the Porphyrite Series, and if so are probably Jurassic.

GENERAL NOTE

ON THE

MINES AND MINERALS OF ECONOMIC VALUE

OF

BRITISH COLUMBIA,

WITH A LIST OF LOCALITIES.

BY

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[*Reprinted, with additions and alterations, from the Canadian Pacific Railway Report*, 1877.]

Mountainous belt of the Pacific coast.

Beyond the elevated western margin of the Great Plains, and intervening between it and the Pacific Ocean, is a region which may be characterized as one of mountains and disturbed rock formations. This runs north-westward and south-eastward, with the general trend of the coast, and is divided into two subordinate mountainous districts by an irregular belt of high plateau-country running in the same direction. South of the 49th parallel, this region, from the Rocky Mountains to the Pacific, in various parts of its length, has been found to contain valuable metalliferous deposits of many kinds, and already appears to be the most important metalliferous area of the United States. In the Province of British Columbia is included over 800 miles in length of this mountain- and plateau-country, with an average breadth of about 400 miles. North of the 49th parallel the Rocky Mountains are now known to extend to the Peace River, and even further northward, to near the mouth of the Mackenzie, and to maintain throughout much the same geological character with that of their southern portion. The Purcell, Selkirk, Columbia, Cariboo, and further north, the Omineca Mountains, may be taken collectively as the representatives of the Bitter Root Ranges of Idaho. The interior plateau of British Columbia represents the great basin of Utah and Nevada, but north of the southern sources of the Columbia this region is not self-contained as to its drainage, but dis-

Correlation of mountain ranges.

Cascade or Coast Range of British Columbia.

charges its waters to the Pacific. The Cascade, or Coast Range of British Columbia, though in a general way bearing the same relation to the interior plateau country as the Sierra Nevada Mountains of California and the Cascade Mountains of Oregon, forms a system distinct from either of these. The main period of uplift of the Sierra Nevada in its typical region probably antedates that of the British Columbia mountains, while the Cascade Mountains of Oregon are described by Professor LeConte and others, as chiefly composed of comparatively modern volcanic materials, which scarcely occur in the main ranges of the west coast of British Columbia. The parallel ranges of Vancouver and the Queen Charlotte Islands may, as far as their structure is yet known, be included with the Coast Range of the mainland.

Auriferous belt.

In British Columbia a belt of rocks, probably corresponding more or less completely with the Gold Rocks of California, has already been proved to be richly auriferous, and I think it may be reasonably expected that the discovery and working of rich metalliferous deposits of other kinds will follow. Promising indications of many are already known. With a general similarity of topographical features in the disturbed belt of the west coast, a great uniformity in the lithological character of the rocks is found to follow, so that while in a comparatively short distance from south-west to north-east considerable lithological change may be found, great distances may be traversed from south-east to north-west and little difference noted. In British Columbia, so far as geological explorations have yet gone, they have tended to show a general resemblance of the rocks to those of the typical sections of California and the Western States, and though metalliferous veins, individually, are very inconstant as compared with rock formations, belts characterised by metalliferous deposits, and dependent on the continuance of some set of beds, are apt to be very much more constant.

Uniformity of rocks in north-west and south-east bearings.

Circumstances retarding development of mining.

In the discovery and development of her mineral riches, British Columbia labours under many disadvantages, chief among which may be mentioned the comparatively short time during which the country has been settled, with the inaccessibility of the known mining regions, and cost of labour and supplies. In addition, a great part of the country is densely forest-clad, and the surface much encumbered with glacial drift, which, though often tending to produce a more fertile soil, conceals the indications to which the prospector trusts in more southern latitudes.

All these circumstances tend to retard the development of British Columbia as a mining country. It is slowly advancing, however, and it is my opinion, that when the country is opened up and the cost of labour and supplies reduced, it will be found capable of rapid development, and may soon take a first place as the mining Province of the Dominion. It must not be omitted to state that, in one very important particular, the rocks of this part of the Pacific Coast differ from those further south—the Cretaceous series changes considerably in its character, and at the same time becomes coal-bearing, furnishing the fuels mined at Nanaimo and Comox.

In the following pages, I have endeavoured to give a somewhat systematic, though brief account, of the mineral resources and mines of British Columbia, applying, where necessary, to the published Memoirs of the Geological Survey, and entering into somewhat greater detail with localities of which no published accounts are yet accessible.

GOLD.

Gold widely distributed.

It may, I think, be said without exaggeration, that there is scarcely a stream of any importance in the Province of British Columbia in which the "colour" of gold can not be found. The discovery of gold, first made known in 1858, led to the great influx of miners of that and the following year. Gold, thus the first cause attracting attention to the country, has ever since been the chief factor in its prosperity.

Statistics of gold production.

The annexed tabular statement shows the annual yield of gold from 1858 to the end of 1876. As no official record of the gold export has been kept, the only means of arriving at an approximate result is to add to that actually known to have been shipped by the banks and express companies, an estimated amount to represent that carried away in private hands. A great part of the gold leaving the country unrecorded, is carried away by Chinamen, and a portion goes from the Kootenay district, without reaching Victoria.

When in Victoria, with the kind assistance of Mr. C. Good, Deputy Minister of Mines, and by reference to the various banks, I revised these figures, which had been variously given by different authorities; and I think, though not absolutely correct, they may be accepted as being as near the truth as we are now likely to attain. Mr. Good has added to the figures in the table, from his books, the number of miners known to have been employed, and calculated the average yearly earnings per man, giving the very high general average of $658 per annum.

TABLE from the Second Annual Report of the Minister of Mines of British Columbia, showing the actually known and estimated yield of gold; the Number of Miners employed; and the average earnings per man, per year from 1858 *to* 1875. [*To which is added the known and estimated yield of gold in* 1876.]

YEAR.	Amount actually known to have been exported by Banks, &c.	Add one-third more, estimate of gold carried away in private hands.	Total.	Number of Miners employed.	Average yearly earnings per man.
	$	$	$	$	$
1858 (6 months.)	390,265	130,088	520,353	3,000	173
1859	1,211,304	403,768	1,615,072	4,000	403
1860	1,671,410	557,133	2,228,543	4,400	506
1861	1,999,589	666,529	2,666,118	4,200	634
1862	3,184,700	1,061,566	4,246,266	4,100	517
1863				4,400	482
1864	2,801,888	933,962	3,735,850	4,400	849
1865	2,618,404	872,801	3,491,205	4,294	813
1866	1,996,580	665,526	2,662,106	2,982	893
1867	1,860,651	620,217	2,480,868	3,044	814
1868	1,779,729	593,243	2,372,972	2,390	992
1869	1,331,234	443,744	1,774,978	2,369	749
1870	1,002,717	334,239	1,336,956	2,348	569
1871	1,349,580	449,860	1,799,440	2,450	734
1872	1,208,229	402,743	1,610,972	2,400	671
1873	979,312	326,437	1,305,749	2,300	567
1874	1,383,464	461,154	1,844,618	2,868	643
1875	1,856,178	618,726	2,474,904	2,024	1,222
1876	1,339,986	446,662	1,786,648		
			38,166,970		

Average number of miners employed yearly............	3,220
Average earnings per man, per year.....................	$658
Total actual and estimated yield of gold, 1858 to 1875....	$38,166,970

Total yield.

Adding the product of 1876, the whole amount of gold exported from the Province, in eighteen and a-half years, is computed at $39,953,618, or stated in round numbers, forty millions, a very remarkable result from a colony, the total European population of which probably did not average during the same period, 10,000.

Fluctuation in yield.

The gold yield shows a fluctuation from year to year, which is due not only to the uncertainty of the deposits worked, and number of miners employed, but depends also on climatic conditions. Thus the decrease of 1876, as compared with 1875, may be attributed in the Cariboo District to the great quantity of snow falling on the mountains during the preceding winter, and more than average rainfall of the summer; circumstances preventing the clearing of the deep claims from water till late in the season. In Cassiar, the unfavorable spring prevented the miners from reaching their claims till late, and heavy floods impeded their operations during the summer.

Sources of the gold in placers.

The very general distribution of alluvial gold over the Province, may indicate that several different rock formations produce it in greater or less quantity, though it is only where "coarse" or "heavy" gold occurs that the original auriferous veins must be supposed to exist in the immediate vicinity of the deposit. "Colours," as the finer particles of gold are called, travel far along the beds of the rapid rivers of this country before they are reduced by attrition to invisible shreds; and the northern and other systems of distribution of drift material have, no doubt, also assisted in spreading the fine gold. The gold formation proper, however, of the country, consists of a series of talcose and chloritic, blackish or greenish-grey slates or schists, which occasionally become micaceous, and generally show evidence of greater metamorphism than the gold-bearing slates of California. Their precise geological horizon is not yet determined, no geological survey to that end having been made; but I am inclined to believe that they will be found to occupy a position intermediate between the more distinctive members of the Lower Cache Creek group of Mr. Selwyn's first provisional classification of the rocks of British Columbia,* and the base of the overlying Mesozoic rocks, called in my report for 1875† the Porphyrite series. If this be so they are not improbably the geological equivalents of some of the richest auriferous rocks of California. By the denudation of the auriferous veins traversing these rocks the gold has been concentrated in the placer deposits.

Areas of gold-bearing rocks.

The greatest areas of these rocks appear in connection with the disturbed region lying west of the Rocky Mountain Range, known in various parts of its length as the Purcell, Selkirk, Columbia, Cariboo and Omineca Ranges. Other considerable belts of auriferous rocks, however, probably belonging to the same age, occur beyond this region, as in the vicinity of Anderson River and Boston Bar, on the Fraser; at Leech River, Vancouver Island, and elsewhere.

Cariboo District.

The Cariboo District, discovered in 1860, has been the most permanent and productive. The fifty-third parallel of latitude passes through the centre of the district, which has been described as a mountainous region,

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* Report of Progress Geological Survey, 1871-72, p. 61.

† Report of Progress, 1875-76.

Physical characteristics.

but is rather to be regarded as the remnant of a great high-level plateau, with an average elevation of from 5,000 to 5,500 feet, dissected by innumerable streams which flow from it in every direction, but all eventually reach branches of the Fraser River. These streams, falling rapidly about their sources over rocky beds, descend into great V-shaped valleys, and with the lessening slope, the rock becomes concealed by gravel deposits, which increase in thickness and extent till the valleys become U-shaped or flat bottomed, and little swampy glades are formed, through which the stream flows tortuously and with gentle current. The steep-sloping banks of the valleys are densely covered with coniferous forest, of which comparatively little has been destroyed by fire, owing to the dampness of the climate at this great altitude. The surface of the broken plateau above is often diversified by open tracts, affording good pasture in summer; and the whole country is more or less thickly covered by drift or detrital matter, concealing the greater part of the surface of the rocky substratum.

Shallow and deep placer mining.

As in all new gold mining districts, the shallower placer deposits, and gravels in the present stream-courses first attracted attention, but with the experience of California and Australia, it was not long before the "deep diggings" were found to be by far the most profitable. Williams' and Lightning Creeks have, so far, yielded the greater part of the gold of Cariboo. They were known from the first to be rich, but have been found specially suited for deep work, in having a hard deposit of boulder clay beneath the beds of the present watercourses, which prevents the access of much of the superficial water to the workings below. By regular mining operations the rocky bottom of the valley is followed beneath fifty to 150 feet of overlying clays and gravels, the course of the ancient stream being traceable by the polished rocks of its bed, and the coarse gravel and boulders which have filled its channel. In the hollow of the rocky channel the richest "lead" of gold is usually found, but in following the rock surface laterally, side-ground, rich enough to pay well, is generally discovered for a greater or less width. The old stream-courses of the Cariboo district are found to have pursued very much the same directions that their present representatives follow, crossing often from side to side of the valley with different flexures, and occasionally running through below a point of drift material projecting into the modern channel, but never, I believe, actually leaving the old valley or running across the modern drainage system, as is so often the case in the deep placers of California and Australia.

Ancient buried river channels.

As an example of the methods employed, and extent of mining operations required to reach the buried channels, the Van Winkle Mine, on Lightning Creek, which is the most successful now in operation, may be taken. This mine is briefly noticed in the Descriptive Catalogue, published in connection with the Geological Survey's collection at the late Philadelphia Exhibition.

Van Winkle mine.

The claim covers about 2,050 feet in length of the valley, the deepest part of the old channel of which had been cleared out to a length of between 1,600 to 1,700 feet in October of 1876. Much side ground, however, yet remains, and the workings sometimes attain a width of from 200 to 300 feet, in following this up as far as it can be made to pay. The claim yielded the first dividend in December, 1873, $40,000 having been expended before gold was found in the channel. It has since continued to pay handsomely, having produced in one week gold worth $15,700, and on other occasions at the weekly " clean up," sums of $14,000, $12,000, &c. At the date above mentioned the total product of gold had amounted to the large sum of $500,964.99.

Outlay and product.

In reaching the buried channel, a shaft is usually sunk at the lower, or down-stream end of the claim, on the sloping side of the valley, where after having gone through a moderate depth of clay or gravel, the slaty rock of the district is reached. The shaft is then continued through this, till a depth supposed to be sufficient is attained, when a drift is started at right angles to the course of the valley, and if the right depth has been chosen—either by rough estimation, or calculation based on that required in other neighbouring workings—the old channel is struck in such a way as to enable the subterranean water collecting in it from the whole upper part of the claim, to be pumped to the surface by the shaft. On cutting out of the slate rock, however, into the gravel, so much water is frequently met with that the pumps are mastered, rendering necessary a cessation of work till the dryest part of the season, or the application of more powerful machinery. When the drift is not found to be at a sufficient depth to cut the bottom of the old channel, it is generally necessary to close it, and after continuing the shaft to a greater depth, to drive out again. The old channel once reached, and cleared of water, is followed up its slope by the workings, to the upper part of the claim, and where paying side-ground occurs it is also opened.

Shaft sinking.

Drifting for the old channel.

In the Van Winkle Mine the average depth of the workings is only about seventy feet, the lowest shaft being placed 300 feet from the creek, on the opposite side of which the rock is seen to rise to the surface, forming steep cliffs. The water is raised to within forty feet of the surface, when it is discharged into an adit 3,000 feet long, which is also

Water.

used by other claims. There are two pumps, ten inches in diameter, with wooden pipes, making about twelve four-foot strokes a minute, the power being supplied by an eighteen-foot breast-wheel. This does not adequately represent the volume of water pumped, however, as the ground of this claim is partly drained by others lower in the series, in which work cannot be carried on till later in the season. The richest pay is obtained in the rock channel of the old stream, but where this is much contracted the force of the water has swept the gold away to those places where its width is increased. The harder rocks still preserve their polished and water-worn forms, but most of the slates are rotten and crumbling to a considerable depth, and in cleaning up in the bottom, a thickness of one to two feet is taken out with a pick and shovel, and sent up to the surface with the overlying gravel, for treatment. In the side-work, as in the central channel, the greater part of the gold is found lying directly on the " bed rock " and only occasionally are paying streaks seen in the gravel a few feet above it. The side ground is worked up from the channel in successive breasts parallel to it. The average yield of the part being worked at the time of my visit may be stated at from two and a-half to three ounces to each set of timber; the set uncovering about thirty-five square feet of bed rock, with a height of six feet.

Side work.

Lowest deposits.

The lowest layers of gravel contain many larger boulders of quartz and slaty fragments not much water-worn, which must have come down from the hill-sides; the appearance being that of deposit by torrential waters to a depth of four to six feet in the channel, above which the gravel is generally better rounded, and more evenly spread, though still mixed with little clayey matter.

In consequence of the unconsolidated nature of the gravel, the pressure on the suports of the workings is excessive. The sets of timber are in some places only a few inches apart, and the whole of the workings are lined with complete lagging. The timber used is very massive, being from one to two feet in average thickness, and consisting of the spruce of the country, simply barked and sawn into lengths. It costs, delivered at the mine, eight cents per running foot, all suitable sizes being taken at the same rate. The lagging, which is merely split out, four feet long, five inches wide, and two thick, costs seven dollars a hundred pieces. With every precaution, the timbers are frequently crushed by the pressure, or the uprights even forced downward into the slate. Where large boulders are removed from the sides, or " slum " is found, spruce brush requires to be extensively used behind the lagging, and in many parts of the mine the water streams from the roof like a heavy shower of rain.

The auriferous gravel is raised to the surface by bucket and rope, with friction gearing and water power.

Pumps.

The whole of the deep workings are annually filled with water at the time of the spring floods, and it is sometimes late in the summer or autumn before the pumps again acquire the mastery. In October of 1876 the following companies on Lightning Creek were driving their pumps day and night, the Van Winkle being the only mine clear of water.

Costello Claim.—Pump, twelve inches diameter, nine-foot stroke, making ten strokes a minute.

Vulcan Claim.—Pump, twelve inches diameter, six-foot stroke, making eighteen strokes a minute.

Vancouver Claim.—Pump, twelve inches diameter, nine-foot stroke, making ten strokes a minute (double acting).

Van Winkle Claim—Pump, ten inches diameter, fourteen-foot stroke, making ten strokes a minute (two pumps).

The quantity of water being raised at this time would, therefore, amount to about 13,870 gallons a minute, or 19,874,000 per diem.

Mines developed without foreign capital

In many cases the machinery and appointment of the mines is very creditable, and almost the whole expense of the mining enterprises is borne by the miners of the district themselves, without the aid of foreign capital, and with labour and materials of all kinds at exorbitant rates. Money earned in one venture is embarked in another, and some of the shareholders of a mine are frequently at work themselves below ground.

Lightning Creek.

On Lightning Creek about 16,000 feet of the valley may be said to be worked out, in so far as the deep channel is concerned; and though some bench claims and tributary creeks have paid well, the material on sides of the valley is not rich enough to pay for hydraulic work at present. In endeavoring to "bottom" the old channel further down the valley, very great difficulties are encountered, owing to the great quantity of water met with and the increased depth of the sinking required. There is no reason to believe, however, that the lowest part of the channel holding good pay has been reached.

The following table, supplied by Mr. James Evans to the Minister of Mines of British Columbia, gives as correct a statement as he has been able to compile of the amount of money taken from some of the more prominent claims on Lightning Creek, up to November 1st, 1875:—

Yield of various mines.

Dutch and Siegel (now Perseverance)	$130,000
Dunbar	30,000
Discovery and Butcher	120,000
Campbell and Whitehall	200,000
South Wales	141,531
Lightning	153,962
Point	136,625
Spruce	99,908
Costello	20,476
Vulcan	56,955
Vancouver	274,190
Victoria	451,642
Van Winkle	363,983

Williams' Creek.

On Williams' Creek, on which the towns of Barkerville and Richfield are situated, the chief workings have been in a space of about two and three-quarter miles in length. In this the deep channel has been worked through, and also as much of the side ground as would pay at the time at which the mining took place. Many of the lateral creeks and gullies here have paid remarkably well; and the hillsides, in some places to a height of 100 feet or more, have proved to be sufficiently rich for the hydraulic method of working, which is now extensively practised. Williams' Creek, however, will not compare with Lightning Creek in richness, its yield for 1875 being, according to Mr. Bowren's estimate, only $68,000. Barkerville, however, has a certain importance in being the centre of a number of outlying mining districts.

Distribution of gold in the valley.

The "cañon" between Barkerville and Richfield divides the creek into two parts. For about half-a-mile above it, the ground was shallow, and has been worked open to the bed rock. Further up, deep drifting was practised in former years; hydraulic work is now carried on. Below the cañon all the work has been deep, in the old channel. Though streaks of "pay" were sometimes found after getting down about twenty feet, these were usually disregarded in early days. In the Cameron claim, however, half-a-mile below Barkerville, the dirt paid nearly to the surface, and was worked in stages from below after the old channel had been cleared out. The workings were about sixty feet deep at Barkerville, only thirty-five feet at the former site of Cameronton, and at the Ballarat claim,—three-fourths of a mile below Barkerville—eighty feet. This is the lowest claim in which the old channel has been bottomed, and most of the gold obtained was light and scaly. The valley is here wide, the present stream turning abruptly to the west, while a wide, low hollow, known as Pleasant Valley, runs off in the opposite direction, to

Antler Creek. It is supposed by many that the main channel of the ancient watercourse turns off in this direction, but, owing to the great quantity of water and loose character of the ground, neither this nor the present valley of Williams' Creek, below the Ballarat, has yet been proved, though much money has been expended in the attempt. The Lane and Kurtz Company imported expensive machinery and erected very complete works some years ago, but have not succeeded in proving their ground, and have, for the present, abandoned the attempt. As some of the tributary streams have paid well, there is reason to believe that a part, if not the whole, of the deep channel of the lower part of Williams' Creek must be rich, notwithstanding the generally fine character of the gold in the Ballarat mine.

Lower part of Williams' Creek.

Inadequate machinery.

As already stated, Lightning and Williams' Creeks have been specially favourable ones for deep working, but even in these it has often been barely possible, with the appliances which can at present be obtained, to bottom many parts of their upper reaches, while the more difficult lower portions of the channels have not been proved in either case. As Mr. Evans very wisely remarks:—"Had many of the companies machinery of powerful capacity at first, one-third of the expense would have sufficed to prospect their ground, but unfortunately many of them were poor, struggling for existence, and coping with enormous difficulties."

Great cost of supplies and labour.

Owing to the isolation of the district, and length and character of the road by which it is reached, the price of food—the whole of which is imported—and of labour is excessively high. The average rate of freight from Yale—the head of navigation on the Fraser—to Barkerville, according to Mr. Bowren, is from seven and a-half to eight cents per pound in spring, and about twelve and a-half cents in autumn; or may be said to average nine cents a pound—a heavy tax on mining machinery and other weighty articles.

The prices current of some staple articles in Cariboo, are as follows:—

Flour per lb.	8	cents.
Beans do	15	"
Bacon do	35	"
Grain, for horse feed, per lb	7	"
Hay do	5	"

Ordinary labourers receive $5 per day; mechanics, from $5 to $7; Chinamen and Indians, $3. These prices, though a great reduction on those ruling before the construction of the waggon road, preclude the working of any but the richest deposits, which necessarily bear but

Gold remaining in ground worked over.

a small proportion to those with a moderate or small amount of gold; and in working over the deep ground in early days much was left that would even now pay handsomely, but cannot be found or reached on account of the treacherous nature of the moved ground, filled with old timbering and water. I do not think it would be an extravagant statement to say that the quantity of gold still remaining in the part of Williams' Creek which has been worked over, is about as great as that which has already been obtained. With regard to Lightning Creek, this statement would scarcely hold, though there must be a great quantity of gold in ground of medium richness even here. To render this gold available, however, and to prove successfully the lower and more difficult parts of the valleys, greater and more exact engineering knowledge, better and larger machinery, and, above all, cheaper labour and supplies, dependent on greater facilities of transport, are required.

Proposed flume.

As an illustration of what might be done in this way, it may be mentioned that it is already suggested, that by cutting a flume to Antler Creek—part of which would require to be a tunnel—free drainage of the whole upper part of Williams' Creek would be obtained; enabling the valley from its sources to the flume level, with all its old workings, and the great depth of tailings holding more or less gold, which have accumulated, to be completely stripped by extensive hydraulic works.

Promising creeks.

So far, mention has been made of Williams' and Lightning Creeks only, but there are many other localities in the Cariboo district which have yielded much gold in surface work or shallow diggings, which it is believed by those best able to form an opinion, would prove rich in their deep ground, if properly explored. Owing, however, to the great cost of prospecting, and of suitable machinery, this has not yet been done. Antler, Cunningham, Jack of Clubs, and Willow River, are supposed to be especially promising, and attempts are now being made to bottom some of them. Mr. Bowren states, however, that the Nason Company have already spent $30,000 on their claim on the first-named stream without having been able to test their ground.

Alluvial deposits only worked.

In most gold-bearing countries the placer mines, though often rich, have eventually led to the mining and treatment of the auriferous quartz from which the alluvial gold has been derived. In British Columbia the alluvial deposits have so far absorbed the mining energy of the country, but in view of the already diminished yield of the best known placers, and the inevitable more or less complete exhaustion of deposits of this kind, within, at best, a moderate term of years, attention can not too soon or too carefully be turned to the more permanent quartz-mining.

Prospects for quartz mining.

Though much of the gold accumulated in the beds of the old streams of Cariboo may have been derived from veins too small to work individually, it seems scarcely to admit of doubt, that in a region where so large a quantity of gold has been obtained within so small an area, rich lodes will be discovered and worked. Indeed, notwithstanding the want of attention to these deposits, and the very difficult nature of the country to prospect, several are already known, which in other parts of the world might justify extensive mining operations. Some of these have been traced with considerable and well-maintained width for several miles. Specimens collected from several of the outcrops in October, 1876, proved, on analysis, the average content of gold and silver to be low, probably too low to repay work at present Cariboo prices. By selecting for crushing, however, only the richer portions of the ore, it is possible that the percentage might be raised to a remunerative figure. A praiseworthy effort is now being made, under the auspices of the Local Government, to test the better known lodes on a practical scale, and it is to be hoped that this, coupled with the energetic prospecting of the many more or less important veins in the surrounding country, will be persisted in, till that eventual success, which in this district may almost be regarded as assured, shall be achieved. The remarks made in connection with the placer mines, as to the cost of labour and provisions, apply in this connection with even greater force. Vein mining, once initiated, will, I believe, rapidly develop, giving to the district a permanent character which it does not now possess, and indirectly tending to cheapen labour by affording employment summer and winter. The gold occurs, as is usual, in association with iron pyrites, but also often with considerable quantities of galena, through crystalline masses of which the precious metal is sometimes strung.

Association of the gold.

Other auriferous districts.

Of the districts of Kootenay, Omineca, and the new Cassair region, I know nothing personally, nor have they ever been visited by any member of the geological staff. Situated on the same belt of auriferous rocks, they, no doubt, in the main features of their deposits resemble those of Cariboo. There are also several other localities on the line of the main development of the auriferous rocks, which have from time to time attracted attention and yielded more or less gold; but from their inaccessible position, limited character, poor pay, or depth of cover, they have been abandoned or allowed to fall into the hands of Chinamen. The greater part of the Gold Range, especially toward the north, is very densely timbered, and covered with moss, peaty swamp and tangled vegetation, rendering its examination very difficult, and the discovery of the rich spots a matter requiring time and labour; in this respect it differs altogether from the bare slopes of California. It is to be remarked, however, that the recognised areas of all the gold-fields will be very much extended when altered conditions render deposits of the lower grades remunerative, and that many of those which have now fallen out of notice will again spring into importance.

Kootenay.

The yield from Kootenay, for 1875, is stated by the Minister of Mines to have been about $41,000—forty White and fifty Chinese miners being employed; the yield for 1876, according to the same authority, was only about $25,000. Much labour and money is being expended to bring in water at a sufficient height to work the hills and benches of Wild Horse Creek.

Omineca.

The Omineca district has certainly not proved as rich as it was at one time supposed to be, and has in great part been abandoned for the new field of Cassiar. In 1875 the total population was sixty-eight; the estimated gold product, $32,000. The number of miners in 1876 was still smaller. I have spoken to several men who have left this district, but who still appear favourably impressed with its prospects. The transport of supplies from Yale costs eighteen cents a pound, causing provisions of all sorts to be so dear that a miner cannot afford to stay unless he has a rich paying claim. Extensive prospecting is quite out of the question as a private enterprise, and, in consequence, great areas remain yet untried. Mr. Page, late government agent in the district, believes the Findlay Branch to be specially worthy of examination.

Argentiferous galena from Omineca.

A sample of quartz, with some galena, obtained on a stream running into Manson Creek, thirty miles from Dunkeld, which was transmitted by Mr. Gavin Hamilton, of Stuart's Lake, proved on examination by Mr. Hoffman, in the laboratory of the survey, to contain 8.971 oz. of silver to the ton, with traces of gold; the silver being contained in the galena, which is confined to a small portion of the vein-stone examined, and must be highly argentiferous.* Other veins reported in this district have not been examined.

Native silver.

Nuggets and pellets of native silver, generally worn and rounded, but occasionally rough, and seeming as though recently freed from the matrix, have been found in considerable abundance in some streams during gold-washing operations. They are specially noticeable in Vital Creek, I believe, but have attracted little attention, and have not been traced to their source. On analysis, the nuggets are found to contain a few per cent.

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* Report of Progress, 1875-76, p. 430

of mercury in combination, and may, therefore, be more correctly classed as native amalgam.

Cassiar district

The Cassiar district is the latest and most northern discovery on the auriferous belt of British Columbia, being situated about north latitude 59°, and separated from Omineca by over 300 miles of rough country, unknown geographically, and scarcely, if at all, prospected. Gold has long been known on the lower part of the River Stickene, by which Cassiar is approached from the coast; but it occurs there in light scaly particles, like those obtained on many of the bars of the Fraser. The rich deposits lately discovered, lie on the sources of the River Dease and about Dease Lake, the upper end of the latter being separated by only a few miles of low country from a part of the Stickene. The Dease empties into the Mackenzie, and thus passes to the Arctic Sea. The discovery of this district is due to Mr. Thibert and a companion, who reached it from the east in 1872, after three years spent in trapping and prospecting. Mr. Good, in the report already referred to, states that the area of the Cassiar gold-field, as at present developed, comprises a tract of country of at least 300 square miles. The number of miners employed during the summer of 1875 was over 800, and the gold obtained is estimated at a little less than a million of dollars. In 1876, according to the Report of the Minister of Mines of British Columbia, the estimated gold yield was $556,474, and 1,500 miners and others visited the mines. The yield for 1877 is estimated by Mr. Vowell, Gold Commissioner, at $499,837. The number of men at the mines, exclusive of Indians, is said at no time to have exceeded 1,200, of whom 300 to 400 were Chinese. Dease and McDame Creeks, the two most important in the district, are about one hundred miles apart, while discoveries have been pushed northward and eastward on river systems connected with the Dease to a distance estimated at 370 miles, in a region which probably lies beyond the Province of British Columbia, and in the as yet unorganised North-west Territory. A promising quartz vein, containing gold, silver and copper, has been discovered on McDame Creek, and a lode of argentiferous galena on the River Francis or Deloire.

Gold yield.

Difficulties of gold mining in Cassiar.

The Cassiar mines are worked under enormous disadvantages, situated in an almost arctic climate, where the soil is permanently frozen at a small depth below the surface on the shady sides of the valleys, with a short season during which the water-courses are liable to floods, disastrous to the mines; reached after a sea voyage from Victoria, by the River Stickene, only a part of which is navigable even under the most favorable circumstances, and with supplies of all sorts at famine prices—only the highly auriferous character of some parts of the district continues to render it attractive. It is scarcely likely that any improvement in the means of communication in the more settled portions of British Columbia will materially affect Cassair, but the existence of its rich deposits is important as showing the continuity of the auriferous belt of the country; and if rich metalliferous veins can be proved to exist, on which more permanent mining may be carried on, Cassair may yet rise on its own merits to be an important mining district, drawing its supplies by improved trails, or by a road, from the central portions of the Province. Beef cattle are even now driven overland from the Lower Fraser to Cassair.

Placers of the Fraser River.

It will be unnecessary to refer at any length to the Fraser River gold deposits, the first to attract notice, but rich in only a small portion of their extent. It is estimated by Mr. Good, that about $50,000 worth of gold was produced on the Fraser during 1875, the mining being chiefly in the hands of Chinamen and Indians. For 1876 a partial return gives a yield of about $42,000. The gold occurs along the whole course of the Fraser, irrespective of the formation over which the river may pass. Heavy gold has been chiefly found from a few miles below Boston Bar to Siska Flat, near Lytton, and on the Thompson, near Nicommen. It is no doubt derived from the rocks of the neighbourhood. The richest deposits are supposed to be worked out, though it is quite probable that many of the benches would pay for hydraulic working properly appointed.

Occurrence of gold on Vancouver Island.

In Vancouver Island, the Leech River District, situated about twenty miles from Victoria, attracted much notice at one time, and yielded a considerable quantity of gold in a small area. The total product has been estimated at $100,000. It is interesting in having been discovered by a government prospecting expedition fitted out for the purpose. The rocks I believe to be of the same age as those of the other gold regions, and if this be so it proves the persistent auriferous character of this horizon over a great area, embracing, it may be said, the whole of British Columbia. Gold in small quantities has also been found in other parts of Vancouver Island, but, owing to the impenetrable character of the forests, comparatively little is known of any part of its interior.

Coal and Lignite Bearing Formations.

Coal-bearing formations of east and west coasts.

A line drawn on the ninety-seventh meridian separates pretty exactly the coal-bearing formations of America into two classes. West of Eastern Nebraska, the Carboniferous formation, properly so called, which yields the coals of Nova Scotia and the States east of the Mississippi, ceases to be productive. The shales and sandstones associated with the coals of the east are gradually replaced by limestones, which underlie the Great Plains, and, though the formation does not preserve its purely calcareous nature on the west coast, it still shows little tendency to resume its coal-bearing character. The coals and lignites of the west are found at various horizons in the Secondary and Tertiary rocks, which in the eastern regions are developed on a comparatively small scale, and are not coal-producing. Valuable coal deposits may yet, however, be found in the Carboniferous formation proper of the far west; and where, as on some parts of the west coast, calcareous rocks of this age are largely replaced by argillaceous and arenaceous beds, the probability of the discovery of coal is greatest. I believe, indeed, that in a few localities in Nevada, coaly shales, used to some extent as fuel in the absence of better, are found in rocks supposed to be of this age. The discovery of certain fossils in 1876 in the limestones of the Lower Cache Creek group now allow these and probably also the associated quartzites and other rocks to be correlated with this period; and it is worthy of mention that black shales, with a considerable percentage of anthracitic carbon, occur in connection with these in several places, and may yet be found, in some parts of their extension, to become of economic value. Mr. Richardson has also found small fragments of true anthracite, in rocks which are very probably of this age, on the shores of Cowitchen Bay; and inland, seams of anthracite, with regard to which nothing certain is yet known, are reported to exist. Of these, several specimens have been brought out, and though probably inconsiderable in thickness, they seem to deserve examination.

Possibility of discovery of Palæozoic coals.

The coal-bearing rocks of British Columbia.

The formations known to produce fuels of economic value in British Columbia may be classed in three divisions, as follows:—1. *Lower Cretaceous or Cretaceo-Jurassic rocks of Queen Charlotte Islands, etc., holding anthracite;* 2. *Cretaceous rocks of Vancouver Island, etc., with bituminous coal;* 3. *Tertiary rocks, with bituminous coal and lignite.*

The first-named series of rocks is only as yet known to hold coal on the Queen Charlotte Islands, where, at a place named Cowgitz, the Queen Charlotte Coal Mining Company, formed by some gentlemen in Victoria, began mining operations some years ago, but eventually abandoned them

Anthracite of Queen Charlotte Islands.

on account of the irregularity of the deposit. This locality has been examined and reported on by Mr. Richardson,[*] who made a short visit to the island for that purpose. The best seam had a thickness of a little over six feet for a distance of about sixty or seventy feet, but became mixed with shale and limestone, and was eventually lost. A second bed of good anthracite, two feet five inches in thickness, also occurs, with other thin seams. A man who was afterwards employed by the company to undertake explorations on their behalf, traced the continuations of the beds for three or four miles, and reports having observed outcrops of coal seams on most of the streams he crossed. It is also reported by the Indians that a well-marked coal seam occurs about fourteen miles from the original locality in a south-easterly direction, on the south side of Skidegate Channel, which would give an extent of at least twenty miles to this area of the coal-bearing rocks in that direction; the facts indicating, as Mr. Richardson remarks, the general permanence and continuity of the coal beds, however variable they may be in detail. Between Cowgitz and Masset, on the north end of the island—from which samples of anthracite coal have also been brought—a level country is reported to exist, below which Mr. Richardson supposes the coal formation may also extend, and should it be found to do so, the total length of the coal area on the Queen Charlotte Islands would be little short of one hundred miles.

Analysis of anthracite.

In composition, the anthracite of the Queen Charlotte Islands compares favourably with that from Pennsylvania. The following analyses by Dr. Harrington[†] were from samples collected by Mr. Richardson; No. 1 being from the six-foot seam; No. 2 from the so-called three-foot seam (2 feet 5 inches):—

	I.	II.
Water	1·60	1·89
Volatile combustible matter	5·02	4·77
Fixed Carbon	83·09	85·76
Sulphur	1·53	0·89
Ash	8·76	6·69
	100·00	100·00

Equivalents of Queen Charlotte Island rocks elsewhere.

Rocks of the same age with the coal-bearing series of the Queen Charlotte Islands are probably present also on the mainland, where fossils indicating a horizon both somewhat higher, and a little lower in the geological scale have already been found, and apparently occur in different parts of a great conformable rock series, though this cannot yet be confidently stated. These rocks are extensively developed on

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[*] Report of Progress, 1872-73, p. 56.

[†] Op. cit., p. 81.

the eastern flanks of the Coast Range, near the head waters of both branches of the Homathco, and probably occur in considerable force, with a similar relation to this axis of disturbance throughout its length, as the explorations of last summer have led to the discovery of rocks near the same horizon, on the Iltasyouco and Salmon Rivers, in latitude 52° 50′. To what extent these lower Mesozoic rocks may continue to hold coal on the mainland, or whether they entirely cease to do so, remains as a matter for future enquiry, though it may be stated here, that on Tatlayaco Lake and elsewhere, some carbonaceous matter, with broken fragments of plants, occurs in connection with shaly beds. The rocks of this group well deserve a more careful and extended examination; and for the purpose of ascertaining their thickness and real character, the coast sections of the Queen Charlotte Islands are probably best adapted, and once worked up would serve as a standard of comparison for other and less accessible regions.

Cretaceous coal measures of Vancouver.

The rocks of the second class are best represented in the coal-fields of Nanaimo and Comox, on Vancouver Island, and are now well ascertained to be of Cretaceous age. Coal is said to have been discovered at Nanaimo by the Indians about twenty-two years ago. Through them the Hudson Bay Company heard of its existence, and subsequently began to work it. In 1861 they sold their mine, now known as the Vancouver Colliery, to an English Company.

The Comox and Nanaimo areas have been thoroughly examined by Mr. Richardson. They are described in his reports for 1871–72, 1872–73, 1873–74, and will be more completely treated of in a forthcoming report.

Extent of coal basins.

Quoting from the report of 1871–72, the coal measures are described as resting in a " narrow trough, which may be said to extend to the vicinity of Cape Mudge on the north-west, and to approach to within fifteen miles of Victoria on the south-east, with a length of about 130 miles." The surface of the country is, generally, rolling, with no elevations rising to a greater height than 800 feet, and, in some places, is comparatively level. The rocks accompanying the coals are sandstones, conglomerates and shales, and are often false-bedded on a large scale. They hold abundance of fossil plants and marine shells in some places, and in appearance and degree of metamorphism much resemble the true Carboniferous rocks of some parts of Eastern America.

Nanaimo area.

On the Nanaimo area there are three companies now at work, the mines being known respectively as the Vancouver, Wellington and Harewood. The two first carry their coal to the wharf by short railways on which locomotives are used; while the last named is provided with an

Number and thickness of seams.

aërial wire tramway. Two seams are worked in the Vancouver Company's Mine, respectively six feet and three feet in thickness, and probably averaging, together, eight feet of clean coal. The seams were lately lost at a fault, but have been recovered at a slightly increased depth by boring, the thickness of the upper seam being reported at nine feet in the bore-hole. The coal bed worked by the Wellington Company, at Departure Bay, averages nine feet six inches, while a second seam, stated to be six feet thick, is known, but is not used. The seam at the Harewood Mine averages five to six feet in thickness, and three and a-half feet below it is a seam three feet thick. It is difficult to ascertain the precise equivalency of the different beds, but Mr. Richardson is of opinion that those of the Vancouver and Wellington areas represent each other.

Statistics of labour and out-put.

The coal is worked, I believe, on the pillar and stall system, though parts of the seams have been so steeply inclined as to require stoping. The miners employed are Whites, Chinese and Indians. Mr. Good states the number of each, for the year 1875, to be as follows:—Whites, 396; Chinese, 176; Indians, 51; giving a total of 623. The wages earned by the Whites vary from $2.00 to $5.00 a day; by the Chinese and Indians, from $1.00 to $1.50. The total out-put of coal for 1875 is given at 110,145 tons, being an increase of 28,597 tons 12 cwt. over that of 1874. During 1876 the out-put is stated to have been 140,187 tons, showing an increase of 29,942 tons over 1875. At the mines the coal sells at $5.00 to $6.00 a ton; in San Francisco it commands about $10.00.

Comox area.

The Comox area has probably a greater extent of productive measures, and may eventually become more important than the Nanaimo, and at the present time a company are in a position to ship coal there, having constructed a railway and the necessary wharves and works. Mr. Richardson gives a number of carefully measured sections of the Comox area,* showing their character along various parts of a line, which, following the direction of the outcrop of the beds, is about thirty miles in length On Brown's River, furthest north, almost the entire mass of the productive measures is exposed in a thickness of 739 feet 6 inches of beds. In this section nine coal seams occur, with an aggregate thickness of 16 feet 3 inches, the thickest bed being the lowest in the series, and averaging 7 feet. In a section of 122 feet at the Union mine, ten coal seams, with an aggregate thickness of 29 feet 3 inches occur, the thickest seam being 10 feet. This section represents only a

Sections across the basin.

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* Report of Progress, 1872-3, p. 85 *et seq.*

small part of the productive division. In a third section, on Trent River—again embracing nearly the entire thickness of the productive measures—thirteen seams are found, with an aggregate thickness of only 18 feet 1 inch, the thickest bed being 3 feet 8 inches. On the area of the Baynes Sound Company, in 220 feet 10 inches of measures, two seams of 6 feet and 5 feet 10 inches, respectively, occur.

Extent of basin.

Mr. Richardson* estimates the extent of country underlain by the productive measures at 300 square miles, without taking into consideration that which may lie beyond the shore; and computing the total thickness of workable coal in the Union Company's property at a little over twenty-five feet, calculates the quantity of coal underlying the surface at 25,000 tons per acre, or 16,000,000 tons per square mile for this part of the region.

Character of the seams.

It will be seen, from the outlines of sections given above, that the productive coal rocks of Comox, though throughout preserving their carboniferous character, probably vary considerably in the number of seams contained, and even more widely in the thickness of the individual seams in different parts of their extent. This variability appears to be equally found in all parts of the Vancouver coal fields which have been examined, and contrasts with the greater comparative regularity of those of many parts of the Palæozoic Carboniferous formation. In the working of these beds, the next most important exploration after the mere definition of the coal-basins, will be the proving of the seams from point to point by boring operations. To this end the diamond drill has already been used with good result.

Quality of Vancouver Island coal.

In quality the Vancouver coals are found superior for all practical purposes, to any worked on the Pacific coast, and command, in consequence, a higher price. The comparatively limited scale on which the workings are at present carried on, is owing to the small demand for local purposes and the high duty imposed on the coal entering San Francisco, the chief foreign market. In spite of this, however, Nanaimo coal is used on the western section of the Central Pacific Railway.

As an impartial estimate showing the superiority of the Vancouver Island coals, the following table establishing the comparative value of these and other fuels for steam raising purposes, by the War Department of the United States, will be interesting.

One cord (8 feet by 4 feet by 4 feet) of merchantable oak wood is there said to be equal to:—

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* Report of Progress, 1871-2, p. 80.

Comparative value of coals of west coast.

1,800	lbs.	Nanaimo Coal (Vancouver Island.)
2,200	"	Bellingham Bay Coal (Washington Territory.)
2,400	"	Seattle Coal (Washington Territory.)
2,500	"	Rocky Mountain Coal (Wyoming, &c.)
2,600	"	Coos Bay Coal (Oregon.)
2,600	"	Mount Diablo Coal (California.)

Average composition of Vancouver coals.

Dr. Harrington has given the following statement of the average composition of the coals of Vancouver Island, as deduced from his analyses: *

	Slow coking.	Fast coking.
Water	1·47	1·47
Volatile combustible matter	28·19	32·69
Fixed carbon	64·05	59·55
Ash	6·29	6·29
	100·00	100·00

In a sample from the Union Mine, Comox, the percentage of ash is only 2·83.

Other coal areas of Vancouver Island.

Nanaimo and Comox are not the only known coal fields of Vancouver Island. Coal occurs, and was worked at one time by the Hudson Bay Company, near Fort Rupert, on the north-eastern coast of the island. A low, flat country is reported to stretch from here to Quatseno Sound on the west coast, where the coal rocks are again known. Some examination of the latter locality was made at one time for an English Company, who had acquired property there, by Mr. Landall. Mr. R. B. Brown, the botanist, also visited the region in 1866, and writes regarding it: "My opinion is decided that the Koskemo (Quatseno) coal field is the best yet discovered in Vancouver Island, though unopened out, not only on account of the superior quality of the coal, but the ready accessibility of the mines from the Pacific, without the tedious inland navigation requisite for reaching the mines on the eastern seaboard of the island." The main seam is stated by Mr. Landall to be four feet six inches in thickness, and the quality of the coals, as shown by his analyses, is good. He estimates the coal of the part of the Quatseno basin he examined, making allowance for faults, &c., at 33,600,000 tons.

Mr. Richardson also describes the occurrence of rocks of the coal series at the head of Alberni Canal, opening into Barclay Sound on the west coast. Specimens of coal have been procured there, but the mode of its occurrence is not known; neither this locality nor those on the

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* Report of Progress, 1872-3, p. 79.

northern part of the island having yet been examined by the Geological Survey.

Probability of further discoveries.

The interior of Vancouver Island being comparatively unknown, even in regard to its main topographical features, it is not improbable that a geological examination may bring to light coal areas, which may be extensive and important, in the valleys of the interior. A considerable part of the crumpling and metamorphism of the older rocks is of post-cretaceous date, a fact which renders it quite possible that outlyers of the coal rocks may be found folded into other synclinals, besides those already known along the coast-line.

The question of the possible occurrence of coal-bearing rocks of the age of those of Vancouver Island on the mainland of British Columbia, is one on which little can be said. The equivalents of these rocks have not yet been distinctly rocognized, nor is it known whether it will eventually be possible to separate them by any well marked line from the lower rocks of the Queen Charlotte Islands and their representatives on the mainland.

The coast sections of Vancouver and the Queen Charlotte Islands will probably afford the means of determining the relations of the two series.

Tertiary coal-bearing rocks.

Coals of Washington Territory.

The Tertiary rocks of British Columbia appear to hold both true coal and brown coal or lignite, though this series is better known in its extension southwards in Washington Territory than within the limits of the province. At Bellingham Bay, and at Seattle, on Puget Sound, it has been worked for a number of years, and the mines of the latter locality are now in a flourishing state, and ship large quantities of coal to San Francisco, which, though inferior to that of Nanaimo, can compete with it, owing to the protective duty. The Seattle coal seams are said to be five in number, and to vary from four to twelve feet in thicknes. In quality they may be considered equal to the better class of lignites from the western plains and Rocky Mountain Region, which are found to be sufficiently good for steam raising and most ordinary purposes, but compare unfavorably with true coals. Mr. Macfarlane, in his work on coals, gives the following analysis of that of Seattle:—

Water	11·60
Volatile combustible matter	35·49
Fixed Carbon	45·97
Ash	6·44

The Tertiary rocks of Puget Sound have never been thoroughly examined, but it is believed by those who have studied them for the purpose of tracing the seams of coal, that, leaving out of consideration the minor irregularities, they lie in a wide trough between the Olympic and Cascade Mountains. In the central part of this trough, and stratigraphically the upper part of the series, the fuels are lignites; lower down in the series these are replaced by fuels more closely resembling true coals, and on the outer edges of the trough by coals in some places so much altered that they have been called anthracites. It is possible that all these Tertiary rocks rest unconformably on the Cretaceous, and are separated from it by a lapse of time during which folding of the older beds and elevation of mountains took place; but it is not improbable that in some places there may be a more or less complete series of passage beds between Cretaceous and Tertiary, as occurs on the eastern slopes of the Rocky Mountains; or that there may even be two uncomformable series of Tertiary rocks.

Same measures continuous on Lower Fraser.

The Tertiary coal measures of Puget Sound and Bellingham Bay are continuous north of the 49th parallel, and must underlie nearly 1,000 square miles of the low country about the estuary of the Fraser and in the lower part of its valley. Lignite has been found in connection with these rocks at Burrard Inlet and other localities, and specimens of a fuel resembling true bituminous coal (and coking on the application of heat) have been obtained near the Fraser above New Westminster. The remarkably good specimen of coal from the River Chilliwack, of which an analysis by Dr. Harrington is given on page 99 of the Geological Survey Report for 1873-74, is probably from this series. The seams, so far as known, are quite thin, but the low country underlain by the formation is deeply covered with drift and alluvium, and exposures are few. Mr. Richardson has made a slight examination of the coast sections on the shores of Burrard Inlet, but the rest of this district has not been worked out. A geological examination, embracing all the known outcrops, would probably have to be supplemented by boring operations in well-chosen localities before the value of the coals and lignites of these rocks can be ascertained.

Tertiary rocks elsewhere on the coast.

Tertiary rocks holding lignite, are found fringing other parts of the coast in greater or less width. They have been seen near Sooke, and at various places on the south-west coast of Vancouver Island. They also occur at Clallam Bay on the south side of the Strait of Fuca, in Washington Territory. None of these localities have been particularly examined, nor are they likely to be of importance in view of the accessibility of the superior coals of the Cretaceous, unless in some place thick beds of lignite, somewhat resembling bituminous coal in its properties, like that of Seattle, should be found to occur. If such beds should prove to exist they may acquire some importance from their less disturbed and more easily workable character.

Tertiary coal-bearing rocks of the interior.

Lignite and coal formations of Tertiary age are known to cover great tracts of the interior of British Columbia, and it can now be shown, from several sections examined last summer, that in most places the horizontal, or slightly-inclined basaltic, and other igneous flows of the interior plateau, are attached to, and form the latest rocks of the lignite-bearing Tertiary. From this fact, and the known relations of the beds in a number of localities, it is highiy probable that sedimentary Tertiary deposits underlie a great part of the area, showing only the later igneous rocks at the surface, and wherever extensive exposures of these Tertiary deposits occur, more or less coal or lignite has been found in association with them. Very roughly, in our present comparatively slender knowledge of the region, it may be estimated that this formation occupies between the 54th and 49th parallel of latitude, an area not less than 12,000 square miles.

Nicola Valley coals.

In the Nicola Valley, near the junction of the Coldwater, the occurrence of coal has been known for some years, and on analysis it has proved to be a bituminous coal of very high class. The average of two determinations, by Dr. Harrington, gives the following result:

Volatile combustible matter and moisture.............	36·065
Fixed carbon..	61·290
Ash	2·645
	100·000

I made a cursory examination of this locality in November of 1876, and a more detailed survey has been made during the past summer, of which the results will be published in the next Report of Progress. The chief exposure of the coal is in the west bank of the Clearwater river, which joins the Nicola from the south, and down which one of the proposed lines for the Canadian Pacific Railway passes in its way from Hope to Kamloops. The original opening on the coal was almost in the bed of the river, and is now quite filled up. A second small opening has, however, been made a little higher up the bank, and here a thickness of five feet three inches of nearly pure coal is exposed, separated by six inches of sandstone from a second underlying seam, one foot four and a-half inches thick. The coal-bed passes below a considerable thickness of pale-yellowish, rather coarse-grained, soft sandstone, which crumbles under the weather and appears to dip here about north, at an angle of 10° to

Exposures.

15°. In a second exposure, at the distance of about a mile, in a ravine in the south bank of the Nicola, similar sandstones occur, associated with blackish shales and again holding coal, of which several beds are seen. Beyond the Coldwater Valley to the east, on the Nicola, older crystaline rocks appear, cutting out the coal measures; but westward the coals, with associated sandstone, pass beneath a great thickness of the rocks of the Tertiary volcanic series, dipping, on the whole, at low angles to the south-west. In following the Nicola Valley westward, the volcanic rocks are found to form the mass of the hills which rise steeply on either side, well stratified tufaceous sandstones, probably connected with those of the coal formation, are seen to rise from time to time in the lower parts of the slopes. These rocks are also seen—presenting much the same characters, but without again showing the lower sandstones—for about thirteen miles below the mouth of the Nicola, on the Thompson, making the width of the belt of country here covered by them about thirty-seven miles.

Relations to volcanic rocks.

Extent of the field.

It has not yet been ascertained whether the sandstones and associated coals underlie the whole breadth occupied by the volcanic rocks, which may be considered as the upper part of the same formation. It is now known, however, that the coals really pass beneath the great volcanic formation, and may reasonably be expected to occur over a considerable portion of its area. This question is well worthy of careful investigation, especially in view of the possible passage of the railway in the vicinity of these newer coal-measures. In the local absence of sections sufficient for the satisfactory definition of the rocks of the lower part of the series —as on the lower Nicola Valley—they are generally so situated that they can be tested with comparative ease by boring in well-chosen localities. The coal-bearing rocks of the Nicola region are also now known to extend far up the Coldwater, and though not satisfactorily exposed, contain more or less coal. Similar rocks have also been examined on the North Thompson, about forty-five miles above Kamloops. They contain coal of excellent quality, but, so far as the present small exposures allow them to be seen, in thin seams. These, and other localities visited during the past summer, will be reported on in detail in the next Report of Progress.

Lignite coals of other localities.

Lignites or brown coals, are found abundantly in the upper part of the same formation. Near Marble Cañon a bed of this material surpasses forty feet in thickness, and important deposits also occur on the North and South Forks of the Similkameen. The lignites and lignite formation of Quesnel will be found described in Mr. Selwyn's

Lignite at Quesnel.

preliminary report of 1871-2, and in my own for 1875-6. These beds are interesting on account of the plant and insect remains preserved in them, but the lignites here are, I believe, of no economic value. They are mixed with clayey matter, and are otherwise poor in quality; and are, apparently, the result of the rather tumultuous deposition of drift-wood and other vegetable matter, by rapidly-moving waters. Lignite of better quality, and apparently, in some instances at least, still resting in the locality where the wood producing it grew, is, however, found in other places. Drift fragments of this fuel, of quality good enough for ordinary purposes, are found on the Nazco, Blackwater, Lower Nechacco, Parsnip, Chilacco, Fraser River at Lillooet, the Thompson below Kamloops Lake, &c., and lignite is known to occur in place on Lightning Creek (Cariboo), the Upper Nechacco (p. 82), and Ko-has-gan-ko Brook (p. 76), besides a number of localities on and near the Fraser River, between Quesnel and Soda Creek, which have not been examined.

Drift lignite.

Value of lignites.

These lignites do not, of course, compare favourably as fuels with the coals of the Nicola Valley, and would scarcely be of value unless found in thick and accessible seams, and then for local use or in the absence of other fuels. Comparatively little is yet known about their distribution, for though, as already stated, they probably underlie a great part of the basaltic plateau, the soft character of the associated beds allows them to be easily worn away, leaving hollows into which the basalts and other hard over-lying volcanic rocks, readily crumbled by the weather, fall, concealing the lignite out-crops.

IRON.

Iron ore at Texada.

The most important deposits of iron yet known in British Columbia are those of Texada Island, which have been examined and briefly reported on by Mr. Richardson.* The ore is a coarsely granular magnetite, containing, according to analysis by Dr. Harrington, 68·40 per cent. of iron, with only ·003 per cent. of phosphorous. It is associated and interbedded with limestones, epidotic and dioritic rocks, supposed to be of Carboniferous age; and is well situated for mining, smelting, and shipment, occurring within twenty miles of the point of shipments of coals of the Comox area, and contiguous to deep harbours; while charcoal in unlimited quantities could be prepared in the immediate vicinity. The largest exposure is on the south side of Texada Island, about three miles north-west of Gillies Bay. Here the ore-bed is

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* Report of Progress, 1873-4, p, 99.

seen to be from twenty to twenty-five feet thick, and to rest on grey crystalline limestone, with which, for about two feet down, are interstratified bands of ore of from half-an-inch to an inch in thickness. From this point to the north-west, for nearly a mile, the bed is occasionally seen, and at one place there is a continuous exposure about 250 feet long, and from one to ten feet thick. To the north-east it is also said to have been traced for more than three miles.* With the present high price of labour on the Pacific coast, and especially in British Columbia, the profitable manufacture of iron may appear to be a contingency of the remote future only; especially in view of the low rate of freight at which the west coast is supplied with coal and iron from Britain, by vessels coming out nearly light, for return cargoes of wheat from California and Oregon. In the neighbouring State of Oregon, however, the manufacture of charcoal iron has been instituted for some years on a small scale, a single blast furnace being in operation with a product in 1874 of 2,500 tons, for 1875 of 1,000 tons.† Where iron ore and fuel of first rate quality can thus be obtained together, it is often possible to compete successfully, for many purposes, with the lower classed and priced iron most abundantly produced in Britain. On the Pacific Coast, too, Chinese labourers can be procured in unlimited numbers, at prices so low as to compare favourably with those of any part of the world; and the Chinese are notably apt in acquiring proficiency in the more skilled mechanical arts.

Possibility of iron smelting.

Iron smelting in Oregon.

Clay ironstones.

Clay iron-stones are of frequent occurrence in the coal rocks of Vancouver and Queen Charlotte Islands. They might, no doubt, in some cases, be profitably worked in conjunction with the coal seams, as they occur at but small distances beneath them, and in some instances are even associated with the coal. The nodules vary in weight from a pound or less up to many tons, and Mr. Richardson says that at the Baynes' Sound Mine a sufficient quantity could probably be obtained for the regular supply of a blast furnace.‡

Iron has been found in smaller quantities in many other localities, but little attention has been paid as yet to these deposits, under the impression that, under present circumstances, they are of no value. The formation containing the iron ore of Texada is believed to be the same as that constituting the greater part of Vancouver and its adjacent islands.

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* Descriptive Catalogue of Economic Minerals of Can., Phil. Inter. Exhib., 1876.

† Journ. Iron and Steel Inst., No. 1, 1876, p. 238.

‡ Dr. B. J. Harrington in Appendix III. to Mr. Richardson's Report, 1872-73, p. 82.

SILVER, COPPER, MERCURY AND OTHER ORES.

Difficulty in opening mines.

No work but such as may be classed as prospecting or preliminary exploration, is, or has been carried out on the deposits of metalliferous ores in British Columbia. Various unfortunate circumstances have prevented the testing, on a large scale, of the localities known to be promising, and much money has been lost from time to time in injudicious enterprises, which with a comparatively small amount of knowledge of mining and metalliferous deposits in other countries would have avoided. These circumstances, coupled with the difficulty and expense incurred in exploring the more rugged and tree-clad portions of the Province, have tended, of late years, to discourage enterprise in this direction, and to throw discredit on even the best of the known deposits. As soon as one or two properly conducted and paying mines can be seen in operation, I feel convinced that the growth of mining industry will become as rapid as it has heretofore been slow.

Silver at Hope.

Silver.—The best known argentiferous locality is that about six miles from Hope, on the Fraser River, which was discovered about 1871. It has not been visited by any member of the Geological Survey, and from its great elevation, is only easily accessible during the summer season. The formation in which the lodes occur consequently remains unknown, but from what I have heard, I am inclined to believe that they may traverse an outlyer of the Lower Cretaceous, which caps the Cascade Crystalline rocks of the region. The Minister of Mines, of British Columbia, describes it as follows:—" The first lead, called the Eureka mine, crops out about 5,000 feet above the river level, is well defined, four to seven feet in thickness, and has been traced 3,000 feet. A tunnel has been driven into this lead 190 feet. The ore is described as argentiferous grey copper, and has yielded, under assay, $20 to $1,050 worth of silver to the ton.

Eureka Mine.

Van Bremer Mine.

" During the time the above lead was being worked, another, about 3,000 feet distant, was discovered; this is of a far more valuable character, and is called the Van Bremer Mine. The ore is described as chloride of silver, and has yielded, under assay, from $25 to $2,403 of silver per ton of rock. A quantity from the outcrop sold at San Francisco at $420 a ton. The lead is distinctly traceable for half a mile."

Specimens assayed by Dr. Harrington and Dr. Hunt gave, respectively, 271·48 oz. and 347·08 oz. of silver to the ton of 2,000 pounds. Lead, copper, antimony, iron, arsenic and sulphur, are also present. As above stated, the ore from this locality has been sold at a remunerative price in the rough state, as extracted from the mine, and carried to the river by the present rude appliances. Certain unfortunate difficulties, with regard to the ownership of the property, now only appear to prevent the successful working of this deposit.

Quite lately lodes, which are supposed to be either the continuations of those above described, or others running parallel to them, have been discovered near the water level of the Fraser, apparently in a granitic matrix. These contain silver and copper, but the former in smaller quantity than in the Eureka veins.

Silver at Cherry Creek.

Cherry Creek, a tributary of the Shushwap or Spillemeechene river, between Okanagan and Arrow Lakes, is noted as a locality from which specimens of remarkably rich silver ore have been brought, and where somewhat extensive exploratory works have been carried on with the hope of finding it in paying quantity. The district has now been examined, and though not yet prepared to report upon it in detail, I may say that, though the vein originally worked on was reported as lost, I am by no means hopeless as to its eventual recovery, and that the number and character of veins in the Cherry Creek country lead to the belief that it may eventually be an important mining region.

Native silver.

As already mentioned, native silver, or silver amalgam, has been found in the Omineca district, and argentiferous galena ores occur in many parts of the Province, but have not yet been developed.

Copper.—Masses of native copper have been found from time to time in various parts of the Province, and though they have never been observed in their matrix, they are probably derived from some of the volcanic rocks. Small cupriferous veins have also been observed in volcanic rocks of Tertiary and Mesozoic ages, in the gold rocks, the crystalline rocks of the Coast Range, and those already referred to as of supposed Carboniferous age in Vancouver Island. The most promising locality at present known is situated among the mountains between Howe's Sound and Jarvis' Inlet, at a height of about 3,000 feet above the sea. Very fine specimens of purple copper ore, associated with quartz, mica and molybdenite, are brought from this place, which is now in course of development. The county-rock is a granite or diorite of the Cascade Crystalline series.

Copper at Howe's Sound.

Knight's Inlet, &c.

Fine specimens of similar ore have been procured further north at Knight's Inlet, and specimens of copper pyrites have also been obtained from rocks of this series at several localities on the Homathco during the railway explorations.

Mercury.—The discovery of this metal has been several times reported in British Columbia, but generally, I believe, on insufficient evidence. It appears certain, however, that small quantities of cinnabar have been obtained in gold-washing on the Fraser River, near Boston Bar, and I am also informed that minute globules of mercury are seen in some decomposed parts of the Hope silver ores. In the autumn of 1876 I received a small but well-authenticated specimen of rich cinnabar ore from Mr. Tiedemann, of the railway survey, which he obtained himself in the vicinity of the located line of the railway, on the Homathco. From Mr. George Webb I learn that the country-rock is slate, the lode well defined, being seen in the front of a steep southward-facing bluff, and traceable for nearly a mile in length. I have also seen lately a rich specimen of cinnabar and native mercury from the west side of the Fraser River near Clinton. Whether mercury occurs, however, in deposits at all comparable with those of California, which are found in rocks of similar age to some of those occurring in British Columbia, remains to be proven.

Mercury.

Cinnabar on the Homathco.

On the Fraser.

Lead.—Galena has been found in many parts of the province, and appears in connection with gold, both in the lodes and superficial gravels of the Cariboo district. Lead ores, as such, will not probably pay to work in the interior, even if found in large quantity, till cheaper means of transport are introduced. Highly argentiferous galenas would pay to smelt as silver ores, if found in moderately accessible localities.

Lead.

Platinum.—This metal has been found in small quantity in several localities in association with alluvial gold.

Platinum.

Nickel.—Dr. Blake has found nickeliferous sand among the heavy materials separated from the fine gold of the Fraser.

Nickel.

BUILDING AND ORNAMENTAL STONES.

The Coast Range will probably furnish, in all parts of its length, good grey diorites and granites. These might be quarried at the water's edge in many of the inlets. Sandstones and freestones occur abundantly in association with the coals of Nanaimo, &c. A sandstone, quarried I believe on Newcastle Island, was employed in the Treasury building at San Francisco, but has not proved very satisfactory, owing to its tendency to exfoliate. By judicious selection, however, no difficulty will probably be found in obtaining building stones of this class in unlimited quantity. Over a great part of the interior, the harder rocks are so fissured and jointed, as to be incapable of yielding sound building stones of large

Granite and freestone.

size. Many localities are known, however, where good stone can be obtained, and it is probable that some of the basalts and other igneous rocks of late date will answer well for building, if proper care be taken to avoid those varieties apt to crumble under the weather. The rocks occurring in the vicinity of the various proposed railway lines are described more fully elsewhere.

Marble.

Marble of good quality is known to occur at Texada Island, Metla Katla Bay, on the Nimpkish River and other localities.

Serpentine.

Serpentine is found abundantly in association with some of the older rocks.

LIST OF LOCALITIES IN THE PROVINCE OF BRITISH COLUMBIA KNOWN TO YIELD GOLD, COAL, IRON, SILVER, COPPER, AND OTHER MINERALS OF ECONOMIC VALUE.

(This list makes no pretension to completeness, the object of its publication being rather to elicit than to impart information. It will show, however, in some degree, how numerous the discoveries have already been; and may, I hope, be largely extended in the course of a few years. Most of the statements made with regard to the various localities are derived from trustworthy sources, though I cannot undertake in all cases to vouch for their absolute accuracy.)

GOLD.

Cariboo District.

Williams' Creek.—Described in the foregoing pages. Its tributaries, in order, down stream, are as follows:—

McCallum's Gulch.—Joins from the east; nearly worked out; no deep ground.

Mink Gulch.—Joins from the west, and prospects not considered very encouraging by owners, who are waiting for the Bed-rock flume, with intention of hydraulic work.

Walker's Gulch.—Joins from the west at Richfield Court House; deep work; good prospects at different times, and some quantity of gold taken out about its mouth, but has not held out. Not yet thoroughly prospected.

Grub, or Black Jack Gulch.—Joins from the west; a mere ravine of no great length, being all embraced in one claim; good pay for hydraulic method, and still worked.

Stout's Gulch.—Joins from the west, below the cañon; very rich, but now worked out for drifting; hydraulic method now employed; ground enough for many years.

Conklin Gulch.—Joins from the east, opposite Barkerville; very rich; still worked by drifting; ground very deep for so small a valley, being ninety feet in lower part and twenty in highest; drifting claim, one and a-half miles up; probably rich for hydraulic working.

McArthur's Creek.—Two miles below Barkerville and one mile above Lane and Kurtz shaft-house; joins from the south-west; paid well in drifting deep ground, but now worked out for this method; no hydraulic work in progress.

Lowhee Creek.—Runs northward, nearly parallel to Williams' Creek, and empties into Jack of Clubs Lake, which also receives Jack of Clubs Creek, and is the source of the Willow River; good pay found in both shallow and deep diggings, and some good ground still being worked; gold, especially near source of creek, very coarse and rough, often including fragments of quartz; found difficult to obtain water for hydraulic work here.

Jack of Clubs Creek.—All deep work on this creek, gravel being 150 feet in depth near the mouth, where a few claims paid well; this creek is a favourite among those which are considered yet unproven, the impression being that an old channel exists which has not yet been found.

Creeks entering Willow River.—

Mosquito Creek and Red Gulch.—Entering Willow River from the south below the last; the former has been very rich, and was fifty feet deep at mouth; now worked out for drifting; hydraulic work paying well.

Whipsaw Creek.—Three miles below Mosquito Creek, on the same side; in former years from $10 to $12 per day per hand taken out, and more or less work carried on ever since by ground-sluicing and drifting.

Several creeks below Whipsaw Creek, on the south-west side of Willow River, have afforded no pay; fair prospects have been obtained in several creeks on north-east side, but no paying ground found.

Sugar Creek.—Twelve miles below Mosquito Creek, joining from the north. Some good prospects, but never much pay.

Creeks lower down Willow River are known to hold some gold, but have not yet yielded it in paying quantity.

Grouse Creek.—Six miles east of Barkerville, heading with Antler Creek. The deep ground was very rich, and extended for about a mile near the upper part of the creek, giving out farther down. Deep ground worked out.

Antler Creek.—Heads in Bald Mountain, opposite Williams' Creek, and was one of the first creeks worked in this part of the country. Shallow ground for two miles, paid well, and has been worked out. The deep ground has not yet been much tested, owing to the absence of clay, and consequent large quantity of water met with in sinking. All the gulches joining Antler Creek from the source down, have paid (Wolf, California, Stevens', and Begg's Gulches). The creek has never been bottomed where these side-valleys fall in. Chinamen are at work, and getting pay on benches 100 feet above the stream, a long way down.

Pleasant Valley.—A transverse depression, four miles in length, uniting the valleys of Williams' and Antler Creeks, and joining the former about four miles below Barkerville. Has never been bottomed or much prospected, but might be embraced in a scheme for draining the valley of Williams' Creek.

Bear Creek, and country about Bear Lake.—Gold has not been found here in paying quantity.

Swamp River.—Has attracted some attention, but no good pay has yet been found.

Cunningham Creek.—In early days, a crevice containing 600 ounces of gold, was found on this creek, about twelve miles from its mouth. Several hydraulic claims working. Since 1864 attempts to reach the deep ground have been made, but have not yet succeeded; a third attempt is now being made by the Victoria Company. It has always been supposed that the deep ground in this creek would turn out rich, and if once proved to be so, a large amount of work would immediately be undertaken.

Harvey's Creek.—The first gold in paying quantity in the Cariboo District was found here in 1860. One claim—the Minnehaha—has been exceedingly rich. Another, at the junction with swamp river, has paid well. The Cummings Company bottomed it at one place, and drifted up in a small cañon (unsuccessfully,) but found pay on entering wide ground. The upper part of the creek is deep, and has not yet been thoroughly proven.

Creeks on the North side of Cariboo Lake.—In Nigger, Pine and Goose

Creeks, small quantities of gold have been found; on the last-named much money was spent in putting in a flume, but with small result.

Kiethly Creek.—The main creek has only moderately deep ground, (twenty to twenty-three feet,) of which much is yet unworked; it being expensive to open on account of the great quantity of water. About thirty white men did well here during the summer of 1876; while a number of Chinamen, at work about the mouth, also got good pay. Benches 100 feet above the stream have paid for open work, and some of them for drifting also. Hydraulic method not yet in use here.

Snow-shoe Creek.—The east branch of the above is considered to be one of the most promising creeks of which the deep ground is yet unprospected; gold obtained from shallow workings.

Duck Creek.—Chinamen have been working here, but not much known as to results.

Black Bear Creek. --Much prospecting has been done here, but rich pay never found; not yet considered fairly tested, the ground being hard to work in.

Cedar Creek.—One pretty rich claim was worked here,—the Aurora. The creek is now worked by Chinamen.

Hazeltine's Creek.—Some encouraging "prospects" have been obtained here.

Moorhead Creek.—Some work done here, but without good result.

Kangaroo Creek.—Joins North Fork of Quesnel about two miles above its junction with the South Fork. Paid well at one time. Chinamen now at work.

Quesnel River.—Most of the work done on bars of river, though many workings on benches one hundred to 150 feet above the water, pay well. The gold is all light. This region is altogether in the hands of Chinamen, who resort chiefly to the Forks and South Branch. About 300 Chinamen work in this district during the summer, and winter at the Forks.

Swift River.—Rather inaccessible, and hard to work, being a rapid stream with many heavy boulders. Considerable quantities of gold have been taken from it, from time to time, and Chinamen still at work, though the stream, as a whole, may be considered unprospected.

French Creek and Canadian Creek.—Joining Pleasant Valley from the south, have both yielded some gold, which, though run through where the working was carried on, is probably not exhausted.

Canon Creek.—A stream running into Willow River far down its course, and reached by a trail twenty miles long from Beaver Pass House, A company last autumn engaged in attempting to bottom it, with good prospects.

Canon Creek.—A second stream of the same name, joins the Fraser from the east above Quesnel. A considerable quantity of gold obtained here formerly, some of it very heavy and mixed with quartz; one nugget worth $700 found by Chinamen on its branch—*Hickson Creek.* An auriferous quartz vein is known.

Lightning Creek.—Has been described on a preceding page. Its chief tributaries are as follows:—

Amador Creek.—No good pay yet found.

Van Winkle Creek.—About 2,000 feet of the lower end of this valley paid well.

Dead Mans Creek.—

Perkin's Creek.—

Chisholm Creek.—Good pay in shallow workings. Deep ground unproved, though great efforts have been made to test it.

Last Chance Creek.—Estimated that $250,000 worth of gold taken out of this creek in the distance of half-a-mile. Rich ground now probably worked out.

Davis Creek.—Good pay in shallow ground.

Anderson Creek.—Good pay in shallow ground.

Jawbone Creek.—No good pay found.

Quartz Veins in the Cariboo District.—Many are known, some very persistent and of large size. So little has yet been done toward the examination of these that it is scarcely worth while attempting to enumerate them. That known as the *Big Bonanza,* between Lowhee Creek and Stout's Gulch; the *Stedman,* at Richfield; and an irregular vein or mass of quartz, at Mosquito Creek, have so far attracted most notice.

Cassiar.

(For the following very interesting local details, concerning Cassiar District, British Columbia's youngest and least known gold field, I am indebted to Mr. G. B. Wright.)

Stickeen River.—54° to 56° north latitude. Discovered in 1867. Highest average yield per day, $4 to $5, bar and bench diggings. A few claims being worked, but nearly exhausted.

Dease Creek.—Latitude, 58° 42′ 50″; altitude, 2,750 feet. Discovered in 1873. Highest average yield per day $8 to $50; the gold being worth $16 an ounce. The richest claims are worked out, but mining will be carried on for a good many years to come. Dease Creek has probably yielded about $700,000 in three seasons. Estimated yield this season (1877) about $125,888.

Thibert's Creek.—Latitude, 58° 50′; altitude, 2,750. Highest average yield per day $8 to $50, the gold being worth $16.40 an ounce. Bar, bench, and creek diggings. A portion of the creek worked out, but still paying well. Bench diggings recently discovered very rich. Yield up to this season estimated at $300,000.

Beady Creek.—Latitude about 58° 53′. Discovered 1874. Bar diggings. Prospects found, but no extensive mining ever done.

Eagle River.—Latitude, 59° 6′ 14″. Discovered 1874. Bar diggings, undeveloped.

McDames' Creek.—Latitude, 59° 15′ 54″; altitude of mouth, 2,550. Discovered 1874. Highest average yield per day $6 to $100, the gold being worth $17.75. Bar bench and creek diggings. This is the most important creek in the Cassiar region, the yield continuing about the same each year. It is being worked in places for a distance of fifteen miles, and will yield largely for several years. Estimated yield for two seasons $425,000; for this season probably $250,000. This includes the yield for several of the small creeks and tributaries of McDame—Somers' Creek, Snow Creek, Quartz Creek, Rosella Creek, Davies' Creek and Gold Creek.

Snow Creek.—Altitude, 3,400 feet. Discovered 1875. Highest average per day, $5 to $20; gold worth $18 an ounce. Bench diggings, still mined extensively; the richest claim in Cassiar, near the mouth of this Creek; it has paid for a week as high as 300 ounces for six or eight men. Seventy-two ounces washed out of one pan of dirt during the past season.

Quartz Creek.—Altitude, 3,550 feet. Discovered 1875. Highest average per day, $5 to $20; gold worth $18 an ounce. Bench and Creek diggings, best claims worked out.

Rosella Creek.—Altitude 3,550 feet. Discovered 1876. Highest average per day, $5 to $15; the gold being worth $18.25 an ounce. Bench and Creek diggings, best claims worked out.

Dennis Creek.—Altitude 3,500 feet. Discovered 1877. Highest average per day, $5 to $20. Gold worth $18.25 an ounce. Bench and Creek diggings; many miners here.

Patterson Creek.—Altitude, 4,380 feet. Discovered 1877. Highest average per day, $5 to $20; the gold being worth $18 an ounce. A few companies at work.

Gold Creek.—Altitude, 4,300 feet. Discovered 1877. Highest average per day, $5 to $50. Gold worth $18 an ounce. Bench and creek diggings, a few companies at work.

Slate Creek.—Altitude, 4,320 feet. Discovered 1877. Highest average per day, $10 ; the gold being worth $18 an ounce. Bar diggings, one company at work.

Somer's Creek, or First North Fork of McDame.—Altitude, 3,000 feet. Discovered 1876. Highest average per day, $10 to $100. Gold worth $18 an ounce. A large number of tunnels being worked, with good prospects.

Third North Fork of McDame,—Altitude, 3,200 feet. Discovered 1877. Creek and Hill diggings ; good prospects obtained and several companies testing.

Sayyeas Creek.—Latitude, about 62°. Discovered 1875. Highest average per day, $8 to $10. Gold worth $18.25 ; abandoned last year.

Spring Creek.—Altitude, 3,800 feet. Discovered 1877. Highest average yield, $10 to $20 ; the gold being worth $18.25. Hill diggings ; only one company working, but a very rich bench ; no prospecting yet in creek.

Fall Creek.—Discovered 1877.

De Liard River.—Latitude, 60° to 62°. Highest average per day, $6 to $8 ; the gold being worth $18. Bar diggings. But little mining done—some tributaries being prospected.

Rapid River.—Latitude 60° ; prospects obtained.

Omineca District.

Germansen Creek.—Good pay in part of course; some creek claims, and part of work by hydraulic method on the benches.

Mansen River.—Only two companies at work in 1875, and making less than wages.

Slate Creek.—Miners stated to be making expenses in 1875.

Elmore Gulch.—Poor pay in 1875—two companies at work.

Lost Creek.—Little work in 1875.

Details of other localities wanting.

Kootenay District.

Wild Horse Creek.—Discovered in 1863 ; in 1864 ordinary claims paid $20 to $30 a day per man ; work still in progress.

Perry Creek.—Discovered 1867. Some good claims, and some work still in progress.

Findlay Creek. — Good prospects; but owing to freshets, never successfully mined.

Boulder Creek.—

Great Bend Country.

(Now almost abandoned.)

Carnes' Creek.—Joins Columbia River from the east. Heavy gold; some pieces weighing as much as $14. Mining on bars; the bed rock not being reached on account of water. For a time, below the cañon, the average earnings were $15.

French Creek.—Empties into Downie River about twenty miles from its mouth. (Downie River flows eastward into Columbia.) This was the richest in the district, and was worked both on bars and to the rock. Average earnings as much as $100 to the hand for some time on the "Half Breed" claim. Worked out.

McCuller's Creek.—Joins Downie River four miles from French Creek. Working on bars; the bed rock not reached on account of water. Probably as high as $100 a day per man taken out in places, but deposit irregular. Fragments of quartz containing gold were found four miles up the creek.

Other Districts.

Parsnip River.—Below its junction with the Nation River, draining the Omineca country. This stream carries fine gold, which has proved highly remunerative in some localities.

Findlay River.—Fine gold found on all the bars, but the head waters (where richer deposits may occur) have not been prospected.

Peace River, east of the Rocky Mountains.—Fine gold is found in some abundance in places. Mr. Selwyn thinks it may be derived from the Laurentian Axis to the north-east.

Fraser River.—Fine gold from its sources to the sea. Heavy gold does not extend far below Boston Bar, but is found in many places from here to Lytton, and also, as I am informed by Mr. D. McIntyre, in spots from Lytton to the mouth of the Chilicotin. Much gold is still obtained by Chinamen and Indians on the Fraser, and I think it probable that, eventually, many of even the higher flats and benches will pay for hydraulic work. The heaviest gold pretty nearly coincides in its distribution with that of the slaty rocks of the Anderson River and Boston Bar series. The largest nugget found above Lytton was obtained ten miles below Lillooet and was worth $22.

McLennan Creek.—(Thirteen miles from Tete Jaune Cache, running into Cranberry Lake and thence to the Fraser.)—Gold found in 1876. Giving wages of $4 to $5 a day, but, owing to heavy boulders in stream and expense of all supplies, will not pay to work.

Nechacco River.—Colours obtained near Fort Fraser, and also abundant near its junction with the Fraser River.

Chilacco River.—In certain banks near its mouth, eight or nine colours to the pan may be obtained. A small quantity of heavy gold found in a lateral creek by one of the men connected with the Canadian Pacific Railway survey in 1876.

Chilicotin River.—Gold in some quantity said to have been found near the mouth of this stream.

Bridge River.—Gold found in heavy pieces, sometimes weighing one to two ounces, and affording excellent mining on this stream for ten miles up from its mouth. One nugget is said to have been worth $300. River prospected to its source in early days, and though gold found in several streams, not enough to justify work at that date.

Lillooet River.—Flowing into Harrison Lake. Some gold found here and also at various points on the portages toward Lillooet.

South Thompson River.—Colours, it is said, can be obtained in all the streams joining this river.

North Thompson River.—Colours found along its whole course, and at Louis Creek, thirty miles from its mouth, on the east side, gold has been found in paying quantities.

Tranquille River.—Joining Kamloops Lake, from the north. Heavy and light gold obtained here; about sixty Chinamen at work last summer, getting good pay; is said to have paid half an ounce per diem at the mouth.

Scotch Creek.—Joining Shuswap Lake from the north. Coarse gold mined here a few years ago.

Main River Thompson.—Heavy gold found on this river up to *Nicommen*, where, it is believed, the first gold in paying quantity in British Columbia was found. This region chiefly worked by the Indians of the country, who, I am assured, have obtained many thousand dollars in specially favourable years.

Anderson River.—Some heavy gold at one time found ten miles above mouth, but not enough to pay.

Coquihalla River.—More or less heavy gold along whole course of this stream.

Nicola River.—"Scale gold" found for about eighteen miles up the Nicola from its mouth.

Bonaparte River.—A little mining done on a tributary east of Clinton, but without encouraging result.

Hat Creek.—Small quantities of gold have been found here.

Horse-fly River.—Good "prospects" here, and in 1876 a considerable influx of miners, but without good returns.

Skagit River.—Colour found in several places in 1858, but no favourable indications.

Similkameen River.—Gold found in sharp and unwashed particles at mouth in 1853 by Captain McLennan's party. In the canon near the 49th parallel, considerable quantity of gold got in 1858-59-60; the largest piece weighing $22.50. This region, soon abandoned by the Whites, was worked for years by Chinamen.

Okanagan River.—Scattered diggings found in 1859-60, but soon abandoned; perhaps as much from want of water as anything else. Miners say colours can be found in every stream running into this valley.

Mission Creek.—Joining Okanagan Lake from the east, yielded at a spot five and a-half miles from its mouth, fine and coarse gold, assaying $18.50; paid at one time from two or three ounces to $2 or $3 a day. Colours occur for eight or ten miles above this.

Rock Creek.—Rising east of Osoyoos Lake, and failing into the Kettle River; about a mile from its mouth paid well, in some instances yielding as much as $100 a day, but generally from one to two ounces. Some of the benches also paid, in one case yielding half an ounce a day to the hand during the season's work. The best paying ground was where the creek crossed a belt of soft slate rock; in following it up, the cover was found very soft and deep.

Boundary Creek.—Joins Kettle River from the east. Some very heavy gold found here, and a good deal of prospecting done, but too much "spotted" to be profitable.

Kettle or Nehoialpitkwa River.—Colours and small quantities of gold found in several localities on the main stream and on tributaries.

Seymour Creek, Burrard Inlet.—Some gold got here at one time, but work abandoned on account of water and quicksand.

Prospect Creek.—East branch Homathco River, above Tatlayoco Lake. Some fine gold found here by men connected with C.P.R.S., 1875.

Lower Homathco River.—Colours obtained in various places.

Other Streams flowing from Cascade Range.—Details are wanting for most, but it is probable that colours, at least, can be found in all.

Kelly's Lake Creek—Near Clinton, Mr. Foster informs me that specimens of quartz found here assayed $25.12 in gold and $3.14 in silver, per ton.

Vancouver Island.

Leech River.—This stream has proved auriferous for four or five miles of its length, where it runs along the strike of a belt of slates. Estimated that $100,000 taken out, but no work now going on. The rich ground was found in the modern river bed, and is supposed to be exhausted, or, what may remain, too much spotted to pay. Banks of drift and cement might possibly pay for working by hydraulic method.

Sooke River.—(Below its junction with Leech River)—Only fine gold found here, and probably derived from Leech River slates.

Goldstream Brook.—Runs on strike of Leech River slates, further east; colours, but no pay, found here.

Jordan River.—Small quantities of gold have been found here.

Nanaimo River.—Attracted some notice in 1877, but does not appear to have paid prospectors.

Other localities on Vancouver Island.—Good colours found by the Vancouver Island exploring expedition on a stream entering Cowichen Lake, on rivers falling into Barclay Sound, on the south side, and on streams tributary to Puntledge Lake, near Comox.

Queen Charlotte Islands.—Gold-bearing quartz found at Mitchell's Harbour, lat. 52° 25′. Some work done in 1853, but lode appears to have run out.

COAL AND LIGNITE.

Vancouver Island.

Nanaimo.—Bituminous coal, worked for many years. Described in foregoing pages.

Comox.—Bituminous coal; now worked.

Quatsino.—Bituminous coal.

Beaver Harbour, near Fort Rupert.—Bituminous coal.

Head of Alberni Canal.—Bituminous coal.

North side Cowitchin Bay.—Small fragments of anthracite in sandstone. Larger specimens have been brought from the interior.

Queen Charlotte Islands.

Cowgitz.—Anthracite; described above.

South side Skidegate Channel.—Anthracite reported by the Indians.

Masset.—(North end of Islands)—Specimens of anthracite have been brought from here.

Mainland of British Columbia.

Vicinity of Langley, and other localities near the Lower Fraser.—Bituminous coal known, but in thin seams only. Probably in Lower Tertiary beds.

Chilliwack River.—Five miles from the Fraser. Bituminous coal of remarkably good quality, but of which the thickness and mode of occurrence remain unknown.

Coal Harbour, Burrard Inlet.—Here and elsewhere in the flat land at the mouth of the Fraser, lignite, in thin seams, occurs. Probably in upper part of Tertiary formation.

Junction of Nicola and Coldwater Rivers.—Bituminous coal. Tertiary. Described above.

Coldwater River.—Bituminous coal, of same formation as last, in several places.

North Thompson River. (Forty-five miles above Kamloops.)—Bituminous coal of good quality in thin seams.

Vicinity of Lillooet.—Bituminous coal said to be found. Thickness or position of seams unknown.

Ten Mile, or Guichon's Creek.—Joining Nicola River from the north. Lignite of good quality. Thickness of seam unknown.

South Fork of Similkameen River.—(Above the mouth of the Passyton or Pasayten.) Lignite in micaceous sandstone.

South Fork of Similkameen River.—(Four miles above Vermillion Fork.) Lignite. See Report for 1876–77.

North Fork of Similkameen River.—(Three miles above Vermillion Fork.) Lignite, seven feet thick, with one shaly parting of three inches. See report for 1877–78.

Boyd's or Cold Spring House.—Lightning Creek. Lignite bed, six to ten feet thick; fair quality.

Fraser River.—Between Soda Creek and Fort George, and at Quesnel—Lignite seams frequently seen; that at Quesnel of poor quality.

Bear River.—(Near crossing of C. P. R surveyed line, lat. 54°.) Coal reported; Mr. E. Dewdney says, about eighteen inches thick and covered with water at high stage of river; on burning, left a hard stony ash. Cretaceous?

Peace River and Pine River.—Beds of bituminous coal (Mesozoic); described by Mr. Selwyn in Report for 1875-76.

Parsnip River.—Drift fragments of lignite indicating a basin of rocks of the lignite-bearing age.

Lower Nechacco River.—East of Fraser Lake. Drift lignite only known.

Upper Nechacco River.—South-west of Fraser Lake. Lignite beds known in several places.

Blackwater River.—Drift lignites at upper and lower cañons, and intermediate portion of river.

Chilacco River.—Drift lignite only known.

Nazco River.—Drift lignite found near Cinderella Mountain.

Pun-chi-as-ko Brook.—(Joining the Tai-a-taesly.) Lignite of good quality, at least four feet thick, base concealed by water.

Nasse-Skeena District.—The Skeena River is said to pass through an extensive coal formation, with coal beds, three to thirty-five feet thick, according to Major Downie. (This may, however, be lignite.)

IRON.

Texada Island.—Magnetite, described above.

Island near the Walker Group, Schooner Passage, Queen Charlotte Sound. Exceptionally rich, 71·57 per cent. iron.

Country between Jordan River and Leech River, V. I.—Have seen a specimen of magnetite with grains of epidote, from here,

Yale and Cariboo Waggon Road.—Ravine half-a-mile below Nicommen. Magnetite vein said to be eight feet thick.

Knight's Inlet.—One mile up river, at head of inlet; 1,200 up mountain, on left bank.

Near Seymour Narrows.—Six miles west from Menzies Bay, V. I.; iron ore reported.

Entrance of River's Inlet.—West side of Fitz Hugh Sound; iron ore reported.

Bay S.E. of Cape Commerell, V. I.—Iron ore reported.

Iron Mountain, Coldwater River.—Specular iron ore, only known in comparatively thin seams.

Cherry Bluff, Kamploop's Lake—Magnetite, in large, but irregular veins. See Report for 1877-78

Baynes' Sound, Comox, V.I.—Clay ironstone in considerable quantity in connection with the coal. Two specimens, assayed by Mr. Hoffman, gave 36·83 and 29·78 per cent. respectively of metallic iron.

Cowgitz, Queen Charlotte Islands.—Clay ironstone in association with the coal-bearing rocks, according to Mr. Richardson.

SILVER.

Silver Peak, near Hope.—Eureka and Victoria, or Van Bremer Mines; veins probably cut Cretaceous or Jurassic rocks, and have been proved rich. Described above.

Other Localities, near Hope.—In at least two other localities, deposits containing silver, in greater or less quantity, are known. Country rock probably granite.

Cherry Creek.—Rich silver ore, not yet fully prospected, or proved to exist in veins of paying width or regularity.

Vital Creek, Omineca.—Rolled, or more or less angular fragments of silver amalgam found in considerable abundance in working placers. Specimen analysed contained 83·30 per cent silver.

Similkameen River.—Near junction of North and South Forks. Small quantities of native silver found in gold placers.

Similkameen River.—Where just south of, but running parallel with 49th parallel; cuts rocks containing numerous small strings of galena "readily yielding a bead of silver."

Mission Creek.—Joins Okanagan Lake from the east; native silver found occasionally with gold.

River Francis.—Above its confluence with the Dease, Cassiar; argentiferous galena. A large sample of the ore was sent for assay, but I have not heard with what result.

Quartz Creek, Cassiar.—A vein, which has given assays over $200 per ton, exists here.

COPPER.

Locality between Jervis Inlet and Howe's Sound.—Purple copper ore (bornite,) and copper pyrites, with mica and quartz. Large and rich masses brought out as specimens. Matrix granite.

Knight's Inlet.—Ore similar to the last; very rich in hand specimens, but I believe not yet found in quantity.

Entrance to Howe's Sound.—(Three miles north of Atkinson Point Lighthouse.) Copper pyrites; a considerable amount of prospecting work done at one time, but now abandoned.

Sansome Narrows.— Copper pyrites. Some work done, but now abandoned. Deposit probably follows cleavage planes.

Coast two miles east of entrance of Sooke Harbour.—Shaft sunk 120 feet, at an expense of $80,000; now abandoned. Ore appears to be chiefly iron pyrites. Scales of native copper found in joints of the trap-rocks.

South-west side Dean Canal.—Specimens of vein-stone, with yellow and purple copper, were collected by Mr. Horetzky.

Head of Kitemat Inlet.—Small deposit of galena, and yellow sulphuret of copper, observed by Mr. Richardson.

Thompson River, six miles below Spence's Bridge.—Mr. Murray has given me a small angular fragment of rich purple ore, found loose, from this place.

Thompson River, nine miles below Spence's Bridge.—A rough fragment of native copper, weighing several ounces, found here.

Fraser River, about thirty miles above Fort George.—Nugget of native copper, weighing several pounds, found loose.

Bates', or 150 *mile House, Waggon Road.*—Nugget of native copper, weighing about fifteen pounds, found near here.

Fraser River, ten miles below Lillooet.—Small lumps of native copper in gold placers.

Quesnel River, near the Forks.—More than half a ton of native copper found during gold washing, sent down from here a few years ago.

Copper Island, Shuswap Lake.—Bed of talcose or nacreous schist impregnated with copper pyrites. See report for 1877-78.

Copper Creek, Kamloops Lake.—Viens with purple copper ore; also reported that the Indians, in former days, obtained native copper in this vicinity.

Moresby Island, Queen Charlotte Islands.—Copper found, and some money spent in prospecting; now abandoned.

Small Island off Port Frederick, Queen Charlotte Islands.—Copper ore reported by Captain Stuart, H. B. Co.

Homathco River.—Many specimens of vein stones containing copper pyrites and some purple ore, were brought from this river. Not explored.

Traces, and small veins discoloured with copper ore, found in many localities in rocks of very different ages.

OTHER MINERALS.

Platinum.—Found in scales in association with gold on the Similkameen River

Platinum.—In fine scales, with gold on the Tranquille River, Kamloops Lake.

Platinum.—On the Fraser River, ten miles below Lillooet, very fine scales of platinum found with gold.

Antimony and Arsenic.—(Arsenical pyrites?) Specimens brought by Indians to Captain Stuart, probably from Kummeshaw, Queen Charlotte Islands.

Antimony. — (Stibnite.) — Little Shuswap Lake. See report for 1877-78.

Iron Pyrites.—Specimen of massive pyrites, said to exist in large quantity brought from Copper Island, Barclay Sound.

Plumbago.—Specimen of Plumbago obtained by the Vancouver Island exploring expedition in the country north-east of Port San Juan.

Nickel.—Nickeliferous sand obtained in gold-washing on the Fraser River, consists of magnetite, and pyritous grains attracted by the magnet, which consist of oxides of iron and nickel. (J. Blake, M.D., Proc. Cal. Acad. Sci., V. p. 200.)

Molybdenite.—Specimen brought from the upper part of the Cowitchen River by Mr. W. Robertson.

Molybdenite.—In association with copper ore at locality between Jarvis Inlet and Howe's Sound.

Cinnabar.—Specimen obtained by Mr. Tiedemann on the Homathco River.

Cinnabar.—Grains obtained in gold-washing near Boston Bar.

Cinnabar and Native Mercury.—A loose fragment of very rich ore, found nearly opposite Clinton, on the west side of the Fraser.

Lead.—A large vein of galena reported on Scotch Creek, about twelve miles from Shuswap Lake.

Lead.—Galena specimens collected by Mr. Tiedemann on the Lower Chilcotin.

Also occurs in connection with gold and silver in veins in Cariboo, Omineca, Cassiar, &c., with silver at Cherry Creek, and in small quantities in many other localities.

NOTES

ON SOME JURASSIC FOSSILS, COLLECTED BY MR. G. M. DAWSON,

IN THE

COAST RANGE OF BRITISH COLUMBIA,

BY

J. F. WHITEAVES, F.G.S.,

PALÆONTOLOGIST TO THE SURVEY.

The fossils which form the subject of the present preliminary report were collected at three localities, the furthest of which are not more than eight miles apart. By far the greatest number of specimens are from the left bank of the Iltasyouco River, four miles above its junction with Salmon or Dean River; two are from the falls of the Iltasyouco, three miles below the last mentioned locality, the rest are from Sigutlat Lake. The Iltasyouco River, it may be mentioned, is a stream about six miles in length, which flows from Sigutlat Lake into the Salmon River. The collection consists of twenty-seven species of Mollusca and one of Annelida. With very few exceptions, the fossils are both imperfect and in a poor state of preservation, so that even their generic position is sometimes doubtful. The Ammonites, in particular, are almost all mere fragments. The following is a provisional list of the species, with short descriptions of such as appear to be new, and critical remarks on others.

1. *Terebratula*——?—Shell (or rather cast) compressed, very gently convex; outline ovate or obovate; length greater than the width at all stages of growth; thickness through the closed valves about equal to one half the width; no mesial fold or sinus. The shape varies in different individuals; the maximum width being nearly always in advance of the middle, but one specimen is broadest at a little distance from the hinge line and somewhat pointed in front. Two half grown examples are ovately-orbicular, and not longer than wide, but the rest are much more elongated. Beak of the ventral valve incurved (but scarcely so much so

in the cast as to entirely conceal the deltidium or beak of the dorsal valve); obliquely and concavely truncate; foramen rather large; lateral ridges distinct. Dorsal valve with an impressed line or groove in the centre, which extends nearly half-way to the front margin, and indicates the position and shape of the mesial septum: on either side of this there is a single (?) divergent muscular scar, of nearly the same length. The shape of the scars is subspathulate or elliptic-ovate, but they each commence as a simple impressed line. Surface marked with coarse, distant, concentric striæ or plications. Sigutlat Lake and Iltasyouco River, abundant.

The only Terebratula yet recorded from rocks which are known to be of Jurassic age in North America, is described and figured by Meek, though without any specific name, in the first volume of the Palæontology of California. It was obtained on the western slope of the Sierra Nevada, and appears to be distinct from the present species, as it (the Nevada shell) has a more globose form and a short mesial fold and sinus. An ovate, elongated Terebratula occurs in the coal-bearing rocks of the Queen Charlotte Islands, in beds which may be Jurassic, but young specimens from the last mentioned locality are much wider than long, which is not the case with any of those collected by Mr. Dawson. In the absence of any knowledge of the test of this species, it is very difficult, and indeed almost impracticable to separate it by any valid character from some European Terebratulæ, such as *T. ovoides*, Sowerby, and *T. punctata*, Sowerby (including *T. subpunctata*) as described and figured by Davidson; more especially from the first of these.

2. *Gryphæa calceola, var Nebrascensis*, Meek & Hayden. Iltasyouco River, one typical and characteristic convex valve, with the test preserved, showing both the internal and external surface markings; also an exfoliated specimen with both valves in situ, and a few casts.

3. *Camptonectes (?) extenuatus*, Meek & Hayden. A cast of the convex valve of a small Pecten from the Iltasyouco River, precisely similar to the specimen figured under the above name on Plate III. (fig. 6), of the "Palæontology of the Upper Missouri." The surface markings of *C. extenuatus* are unknown, as is also the shape of its ears, and its generic position too is quite problematical, though its aspect is more that of a *Syncyclonema* than of a *Camptonectes.* Casts of the flat valve of a thin, compressed Pecten are rather frequent in the Iltasyouco River porphyrite, which may belong to the same species. These are strikingly like *Syncyclonema Meekiana*, from the Queen Charlotte Islands, in the condition in which that fossil is most commonly obtained, but the exterior of the

test of the convex valve of *S. Meekiana* is known to be both closely and nodosely cancellated.

4. *Lima duplicata*, Sowerby, (Sp). Two left valves of a Lima, both from Sigutlat Lake, which if not identical with the *Plagiostoma duplicata* of the "Mineral Conchology," are remarkably like it in shape, and so far as can be ascertained at present, in sculpture also. One specimen has the test partly exfoliated; in the other the shell is considerably decomposed, but its original surface markings are sharply impressed on part of the rock which was broken from the specimen, and which originally enveloped most of one side of it. The sculpture consists apparently of about twenty-eight acute, angular, radiating costæ, each of which alternates with a single, fine, raised line, just as in *L. duplicata.*

In the Quarterly Journal of the Geological Society of London for 1866 (Vol. XXII., p. 82) Mr. Tawney has described a species with very similar shape and style of ornamentation, from the Lower Lias of South Wales, under the name *Lima subduplicata.* Mr. Charles Moore, however, in a paper on "Abnormal Secondary Deposits," published in the Journal of the same society for the following year, places *L. subduplicata* as a synonym of *L. duplicata* on page 509, though on page 530 of the same paper it is said to be identical with *L. dentata* Terquem, which is admitted to be distinct from *L. duplicata.* It may be, therefore, that more than one species have been confounded under this name, but if not, few if any Mesozoic molluscs have a wider range in time than *L. duplicata.* Originally described from the Coralline Oolite of Yorkshire, it is abundant in the Cornbrash, Forest Marble, Great and Inferior Oolite of many parts of England, as the writer can testify from direct observations in the field. Munster says it is found in the Lias of Germany associated with *Rhynchonella rimosa*, and Goldfuss mentions it as occurring in the Inferior Oolite of Hanover and Brunswick. It is included by Rev. P. B. Brodie in a list of Lower Lias fossils from near Wells, (Somerset), also by Mr. C. Moore, in lists of species from the same formation in South Wales, and from several localities in Somersetshire in the zone of *Ammonites Bucklandi.*

5. *Inoceramus*——(?) Falls of the Iltasyouco River, a fragment only of a species, with wide, rounded, concentric folds. Mr. Dawson made a rough sketch of the specimen as it originally appeared in the rock, and, judging by this, the shell appears to have been very similar to the *Inoceramus venustus*, Sowerby, of the English Lias.

6. *Eumicrotis curta* (?) Meek and Hayden. Iltasyouco River, two imperfect right valves, both marked with distinct raised lines. Almost certainly identical with *Monotis substriata*, Munster, as suggested by Meek.

Stoliczka has shown that Beyrich's generic name *Pseudomonotis* has two years' priority over *Eumicrotis* Meek, so that the name of this shell ought probably to be written *Pseudomonotis substriata*, Munster, Sp.

7. *Pteroperna*——(?) Two specimens of a smooth, oblique and elongated species of *Pteroperna*, with a long and deeply emarginate posterior wing, both from the Iltasyouco River; probably new to science, but not in a sufficiently good condition to be properly characterized.

8. *Pinna subcancellata*, N. Sp.—Shell moderately convex, wedge-shaped, elongated: squarely truncate behind, or nearly so; hinge line straight; ventral margin also straight for the greater part of its length, but rounded at its junction with the posterior end. Surface marked by coarse, irregularly and unequally disposed concentric plications, which, in the upper two-thirds of the shell, are crossed by about eighteen radiating, but nearly longitudinal raised lines. The amount of convexity of the valves cannot be precisely defined, as the only specimen yet obtained is distorted by pressure. Falls of the Iltasyouco River. A solitary example, with both valves *in situ*. The beaks are broken off, but the sculpture of both sides of the fossil is well shown. Perhaps only a variety of *Pinna Hartmanni*, Zieten, from which it differs in being more squarely truncated at the anal end, and in having the radiating costæ confined to the upper two-thirds of the shell.

9. *Modiola formosa* Meek & Hayden. One very good specimen from Sigutlat Lake. Very near to *M. cancellata*, Goldfuss.

10. *Modiola pertenuis*, Meek & Hayden. Three left valves of a small, smooth Modiola, (two from the Iltasyouco River; the other one from Sigutlat Lake), one of which appears to be a distorted but otherwise tolerably typical example of *M. pertenuis*, while the two others are probably only a short, broad variety of the same species. It is not easy to see how *M. pertenuis* can be distinguished from *M. minima*, Sowerby, of the European Lias, as figured and described in the Mineral Conchology and by Goldfuss.

11. *Grammatodon inornatus*, Meek & Hayden. Iltasyouco River, two single valves. Apparently very near to *Arca Lineata* Goldfuss, from the Lias of Germany.

12. *Grammatodon* (?) *Iltasyoucoensis*, N. Sp.—Shell moderately convex, but slightly depressed near the middle below; very inequilateral; anterior end short narrow and obtusely pointed; posterior end elongated, widening gradually both above and below; truncated almost squarely at its extremity. Hinge line straight, ascending gradually behind the beaks, and sloping downwards rather abruptly in front of them. Beaks

broad, depressed, curved inwards and forwards, situated very near to the anterior end, but not quite terminal. Right valve (the only one known) with indications of one or two elongated, linear posterior teeth, placed parallel to the hinge line, and of at least three obliquely transverse anterior teeth. Surface marked with close-set, crowded and extremely fine, radiating striæ, which are scarcely visible to the naked eye, and which become almost obsolete on the ill defined posterior area.

Iltasyouco River, a single specimen of the right valve, with the lower half of the posterior end broken away. The pallial line and muscular impressions are not visible, and the hinge characters are imperfectly shown, so that it is doubtful whether this shell is a *Grammatodon* or a true *Macrodon.*

13. *Cucullæa* (?) Sp. Undt.—A small, rather ventricose, subrhomboidal species, with prominent, nearly central, incurved beaks. An obtuse keel runs from the beaks to the base, and separates an obliquely flattened posterior area from the main body of the shell. The surface is marked by close-set, raised striations, which are crossed by rather more distant, radiating lines.

14. *Yoldia* (or *Corbis*) Sp. Undt.—A single valve of a small shell from the Iltasyouco River, with no vestiges of the hinge teeth or of any of the markings of the interior remaining The outline of the specimen is remarkably like that of *Nucula speciosa,* Munster, from the Muschelkalk of Germany, which is, probably, a *Yoldia* or *Portlandia*, but it is also almost equally similar in shape to *Corbis uniformis,* Phillips, from the Yorkshire Lias. It is not a *Tancredia,* in the writer's judgment, though its contour is not very dissimilar to a fossil doubtfully referred to that genus by Meek and Hayden, under the name *T. inæquilateralis;* but the latter species has a much flatter shell, and is more angular at the junction of the hinge line with the posterior end.

15. *Trigonia Dawsoni,* N. Sp.—Shell gently convex, compressed; outline ovately-subtrigonal; anterior end very short, broadly rounded, as is also the ventral margin; beaks elevated, recurved, anterior, subterminal; hinge line sloping concavely downwards behind the beaks; extremity of the somewhat elongated posterior end truncated rather obliquely. Surface of the main body of the shell marked by about twelve curved, nodulous costæ, all of which commence at the margin of the posterior area. The five nearest the beaks curve downwards, and terminate at the anterior end. The middle ones, though curved, are nearly transverse, and end at the centre of the ventral margin, while the three last incline decidedly backwards. The posterior area is marked either

by crowded, transverse, regularly arranged and continuous raised striæ, or by coarse, irregular and broken up or angularly bent, short, transverse folds. Iltasyouco River and Sigutlat Lake, frequent and well preserved. A well marked and characteristic species, which the writer has much pleasure in naming after its discoverer, Mr. G. M. Dawson. It would appear that *T. Dawsoni* occurs also in the Jurassic rocks of the western slopes of the Sierra Nevada, for on page 49 of Vol. I. of the "Palæontology of California," after describing Trigonia *pandicosta* from that locality, Mr. Meek says :—"There are in the collection fragments of apparently two other species of this genus. One of those is considerably larger than that described, and has the costæ distinctly nodose. They are, however, not angularly deflected, but curved gradually forward."

16. *Astarte ventricosa,* Meek. Iltasyouco River, three or four rather imperfect specimens, whose specific characters are obscurely shown, and whose identification is, therefore, somewhat uncertain. They vary considerably in shape, two being rather longer than wide; in the others the height and length are nearly equal. The pallial border of the test is distinctly crenulated.

17. *Astarte fragilis,* Meek & Hayden. A badly preserved specimen of an Astarte, from the Iltasyouco River, which although much larger than the type of *A. fragilis* from Dakota, and more convex on the posterior part of the hinge margin, is probably referable to that species.

18. *Pleuromya subelliptica,* Meek & Hayden. Six or seven specimens of an elongated, nearly smooth *Pleuromya*, from the Iltasyouco River, which, though very variable in shape, on the whole agree tolerably well with Meek & Hayden's description of *Myacites subellipticus* from the Black Hills, much better in fact than they do with the figures of that species. *M. subellipticus* is said to be very similar in shape and sculpture to *Panopæa peregrina*, D'Orbigny, from the Oxfordien beds of Russia, and so are some of the Iltasyouco River *Pleuromyæ*, but the latter, in shape at least, are equally like some forms of *P. Terquemea* Buvignier as figured by Agassiz under the name *P. tenuistriata*, but in that shell the concentric striations are much more numerous and regularly arranged than they are in the specimens collected by Mr. Dawson.

19. *Pleuromya unionides,* Rœmer, Sp. Six casts of a ribbed Pleuromya, (one from Sigutlat Lake, the others from the Iltasyouco River), which have been carefully compared with Goldfuss' and Agassiz's descriptions and figures of the above mentioned European Liassic species, and which do not appear to be separable from it even as a local variety. The Sigutlat Lake specimen, and three of those from the Iltasyouco River

are much distorted, and have their original shape much altered by pressure, but two from the latter locality seem to have retained their normal form. *Pleuromya Carlottensis*, from the Queen Charlotte Islands, has a shorter, higher and more ventricose shell ; its beaks are more elevated and curve forwards as well as inwards ; its posterior extremity, too, is more pointed. *P. Carlottensis* is, perhaps, synonymous with *P. Alduini*, Bngt. (sp.) of the European Jurassic.

20. *Planorbis veternus*, Meek and Hayden. While breaking a large piece of the Iltasyouco River porphyrite containing a valve of *Grammatodon inornatus* and a cast of the shell supposed to be referable to *Pleuromya unionides*, the writer was so fortunate as to obtain a perfect specimen of this shell, *in situ*, in one of the fragments. *Planorbis veternus*, and three other species of fresh water shells, were first found in loose pieces of rock at the base of the Black Hills in Dakota, and some doubt previously existed as to the true geological horizon of these fossils. Writing in 1864, Mr. Meek says, " they may possibly be Tertiary species, but differ from all those we have seen from rocks of that age in the North West. It is only provisionally we place them along with the Jurassic forms." The finding of *P. veternus*, in place, associated with fossils that are almost undoubtedly Jurassic, make its age tolerably certain, and strikingly confirm Mr. Meek's conclusions. Mr Moore has described another species of Planorbis, (*P. Mendipensis*), from the Charter House Liassic lead mine in the Mendip Hills of Somerset, in rocks of a very similar geological horizon.

21. *Stephanoceras Humphreysianum*, Sowerby, Sp. Sigutlat Lake, one specimen, the only tolerably perfect ammonite in the collection. Prof. A. Hyatt, to whom all the ammonites were sent for examination, says of this fossil,—" If found in Europe it would be unhesitatingly referred to this polymorphic species and identified with the typical forms."

22. *Stephanoceras Braikenridgii* (?)—Sowerby, Sp. Iltasyouco River, two small fragments. " These are very interesting fragments, with all the marks of the mature forms of *Steph. Braikenridgii*, but ought to be queried because the young characteristics are not visible."—Hyatt.

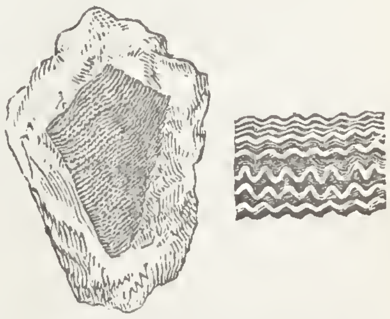
23. *Stephanoceras*—— (?)—Seven fragments of a small *Stephanoceras*, from the Iltasyouco River, which Prof. Hyatt has compared with European specimens, and pronounces the former to be closely allied to *S. Gervillei* (*Ammonites Gervillei*, Sowerby) and *S. platystomum*, Reinecke, (sp.) but adds that the young look rather like the early state of *S. macrocephalum* or *S. Herveyi*. The penultimate whorl is rather finely ribbed, and the outer surface of the body chamber is quite smooth, at

least in the cast; the umbilicus is not distinctly shown, but it must have been exceedingly small. The shape of the lip is indicated to a certain extent by an obliquely transverse, slightly flexuous, incised groove, which curves forward from the umbilicus, and is produced into a bluntly pointed, beak-like process in passing over the periphery.

24. *Perisphinctes anceps?* Reinecke, Sp. Iltasyouco River, a solitary fragment, which, according to Prof. Hyatt, " has the peculiar abdominal ribs and knob-like spines of *P. anceps.* The abdomen may have been channeled, and, if so, the above indentification could be given without the query."

25. *Belemnites* (?)—— Seven or eight imperfect specimens of a Belemnite with an exceedingly slender, parallel-sided guard. These are in such a bad state of preservation that it would be a hopeless task to try and identify the species, or to describe it with sufficient accurracy if new. At the commencement of the phragmocone, the largest example does not measure quite three lines in diameter, while several of the specimens would lie loosely in the cavity of a wheaten straw. The surface of the whole is so much worn that it is impossible to tell whether there was a median or an apical groove, or none at all. Iltasyouco River.

26. *Belemnites* (?)—— At the same locality as the preceding shell, and associated with it, are portions of what seems to be either another species of Belemnite, or at least a different varietal form, and unfortunately, in quite as bad a state of preservation. The guard, though elongated and narrowly cylindrical in shape, is much thicker and more conical than is that of the fossil last described, and it is not improbable that the present species may prove to be conspecific with a Belemnite from Dakota, supposed by Meek and Hayden to be a slender variety of their *Belemnites densus*, and figured on Plate V. (figs. 1 a, 1 b, 1 c,) of the " Palæontology of the Upper Missouri." Detached phragmocones, probably belonging to both species, are not unfrequent also at the Iltasyouco River. These, though not very well preserved, appear to show that the fossils of which they formed a part are referable to *Belemnites* proper and not to *Belemnitella.*



27. The nature of the curious fragment represented in the wood-cut is uncertain, but it may have been a portion of an *Aptychus*, a fragment of the pen of a calamary allied to *Teudopsis*, or a piece of an aviculoid shell.

28. *Serpula*—— (?)—Three casts of the shelly tube of a species of Serpula. The most perfect specimen has been

secreted by the animal on nearly the same plane, and is twice bent, so as to present the appearance of a flexuous-sided triangle with the angles blunted and half of one of the sides wanting. The others are simply flexuous, and no vestige of the test or of its surface markings is preserved on any of them. Locality, Iltasyouco River.

The fossils above enumerated are of much interest as affording the first instance yet observed of the occurrence of a well marked fauna of Jurassic age in British Columbia. It is true that fossils, probably from a very similar geological horizon, were collected by Mr. Selwyn in 1875, at Rock Island Gates below Hudson's Hope on the Peace River, but these specimens, which were described in the Report of Progress for 1875-6, are very few in number, and so imperfect that none of the species could be satisfactorily determined.

If the identifications in the present paper be correct, it would appear that nine of Meek & Hayden's species, from the Jurassic rocks of Dakota, are found also in the Coast Range of British Columbia. These are:—

Gryphœa calceola, var., *Nebrascensis.*
Camptonectes extenuatus.
Eumicrotis curta.
Modiola (Volsella) formosa.
" " *pertenuis.*
Grammatodon inornatus.
Astarte fragilis.
Pleuromya subelliptica.
Planorbis veternus.

It would seem, therefore, that the sea of the Jurassic epoch once covered an extensive, and probably continuous tract of country on the western portion (at least) of this Continent; and there are strong reasons for supposing that the marine faunæ of the Triassic and Cretaceous periods were no less widely spread. The Upper Trias is known to extend from Mexico, through California and Nevada, to British Columbia, and *Monotis subcircularis*, Gabb, one of its most characteristic fossils, has recently been found in the northern part of Vancouver Island; also, on the mainland of British Columbia, at a few miles from Fossil Point, on Peace River, and on Upper Pine River, east of the mountains.*

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* The last mentioned locality, represented by specimens collected for Mr. Dawson by Mr. J. Hunter, of the Railway Survey.

Two species of fossils, which were originally described from the Cretaceous rocks of Texas, have been found by Mr. Selwyn in deposits of the same age on the Upper Peace River, and among the extensive collections of Cretaceous fossils obtained by Mr. Richardson from Vancouver and adjacent islands, there are several species which occur also in Texas, Nebraska or New Jersey. From these, and from similar circumstances, it seems highly probable that nearly the whole of North America must have been submerged during the deposition of the later portion of the Cretaceous series. It has been supposed, indeed, that towards the close of the Mesozoic period the Rocky Mountains formed a land barrier between two oceans, each of which was tenanted by a distinct local fauna, but this hypothesis is not borne out by the facts of the case as we now know them, and the existence of Cretaceous rocks at very high elevations, both in the Cascade range and in the Rocky Mountains, goes far to prove that some of the loftiest peaks of these two mountain chains owe their elevation to movements of Post Cretaceous date.

Trigonia Dawsoni and Astarte ventricosa, from the Iltasyouco River, are also found in the Jurassic rocks of the western slope of the mountains in Nevada; and it may be that there is no physical or geological break between the coast range of British Columbia and the Sierra Nevada. Mr. Gabb has pointed out that the Jurassic fossils of Nevada are probably of the age of the Lias, and some of the Iltasyouco lamellibranchs, as has already been stated, are barely distinguishable from European Liassic species. On the other hand, the few Ammonites collected by Mr. Dawson, so far as very fragmentary specimens enable one to judge, appear to be conspecific for the most part with well known forms from the English Inferior Oolite, though one, which has been doubtfully referred to *Perisphinctes anceps*, may indicate an horizon as high as the Oxford Clay or Coral Rag. On the whole, however, the evidence, as far as it goes, is in favour of the supposition that these fossils from British Columbia belong to the lower rather to the upper part of the Jurassic series.

REPORT

ON THE

COAL FIELDS OF NANAIMO, COMOX,

COWICHEN, BURRARD INLET AND SOOKE,

BRITISH COLUMBIA,

BY

MR. JAMES RICHARDSON,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Work included in this report.

In presenting this report on the coal bearing rocks of Vancouver Island, (referred to on page five of your Summary Report for 1875-76) it may be stated that the surveys made in the summer of 1873,* and also in the summer of 1874† have now been included with the work of 1875, and the results embodied in a map on a scale of two miles to one inch, a reduction of which accompanies this report. ‡

Definition of coal areas of Vancouver Island.

In the report of 1871-72 on the coal fields of the east coast of Vancouver Island, it was stated on page seventy-six that belonging to these " there appears to be a narrow trough which may be said to extend from the vicinity of Cape Mudge on the north-west, and to approach to within fifteen miles of Victoria on the south-east, with a length of about 130 miles ;" and again, that " the north-east side of this trough lies beneath the waters of the Strait of Georgia, and on that side is bounded by crystalline rocks, coming apparently from beneath it in Lasqueti, Texada and other Islands, and on the mainland beyond, while on the south-west it occupies a strip along Vancouver Island,

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* Report of Progress 1873-74, pages 95, 96.

† Report of Progress 1874-75, pages 82, 83.

‡ The bearings throughout this report are with reference to the true meridian.

limited by a range of bold mountains of the crystalline series, which runs nearly parallel with the coast." The trough thus generally defined is divided into two subordinate areas, separated from one another by crystalline rocks in the neighbourhood of Nanaimo Harbour, the north-western one of which is distinguished as the Comox, and the south-eastern as the Nanaimo coal field.*

Region described in Report of 1872-73.

The portion more particularly described in the Report of 1872-73 is bounded on the south-west by the Beaufort Range of Mountains, on the north-east by the Strait of Georgia, and extends from Comox Harbour to about twelve miles to the west, and about thirty miles to the south-east, including Denman and Hornby Islands. On account of the difference in the character of the Comox and Nanaimo coal areas, I have thought it better to describe them separately.

THE COMOX AREA.

Boundaries of Comox area.

The portion of this area which will first be described, is bounded on the south-west by the south-east end of the Beaufort Range of Mountains, and further south-east by Mounts Mark, Wesley and others, rising to heights of from 2,530 to 5,420 feet. On the north-east it is bounded by the Strait of Georgia, extending from Sable River on the north-west to North West Bay on the south-east, a distance of about thirty-six miles.

Lines measured in this area.

Measurements upon the coast line were made partly in 1872 and partly in 1873 † from Sable River to Deep Bay, opposite the south-east end of Denman Island, thence an examination of the coast line was made without measurements to the Great and Little Qualicum Rivers. From the latter, measurements were made to Englishman's River, and the coast was examined from there to North West Bay without measurements.

Measurements were also made up a stream falling into Baynes Sound, a little to the east of Fanny Bay, or two and a-half miles south-east of Sable River; up Donaldson's River, which falls into the same Sound about two miles further east; and also up a stream fully half-way between the last and Deep Bay. The next measurements to the south-east were along the Alberni trail, and the Little Qualicum River, while still further on, this river was ascended for an estimated distance of six or seven miles; but on account of the difficulty met with in penetrating the thick wood along its banks, and the only exposures of rocks being in the bed of the stream, it had to be ascended by wading in the clear, cold

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* Report of 1871-72, pp. 80, 81.

† See Report of 1872-73, page 35, and Report 1873-74, page 95

water of from one to four feet in depth, and no measurements were made. The only other stream examined for a short distance up, falls into the Strait of Georgia about five miles south-east of the Little Qualicum.

The two large Islands, Texada and Lasqueti, properly belong to this area, also a number of smaller ones to the north-east and south-west of the latter.

Nature of data.

The evidence afforded in the exposures observed in these examinations, in the streams and on the coast and islands, is scant enough, and but for the many well defined sections to be found in the streams further to the north-west, as well as on Denman and Hornby Islands, (see report of 1872-73,) there would be but few data by which to determine the structure. Combining the knowledge previously obtained, however, with the facts now at command, I hope to be able to give a close approximation to the truth.

General arrangement of the section.

In the report of 1872-73, page 51, the several groups, with their ascertained thickness, were defined as follows, in ascending order :—

	Feet.	Inches.
A.—*Productive Coal Measures*	739	6
B.—*Lower Shales*	1,000	0
C.—*Lower Conglomerate*	900	0
D.—*Middle Shales*	76	0
E.—*Middle Conglomerate*	1,100	0
F.—*Upper Shales*	776	0
G.—*Upper Conglomerate*	320	0
	4,972	6

Division A.—Productive Coal Measures.

Recapitulation of sections given in report of 1872-73.

In the same report eight sections of the productive coal measures were given, the most westerly being on Brown's River, a tributary of the Puntledge. This section gave a total thickness of 739 feet 6 inches, with nine seams of coal, varying in thickness from six inches to seven feet; the seven-foot seam, however, not being always continuous. The whole thickness of coal is about sixteen feet five inches. The next section was on the Puntledge; but the details are not well seen, and none of the coal seams are exposed. Bearing from the outlet of Puntledge Lake, S. 48° E., about two and three-quarter miles, is section No. 3, at the Union Mine Claim, in an almost perpendicular cliff. The whole thickness seen in the cliff is 122 feet, with eleven seams of coal, of from one to ten feet in thickness, and an aggregate thickness of twenty nine feet three inches*. Section No. 4 is twenty-nine chains to the north-west of No. 3, and contains three coal seams, with an aggregate thickness of fifteen feet six inches, being respectively, in ascending order, four feet six inches, two feet and three feet; this section may be wholly, or in part, a continuation of section No. 3.

A line bearing S. 38° E., from section 3, two and a-third miles in length, strikes the Trent River, where the details of Section 5 were obtained. Here the whole thickness of the measures is 710 feet 7 inches, with thirteen coal seams, the thickness of which varies from two inches to four feet. The next locality where the measures were met with on the strike is Bradley's Creek, a tributary of the Trent, the distance being about a mile from the latter to the south-east. This was called Section No. 6. Owing to great irregularity of dip, and considerable intervals of concealment, it was, however, difficult to estimate the thickness. The coal observed occurs in four seams of from eight inches to three feet two inches thick.

Section at Baynes Sound mine.

The last place examined was at the Baynes Sound Coal Mine, on the River Sable (Section No. 7.) This mine is about five and a-half miles S. 53° E. from the base of Section No. 6 on Bradley's Creek. The section comprises 220 feet ten inches, with two seams of coal, respectively of five feet ten inches and six feet; also, a bed six feet thick, which consists mostly of black carbonaceous shale, showing impressions of plants; but includes, also, seams of good coal from two to eight inches thick. In some parts the greater portion of the whole bed consists of thin coal seams. In the report last referred to, it was stated (page 43) that a fault occurs, cutting the above measures off, the underlie of the fault being S. 62° E. < 38°. On the east side of the fault, which appears to be an upthrow, there is a thickness of 146 feet of measures (Section 8) which dip under the shales of Division 13. The Baynes Sound Coal Mine is situated two and three-quarter miles due west from the mouth of the Sable River, which falls into Fanny Bay; and, as already stated, this is the furthest south-eastern exposure of the Productive Coal Measures, described in the Report of 1872-73.

Rocks seen near Fanny Bay.

The first place on the continuation of the measures to the south-east, where a few facts were obtained, is on a bearing S. 52° E. from the base of Section 7, three and a-quarter miles distant and about two miles at right angles from the coast, in a gorge of an unnamed brook, already mentioned as falling into Baynes Sound, a little east of Fanny Bay. In

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* Report of 1872-73, pp. 38 and 39.

Lowest coal seam.

Section.

this deep gorge, through which the stream finds its way to the coast, the beds enumerated below occur, resting on a greenish-brown dioritic rock. Immediately overlying the diorite is a seam of coal about fifty feet above the bed of the stream, but from its inaccessible position and the surrounding *debris*, its thickness could not be determined. It did not, however, appear to be less than two feet, although it may be considerably more. The dip of the overlying sandstones is N. 8° E., < 12°. From the abrupt nature of the banks, and the rapid current, the bed of the stream below the coal crop was not accessible for twelve and a-half chains. The dip is then, N. 33° E., < 23° ; and two chains further down a second seam of coal occurs, of from one foot six inches to two feet in thickness. Another, or third seam, of three inches in thickness, occurs sixteen chains further on ; and fourteen chains still lower the rocks cease to be exposed. From the prevalence of false bedding and the difficulty in reaching the exposures in the bed of the stream, it was almost impossible to determine the dip accurately, but the average appeared to be about N. 35° E., < 9°. From these data, the following section would be near the truth as regards the whole thickness, but as there were many concealed intervals, it may reasonably be supposed that only some of the coal seams were seen :—

	FEET.	IN.
Coal	2	0
Brownish-grey sandstones, in beds of from two inches to four feet, with interstratified beds of black soft shale	286	0
Coal	1	6
Brownish-grey sandstones, similar to the above	308	0
Coal	0	3
Sandstones, similar to the above	176	0
	773	9

Breadth occupied by productive measures.

Allowing seventy-three feet for the fall in the river, we have a very near approximation in this section to the thickness shown by the sections further to the north-west, on Trent and Brown's Rivers, and may, therefore, reasonably presume that nearly the whole of the productive coal measures are included in it, and that it is immediately succeeded by the softer, but here concealed, shales of Division B. If this is the case, the whole breadth of Division A, at right angles to the strike, is something over half-a-mile wide, across the measures ; and including the shales of Division B, would extend to about one mile from the coast.

Two miles from the base of the above section, on a line bearing S. 38° E., there is a considerable stream, already mentioned, which joins Donaldson's River at a point less than half-a-mile from the head of a shallow cove in Baynes Sound, and although rocks of the crystalline series, mostly compact crystalline diorite, were observed, rising up from the low land into lofty and rugged cliffs, it is but reasonable to infer that the base of the coal measures is not far off; for, continuing on the same bearing S. 38° E., a little over two miles, in a brook at a point a-mile and three-quarters from the coast, at the head of Deep Bay, sandstones are seen, resting on a mottled dark-green diorite, with small geodes of white quartz. These sandstones, which are probably at the base of the coal measures, have a breadth, at right angles to the strike, of forty-seven chains. For this distance the waters of the brook intersect them in a deep, narrow ravine, the bottom and sides of which are so much entangled with brush and fallen timber that the details of the measures are by no means well shown, and none of the coal seams are visible. Here the average dip appears to be about N. 30° E., <7°; this would give in forty-seven chains a thickness of 130 feet. Assuming this to be the base of the productive coal measures and the same dip of N. 30° E., < 7° to continue across the measures for a distance from the base of a mile and five-twelfths, we would have a thickness of 924 feet. Deducting 200 feet for the fall of the surface, in this distance, there would remain 724 feet for the total thickness. This agrees very closely with the thickness of the formation, in other localities to the north-west of the Productive Coal Measures here, and would indicate the position of the summit of the productive measures to be about forty-seven chains south-west from the coast at the west end of Deep Bay.

Section on Donaldson's River.

Twelve miles and a-half from the west end of Deep Bay, a line bearing S. 65° E. strikes the mouth of the Little Qualicum River already mentioned. In this distance no exposures were met with on the coast or in the interior. The Qualicum River, which falls into the Strait of Georgia seven and a-half miles eastward from the above point in Deep Bay, and five miles westward from the Little Qualicum, shows no rock exposures to within one mile of Horne Lake, a distance of about four and a-half miles at right angles from the coast. Here a bed of dark, almost black, dioritic rock crosses the stream, forming a perpendicular fall of from sixty to seventy feet. This is succeeded higher up mostly by crystalline limestone, while downward towards the Strait of Georgia no indication of coal rocks is met with, the river channel being cut through deposits of gravel and sand. The Alberni Trail leaves the coast

Rocks exposed on Qualicum River.

about a-quarter of a mile to the eastward of the Qualicum River, and for nearly five miles run almost parallel with it over gravel and sand similar to that seen in the banks of the stream.

Section on the Little Qualicum.

In a line at right angles to the coast, about two miles up the Little Qualicum River, the lowest beds in this division are seen. None of the crystalline rocks are here exposed, and the only evidence of their presence is the abundance of loose masses which pave the bed of the stream for a distance of from two to three miles above the lowest exposed beds of the Productive Coal Measures. The latter here consist of soft black shales, interstratified with a few beds of grey, slightly calcareous sandstone, in layers of from two to four inches in thickness. The dip at first is N. < 10°, the angle soon changing to from 4° to 5° immediately above a bend in the river about two miles up, but only about one mile from the coast. The dip at the bend is N. 75 E. < 4°, while below it is N. 63° E. < 5° about three-quarters of a mile from the coast. Below this there are no exposures. Those seen higher up are shales interstratified with sandstones similar to the lowest exposed beds above. No coal was observed, but some beds of the shale are marked with imperfect impressions of leaves, and also contain fossil wood.

Thickness of Productive Measures.

A calculation of the thickness, from the above dips, on a line across the measures at right angles to the coast, gives a total of 704 feet, but probably as much as 180 feet ought to be deducted for the fall in the river, leaving a total thickness of 524 feet. If in this section the base has been reached (which, from the facts obtained, is open to doubt) and assuming the average thickness to be over 700 feet, then the summit of the division would be some distance out under the water of the Strait of Georgia.

About six miles S. 85° E. from the mouth of the Little Qualicum is the mouth of an unnamed brook, a little over a-quarter of a mile up which a small thickness of conglomerates, interstratified with grey sandstone, is met with, while another exposure of similar beds occurs on the coast, about a mile to the eastward. The dip in the brook is N. 62° E. < 5°, and on the coast N. 27° E. < 5°. Although no other exposures were seen up to this brook, I have placed the base two miles inland, to accord with the observed strike furthest up the Little Qualicum River.

Exposures near North West Bay.

Three and a-half miles to the eastward of the brook, and somewhat less than three miles to the west of North West Bay, a stream of considerable size, called Englishman's River, falls into the Strait. Although it is said that coal has been found in this stream somewhat less than two miles from the coast, I did not visit the place, owing to the difficulty of penetrating the dense tangled forest, or wading in the bed of the deep rapid stream. On this stream I have placed the base at somewhat under two miles at right angles from the coast. This agrees very well with its supposed position on the south-west side of North West Bay, viz., about three miles due east from Englishman's River. These beds where they are first met with on the east side of the Shallow Bay to the North West Bay are grey sandstones, in beds of from two inches to five feet. The dip is N. 43° E. < 16, while further east, approaching the head of North West Bay, strata of a similar character dip N. 12° W. < 7°, apparently bringing the edges up against the cyrstalline rock that forms Tongue Point, on the north-east side of the bay. Throughout the whole thickness, which is here a little over one hundred feet, obscure leaves of plants and fossil wood are met with, as well as fossil shells, which were not observed to the north-west, although it will be shown that they characterize the base of the productive coal measures in the Nanaimo area.

Fossils.

Among the more characteristic fossils collected here are *Ammonites complexus* var. *Suciaensis*, *A. Breweri*, *Inoceramus undulatoplicatus*, *Cucullœa truncata*, *Axinœa Veatchii*, *Trigonia Evansi*, and *Astarte Conradiana.*

Rocks near Tongue Point.

Commencing at the extreme end of Tongue Point there are about twenty feet of sandstones similar to those on the shore of the bay opposite. They occupy the coast here for nearly half-a-mile. Some of the beds are full of fossils similar to those above named, but too much broken to be worth collecting.

These beds rest on and fill up hollows in the older rocks, which here, and for some distance along the coast, are much disturbed, and consist of greenish-grey, finely laminated, compact beds, interstratified with bluish-grey limestone. In some of the hollows of these rocks, boulder-like masses of epidotic and chloritic rocks, imbedded in sandstone, are numerous. The largest of these observed measured twenty-six feet long, twelve feet wide and five to seven feet high, and would probably weigh not far from 150 tons.

Probable occurrence of coals between Sable River and North West Bay.

The facts obtained from the various exposures met with from Sable River on the north-west, to North West Bay on the south-east, as already mentioned, a distance of thirty-six miles, are meagre enough, although there can be no doubt that we have in this distance a continuation of the Productive Coal Measures between Brown's and Sable Rivers, where workable seams of coal are seen in sections displaying every bed. It therefore can hardly be supposed that in their continuation south-east to

North West Bay, seams of good workable coal are entirely wanting. Indeed it appears to me that they may reasonably be looked for. On account, however, of the few and badly exposed sections, as compared with those to the north-west, the only practicable way of proving the value of this comparatively long stretch of productive measures is by boring or by sinking a shaft.

Average thickness of productive measures of Comox.

The thickness of these measures has already been several times stated to be somewhat over 700 feet, and by consulting the map, the summit of the formation is easily seen, except where it lies beneath the Strait. In sinking anywhere on this line over 700 feet of measures would have to be gone through before reaching the base, and although seams of coal are found toward the summit, those which are workable have so far been found in the lower half of the thickness, so that, in a general way, a shaft or bore-hole sunk somewhere between the summit and base would require only to go through half the thickness, or somewhat over 350 feet. In the event of bore-holes or shafts being sunk, some of the streams in the region might be made available for water-power.

Division B.—Lower Shales.

Exposures of Lower Shales near Fanny Bay.

The only exposure of this division seen on the coast, is on a peninsula-like piece of land to the east of Fanny Bay, facing Baynes Sound. It extends to the east a little over one mile. The beds here consist of a series of brownish-black argillaceous shales, interstratified at intervals with soft grey and arenaceous sandstone, in layers of from one to six inches thick, the general dip being N. 33° to 35° E., $<$ 5° to 20°. This exposure, as will be seen by referring to the map, is somewhat above the summit of Division A. The only other exposures in the Comox area have already been described in the Report of 1872–73 (page 44), most of this division being either concealed by superficial deposits, or else under the water of the Strait of Georgia.

Occurrence of Divisions C to G.

Divisions C, D, E, F and G, are not exposed in the Comox area within the limit of this season's examination, but have all been described as occurring on Denman and Hornby Islands,* and they doubtless occupy a considerable breadth beneath the waters of the Strait of Georgia.

Outlying patches.

There are a few patches, not yet mentioned, which appear to belong to Division A, and are seen lying on Lasqueti, Texada and other small islands. The most southerly one is on Sangster Island, about one mile

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* See Report 1872-73, pages 46 to 61.

south of Point Young, Lasqueti Island. It is wholly composed of sandstone and conglomerate, the latter being largely made up of rounded pebbles of white, yellow and brownish quartzite, ranging from half-an-inch to fifteen inches in diameter, together with other rounded pebbles of dioritic rocks. The pebbles are held in a matrix of greenish-brown sandstone. On Lasqueti Island, to the north-west of Point Young, similar rocks skirt the shore for about three-quarters of a mile. In neither of these exposures could I satisfy myself as to the attitude.

Coal rocks on Lasqueti Island.

On the coast to the north of False Bay (Lasqueti Island) a narrow strip skirts the shore, extending north-eastward for more than a mile, and opposite, on the largest of the Flat Islands, what are apparently the same beds, occupy a narrow strip on the east side. These beds are a grey calcareous sandstone, in layers of from two inches to one foot in thickness, holding numerous obscure fossils.

On the north-east side of Lasqueti Island, about a mile from the extreme north point, a small island in a bay, as well as a narrow strip on the shore opposite the latter, lying on the dioritic rocks round the bay, consists of beds of calcareous sandstone, similar in every respect to those north of False Bay.

On Texada Island.

The most northerly exposure is seen in Gillies Bay, on the south-west side of Texada Island. Around this bay beds of grey sandstone come to the surface, in one place interstratified with black and grey argillo-arenaceous shale containing numerous leaves of plants, and resembling, in this respect, the base of the productive coal measures. In the Report of 1872–73, page 51, it was shown that the formation to the east of Tribune Bay is the centre of a trough, and wholly occupied by Division G (Upper Conglomerate). In relation to this, it was likewise stated that "it would not be extravagant to suppose that the rise of the measures "on the north-east side of this would be something like the rise to the "south-west, on the Comox side of the Strait of Georgia, and that as great "a breadth of the coal-bearing formation would occur on the one side of the anticlinal axis as on the other." If such is the case, the measures spread out under the Strait of Georgia to near the vicinity of the crystalline rocks on the shore of Texada Island.

Judging from what is seen in Gillies Bay, there is little doubt that the beds there are really the outcrop of the Productive Coal Measures on the north-east side of the trough. Section No. 1 illustrates what would be the arrangement of the measures. It begins on the brook, about two miles to the south-west of Deep Bay, at the base of the Productive Coal Measures on the south-west side of the trough, and runs N. 45° 30′ E., across Baynes Sound, Denman Island, Lambert Channel and Hornby Island, a distance of nearly ten miles; thence, N. 31° 30′ E., to Gillies Bay, a length of twelve miles further, to the base of the productive coal measures on the north-east side of the trough.

NANAIMO COAL AREA.

Outlying patches between Nanaimo and Comox areas.

This area, as already stated, is separated from the Comox area, on the north-west, by crystalline rocks in the neighbourhood of Nanoose Harbour, although there are two intermediate patches, one at the head of Nanoose Harbour, and another, in the form of a narrow strip, dipping towards the sea extending about half-a-mile west of Blunden Point and about four and a-half miles eastward. The boundary of the Nanaimo area on the north-west would be in Departure Bay, where, on the north-west side, the Productive Coal Measures are seen, leaning against the crystalline rocks; and hence they run inland and westward for nearly five miles, and turning south-eastward for about six miles, are bounded by and overlie the crystalline rocks of Mount Benson or Wake-Siah, which rises on the south-west to a height of 3,373 feet above the sea. From here two undulations bring the base to the south and west, round the south-east flank of Mount Benson, to the west of the south-flowing portion of Nanaimo River. Thence, in a pretty straight line, bearing S. 59° E., to Horse-Shoe Bay, a mile beyond which they leave the mainland of Vancouver Island, and, on the same bearing, reach Salt Spring Island, to the west of Vesuvius Bay. From here the measures gain south-eastward for about five and a-half miles. From this place the rocks are affected by undulations bringing the base north-east, to the south-west side of Ganges Harbour, about two miles south-east from its head. Further to the south-east, the lower beds are mostly hidden by the water; but, opposite the Channel Islands and to the north-west, they are seen to lie on and fill up hollows in the crystalline rocks. From here the base is, probably, under water beyond the south-west side of Pender and Saturna Islands, but reappears on the Sucia Islands, in Washington Territory, probably at the south-east end of a trough. This bears S. 59° E. from the north-west end, west of Departure Bay sixty-one miles. The north-east boundary of the trough must lie beneath the waters of the Strait of Georgia, and probably extends under the flats at the mouth of the Fraser River.

Boundaries of Nanaimo area.

Cowitchen area.

In addition to the main trough there is a smaller one (which may be called the Cowitchen area), to the south-west, separated from it by crystalline rocks. The north-west boundary of this minor trough is

PLATE VIII.

From Photo. June 15th, 1875.

Photo Lith. by the Burland Desbarats Co Montreal.

VANCOUVER COAL COMPANY'S WHARF, NANAIMO.

With U. S. Gun-Boat Saranac coaling, a few days before her loss in Seymour Narrows.

somewhat less than six miles west of Maple Bay, in Somenos, where the base rests on the crystalline rocks of Mount Prevost, which rises on the north-west to a height of 2,687 feet above sea level. From here the lowest beds run to the north-east about two miles, and then south-east to Maple Bay, a distance of four and a-half miles. In the opposite direction the base continues its course south-west for about two miles and a-half across the Cowitchen River, and then turns south-eastward to about a mile south from Hatch Point, where it reaches Saanich Inlet. It then appears opposite, in North Saanich, at Boulder Point. From here the lower beds run in an irregular line around the north flank of Saddle Mountain and reach the coast on the south shore of Shoal Bay, where they are seen leaving the mainland of Vancouver Island, and reappear on several islands to the south-east.

Extreme length of Cowitchen area.

The south-east boundary is supposed to be Stuart's Island, in Washington Territory. The whole distance from Mount Prevost, on the north-west, to the south-east end of Stuart's Island, on a bearing S. 63° E., is nearly thirty miles.

Localities where measurements made.

The only measurements made in the two troughs, the boundaries of which have been described, were in the neighbourhood of Nanaimo and Maple Bay. At Nanaimo they were along the coast as well as in the interior, so as to enable me more readily to determine the structure and position of the various coal seams. At Maple Bay measurements were made into the interior in varions directions towards Somenos and Cowitchen River. For the coast line and the position of the numerous islands in the Strait of Georgia, dependence was placed on the correctness of the Admiralty charts by Capt. G. H. Richards, R.N.

From the exposures observed in the measured lines, above mentioned, as well as along the coast and on the numerous islands, all that I am able to give of the character and distribution of the rocks of the Nanaimo coal-bearing area has been ascertained.

As already stated, the rocks of the Comox area were separated into seven divisions, as given on page 162.

Divisions A and B only, recognised.

In that area they are well defined and easily traceable throughout, while in the Nanaimo area only two are fairly marked: viz, A,—the Productive Coal Measures; and B,—the Lower Shales. The rocks overlying these two divisions, are either altogether sandstone and conglomerate, or sandstone alternating with shale, but are not continuous on the strike; sandstones and conglomerates in one place being represented by shale in another on the same horizon. I will, therefore, General arrangement of Nanaimo section.

separate the rocks of this area in ascending order into the following divisions:—

A.—Productive Coal Measures.
B.—Shale.
C to G.—Sandstones, conglomerates and shales.

Division A.—Productive Coal Measures.

General section Departure Bay, Newcastle and Protection Islands.

The most westerly point of the Nanaimo area is near the Wellington coal mine; but what appear to be the lowest beds are only seen where they lie on the crystalline rocks on the north side of Departure Bay. From these exposures, together with those on Newcastle, Protection and other islands, the following section, in ascending order, may be constructed:

	FEET.	IN.
Brownish-grey sandstone, in beds of from six to eighteen inches, occasionally passing into impure limestone from the presence of calcareous remains, *Bryozoa* and *Aviculina**...	30	0
Concealed under water....................................	35	0
Grey sandstone with beds of fine conglomerate............	40	0
Concealed under water....................................	35	0
Grey Conglomerate with silicious pebbles; varying in size from a quarter-of-an-inch to an inch, in a matrix of fine sand and much carbonate of lime........................	77	0
Concealed by water, between Small and Newcastle Islands...	165	0
Brownish-grey coarse conglomerate, with rounded masses varying in diameter from a quarter-of-an-inch to a foot; consisting of diorite, quartzite and other hard materials †..	100	0
Greenish-grey, thinly laminated sandstone, separated into beds from half-an-inch to four inches thick by carbonaceous partings: showing the remains of plants, and also of *Inoceramus*..	37	0
Black argillaceous shale.................................	4	0
Coal, (1.)—Clean and hard; with clear planes oblique to the bedding; thin leaves of carbonate of lime filling the joints in places. This seam is known as the Newcastle seam. Thickness, from three and a-half feet to..................	4	0
Concealed..	24	0
Brownish-grey sandstone..................................	5	0

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* Concerning these fossils, see Report of Progress, 1871-72, p. 82.

† The thickness of this conglomerate and the beds directly below it (concealed by water) were overestimated in the report for 1871-72, page 83. This arose partly from the distance being made too great owing to the want of a correct map, and partly from taking the higher dip on the north side of the bay instead of the lower one on Newcastle Island, which subsequent and more careful examination has shown to be nearer the average.

	FEET.	IN.
Brownish-grey sandstone, holding sub-globular masses harder than the rest of the rock, from two to four feet in diameter, and standing out in relief on surfaces exposed to the waves.	4	0
Brownish-grey or light drab sandstone, in beds of from six to eighteen inches; interstratified with bands of conglomerate, with pebbles, up to two inches in diameter..............	21	0
Brownish-grey sandstone, with sub-globular masses, as before..	3	0
Concealed	10	0
Coal, (2.)—Clean and hard. Locally known as the Douglas seam. From three feet thick to........................	4	0
Concealed	17	0
Grey, thinnly bedded sandstones, with fragmentry remains of stems and leaves of plants...........................	3	0
Grey, fine-grained sandstone, holding iron pyrites in minute grains, causing the rock to crumble on weathering.........	6	0
Grey, fine-grained and finely laminated sandstone beds, from an inch to a foot in thickness separated by thin carbonaceous partings	4	0
Grey, fine-grained sandstone in one bed.....................	5	0
Do. Do. Do.	4	0
Grey, fine-grained, finely laminated sandstone: separated into beds from one inch to a foot in thickness by thin carbonaceous partings, and yielding excellent flagstones; on some of the surfaces remains of plants are displayed...........	12	0
Grey, fine-grained sandstone, which constitutes a good building stone in some places, and in others, from the decomposition of finely disseminated iron-pyrites, crumbles on weathering.	3	0
Dark-grey argillo-arenaceous shale......................	3	0
Grey, fine-grained sandstone, in beds of from six to eighteen inches thick..	6	0
Coal, (3.)—Grey, argillo-arenaceous shale, separated into beds from half-an-inch to six inches thick, by carbonaceous partings, showing numerous remains of plants and irregular thin seams of good coal................................	4	0
Grey, fine-grained sandstone; in one bed, yielding excellent building material*......................................	10	0

The lowest beds of the following section are seen on the north end of Protection Island, and are a continuation of the above:—

	FEET.	IN.
Grey, fine-grained sandstones, in one bed	4	6
Dark-grey argillaceous shale..............................	0	6
Grey, fine-grained sandstone, separated by partings of dark-argillaceous shale..................................	3	9

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* For a more detailed description of the last thirty-eight feet of the above section, see page 84, Report 1871-72.

	FEET.	IN.
Coal, (4.)—Black, bituminous shale, with some coal	0	3
Dark-grey, argillaceous shale	4	0
Grey, arenaceous, and argillaceous shale, some parts calcareous; in beds of from one to nine inches in thickness...	1	8
Grey, arenaceo-argillaceous beds from one to eight inches thick	4	0
Light-grey, fine-grained sandstone, in beds of from two to six feet thick	20	0
Shale and sandstone, not well seen	14	0
Fine olive-grey shale, holding masses that are quite compact, and separate from the shale in pieces of from two to eight inches in diameter and from one to three feet in length, filled with leaves and stems of plants	2	0
Coal, (5.)—Clean and hard; from three inches thick to	0	4
Fine, olive-grey shale	1	8
Coal, (6.)—Clean and hard; from three inches thick to	0	5
Light-grey, fine-grained sandstones, slightly calcareous, in even beds of from six inches to two feet thick	20	0
Brownish-grey or light-drab sandstones, in beds from six inches to ten feet thick; some beds holding sub-globular masses, harder and more calcareous than the rest of the rock, of from one to eight feet in diameter, and standing out in relief on surfaces exposed to the action of the waves	75	0
	827	1

The last thickness is at the most southerly point of Protection Island, where the dip is S. 28° E., < 4°. It is uncertain what thickness of strata is concealed beneath the water before reaching Rocky Bay, Gabriola Island, where the summit of the Productive Coal Measures comes in contact with overlying shale. It appears, however, that the rocks of Sharp Point, and those on the coast towards Dodd Narrows, if there is no break, overlie those given in the section, and would correspond to the concealed interval above described.

Section from Sharp Point to near Dodd Narrows.

The following section of these is in ascending order. It commences at the south end of, and inside the long narrow promontory forming Sharp Point, and extends south-eastward along the shore of Northumberland Channel to within half-a-mile of Dodd Narrows:—

	FEET.	IN.
Brownish-grey sandstones, in beds of from one to two feet	4	6
Black, arenaceous shale, with lenticular streaks or seams of coal, from a quarter-of-an-inch in thickness to	0	3
Sandstone, similar to the first	11	3
Concealed	8	0

	FEET.	IN.
Sandstone, similar to the first	7	8
Concealed	2	4
Sandstones, similar to the first	17	6
Concealed	20	0
Sandstones	22	6
Concealed	14	6
Brownish-grey sandstones, in beds of from one foot to ten feet in thickness; holding sub-globular masses, harder and more calcareous than the rest of the rock, of from one to five feet in diameter, standing out in relief on surfaces exposed to the action of the weather and the waves	24	0
Brownish-black, soft shale, with thin lenticular streaks of coal.	0	6
Brownish-grey or drab sandstones, in beds from six inches to two feet	11	0
Concealed under water	10	0
Sandstones, similar to the last	15	0
Concealed, but may be shale	4	0
Sandstones, as above	140	6
Concealed	9	0
Brownish-grey sandstones, in beds of from one foot to five and six feet; holding sub-globular masses, harder and more calcareous than the rest of the rock, of from six inches to five feet in diameter	20	0
Dark-brown shale	0	3
Sandstones similar to the above	30	0
Concealed	12	0
Sandstones similar to the above	14	6
	399	3

Probable overlying beds.

At the summit of the coal-bearing strata, already described, on the shore of Rocky Bay, the overlying shales of the next division are seen, dipping S. 84° E., < 9°. These shales appear to the south and south-east, running parallel with the coast to a point in False Narrows nearly opposite the middle of Mudge Island, where they come down to the waters' edge. The dip is N. 53° E., < 5°. Along the shore, beneath the shales, about one hundred feet of sandstone and conglomerate, in alternating beds of from four to twelve or fourteen feet in thickness, is exposed. These beds, probably, ought to be added to the Sharp Point section.

Recapitulation of Section.

	FEET	IN.
Thickness of section from north side of Departure Bay to south-east side of Protection Island	827	1
Rocks of Sharp, and south side of Northumberland Channel.		
Supposed to succeed on the line of section under the water	399	3
Additional on Gabriola Island	100	0
	1,326	4

It may be as well to state here that the reason for accepting the thickness given in the above detailed section of the Productive Coal Measures is, that it is succeeded by an overlying mass of shale, of from 500 to 1,000 feet thick, which is pretty well defined and traceable throughout.

Irregular shales, sandstones, etc.

Both above and below this shale the character of the sediments is very irregular: sandstones and conglomerates changing on their strike into soft, easily denuded shales, and giving rise to many bays, harbours, and long stretches of water alternating with narrow strips of land. The water stretches are hollowed out of the shale, while, as a rule, the sandstones form the projecting points and all the smaller islands.

Position of valuable seams.

The most valuable coal seams in the Nanaimo area, as in that of Comox, are in the lower part of the measures. In the Nanaimo area no workable coal has been found above the Douglas seam, which, as shown in the section, is about 600 feet from the base. Coals 1 and 2 of the section have been known from the first opening of the Nanaimo mine by the Hudson Bay Company, in 1854; the first as the Newcastle seam, and the second as the Douglas seam.

Coal on Newcastle Island.

The coal seams which occur on the north-west end of Newcastle Island, shown in Section No. 2, have both been worked at intervals to some extent. Their outcrop is seen on the east side of the island, where, although not quite so thick as where worked, they have the same relative position and character, thus showing that they are continuous through the island.

Attitude of strata.

The strata on the line of section at the coal seams dip from S. 25° E. < 15° to S. 39° E. < 7°. To the south, along the channel on the west side of the island, the dip of the strata becomes less, and the strike changes to N. 63° E. < to 3°. On the main shore at Nanaimo, a little to the south-west of Mill Brook, there are also two seams, the Newcastle and the Douglas. These show the same relations as those on the island, but their position would indicate either an upthrow on the west side of about 150 feet, or a turn in the strike and a rapid descent beneath the

Outcrop of seams near Mill Brook.

intervening channel. Just west of Mill Brook the Newcastle seam crops out near the base of an escarpment of overlying sandstones and conglomerate dipping N. 72° E. < 11°, while across a narrow ridge near the waters' edge is the outcrop of the Douglas seam. The workings on the seam here have been abandoned for some time, and I am unable to state, from my own observation, the thickness of the seam. Doctor Hector, who visited this place in 1859, says:—* "At Nanaimo, as well as New-"castle Island, there are two seams, the Newcastle and the Douglas: the "first of which is everywhere about six feet in thickness, with sometimes "a floor of 'fire clay,' and the roof consisting of a fine conglomerate "bed about sixty feet thick, on which rests the Douglas seam of from "three and a-half to four feet thick." A little over a quarter-of-a-mile southward from the wharf of the Vancouver Coal Mining Company, the measures are again affected by a dislocation, bringing the seam still further to the south, which would indicate another upthrow on the south of from 150 to 200 feet. A little over half-a-mile from the company's wharf, on a line bearing S. 23° W., and twenty-eight chains at right angles from the shore, the Douglas seam is brought to the surface near the Engine House.

Dislocation.

Coals in Vancouver Company's mine.

I am indebted to Mr. John Brydon, under-ground overseer for the Vancouver Coal Mining Company, for the following section, in descending order, showing the relative position of the Douglas and Newcastle seams:—

	FT.	IN.
Hard blue shale	12	0
Conglomerate	12	0
Coal.— (Douglas seam,) varying in thickness from two feet six inches to	6	0
Conglomerate from sixty-six feet to	72	0
Hard close-grained sandstones	84	0
Coal.— (Newcastle seam,) mixed in places with soft bluish shale, from two to three feet thick, both coal and shale being very irregular	8	0
	194	0

Irregularity of measures.

The thickness between the seams shows the great irregularity of these deposits. According to Mr. Brydon, in the present working at Nanaimo, it is 156 feet, while on Newcastle Island it is only sixty-seven feet, and to the south of Mill Brook (according to Hector) it is only sixty feet.

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* Proceedings of the Geological Society, 1861, page 433.

† I have not observed in any of the places examined by myself a true bed of fire clay, but generally of sandstone.

Varying dip of the measures.

The dip near the Engine House, where the under-ground tramway comes to the surface, is S. 67° E. < 16°, and remains the same for sixteen chains, when it suddenly increases to from 70° to 80°, for 300 feet. The beds then dip in an opposite direction, < 12°, but here have only been followed for about sixty feet, beyond which the dip probably increases to 40° or 50°, as in a corresponding position they are seen dipping at that angle. This sudden disturbance in the strata is in some way connected with the supposed up-throw referred to above, but as no corresponding disturbance has been observed in the beds to the north or west of either of the supposed up-throws mentioned, it is probable that the disturbance may be local and limited. The irregularity may, however, be due in part to the deposits having been originally formed over an uneven surface.

Extension of seams proved by boring.

At the time of my last visit, in 1875, the Company were preparing to further test their property, by boring with a diamond drill imported from England for the purpose.

The results up to the month of March last have been furnished me by Mr. John Dick, of Nanaimo, who states that they have just put down three bores to the Douglas seam. No. 1 (500 feet deep), was near the shore, and about east from the Engine House. It passed through the usual strata, and showed the thickness of the seam to be eight feet nine inches of good clean coal. No. 2 was put down close to the shore, near the mouth of the Nanaimo River, to a depth of 360 feet, the thickness of coal found being four feet six inches. This Mr. Dick says is soft. No. 3 is about one mile and three-quarters due west from No. 2, and the depth to the coal 290 feet, the seam being fourteen feet in thickness, and of good clear hard coal. As no information is given about the Newcastle seam, it is most likely that none of the bores were put down below the Douglas seam.

Measures below Newcastle seam.

Under date 9th March, 1877, Mr. John Dick informs me a bore-hole 360 feet deep has been put down in measures below the Newcastle seam, mostly through soft shale, but that no coal was reached.

Wellington Mine.

In addition to that of the Vancouver Coal Mining Company there are two other mines opened on the Newcastle seam, the Wellington and the Harewood Mines. The first of these was opened in 1871, and is five and a-half miles N. 56° W. from Nanaimo, and west three miles from Departure Bay. The second is S. 29° 30′ W., 2·80 miles from Nanaimo. At the Wellington Mine the dip is S. 29° E., < 4° to 6°. The drift is through the coal, and the following section shows the average character of the seam. It rests on a dark grey sandstone.

	FT.	IN.
Coal.—Good, but does not separate well from the sandstone below	1	4
Parting of black shale, from one-eigth of an inch to	0	1
Coal.—Clear and hard, from eighteen inches to	1	10
Soft, black bituminous shale	0	3
Coal.—Clear and hard, from six feet to	7	0
	10	6

I am informed that since the above section was taken, the thickness in some places has been found to be as much as thirteen feet. At the time of my visit the coal was conveyed by horses over a tramway to Departure Bay for shipment, a distance, as already stated, of about three miles. I have, however, been informed that steam is now the motive power used in hauling from the mine.

Thick coal west of the Wellington Mine.

According to Mr. Dick, a shaft was sunk last winter (1876) on the farm of Messrs. Nicholes and Francis, about a mile west of the Wellington Mine, through shale and sandstone, to a depth of 150 feet, when the coal was struck; found to be seventeen feet thick, and of good quality.

Harewood Mine.

The Harewood Mine was at first opened by the present owner in 1874. It had been worked previously in 1864-65, but was abandoned for want of sufficient capital to carry on the work.

The present workings are on a free drift level commanding about forty-four acres. The thickness of the coal on this drift, which is 400 yards in length, and was completed when I was there in 1875, is about five feet, with a dip of N. 83° E. < 12°. In 1875 an aërial tramway was being constructed for carrying the coal to a wharf at Nanaimo; this has been in successful operation for some time, being worked by a stationary engine at the wharf.

Shipments of coal.

The actual shipments of coal from the Nanaimo, Wellington and Harewood Collieries in 1876, are as below:—

Coal shipments for the six months ending 31st Dec., 1876.

NANAIMO COLLIERY—VANCOUVER COAL COMPANY.

	TONS.	CWT.
For export	30,705	00
Domestic	7,122	12
Total	37,827	12
For the previous six months	40,708	10
Total for year 1876	78,536	02

WELLINGTON COLLIERY—DUNSMUIR, DIGGLE & CO.

	TONS.	CWT.
Por export	15,061	00
Domestic	3,840	00
Total	18,901	00
For the previous six months	34,034	10
Total for 1876	52,935	10

HAREWOOD COLLIERY—THOS. A. BULKLEY.

For export	5,465	00
Domestic	1,049	00
Total	6,514	00
For the previous two months	2,102	00
Total for 1876 (8 months)	8,616	00
Grand Total for 1876	140,087	12
" " 1875	97,644	10
" " 1884	81,060	15

The large decrease in the shipments from the Wellington Colliery during the last six months of 1876 was caused by a fire in the mine, and a strike.

Coal exported to San Francisco

The following table shows the quantity and value of British Columbia coal entered at the port of San Francisco during the past fourteen years. It is taken from the annual review of the *Journal of Commerce* of that city:—

YEARS.	TONS.	VALUE.
1862	6,015	$42,833
1863	3,413	23,258
1864	9,790	55,458
1865	21,937	112,962
1866	9,066	46,887
1867	14,653	66,792
1868	20,790	123,214
1869	16,779	97,784
1870	13,979	84,467
1871	16,004	92,093
1872	23,574	133,772
1873	32,327	178,504
1874	62,672	324,362
1875	62,119	326,588
1876	101,572	522,555

An inspection of the maps and sections accompanying this report will

Photo. Lith. by the Burland Desbarats Co. Montreal.

From Photo. June 15th, 1875.

WELLINGTON MINE, DEPARTURE BAY, B.C.

Engine House at Head of Slope.

explain the details of the valuable coal area of the vicinity of Nanaimo better than a lengthened verbal description.

Coal seam on Nanaimo River.

The only other locality where a workable seam has been observed and not mentioned in this report is on Nanaimo River, at a point about eight miles S. 10° W. from Nanaimo Harbour, where the following section, in ascending order, is seen in the bed of the river:—

	FT.	IN.
Grey moderately fine-grained sandstone....................	10	0
Black shale, with impressions of plants, and some irregular seams of coal	1	8
Coal.—Clean and bright, from three feet six inches to.........	4	0
Sandstones as above.	8	0
	23	8

The dip of these beds is N. 71° E., $< 19°$; but ten chains further up the river the dip is S. 25° W., $< 15°$, thus showing that the measures have a synclinal form.

These measures were followed about N. 37° W. for nearly one mile up the stream, over beds, consisting mostly of soft blackish shale, containing specimens of *Ammonites Gardeni*, Bailey, and a species of *Inoceramus*.

Section on Nanaimo River.

Further down the river, which flows nearly east for over five and a-half miles from the coal seam, is a deep gorge, cut, for the last three miles, out of sandstones resembling those of Newcastle Island, between Coal No. 2, and Coal No. 4, of Section No. 2. The coal seam just described may, therefore, be referable either to the Newcastle or the Douglas seam; probably the former. Where the gorge terminates the river turns suddenly, and flows to the northward, almost on the strike of the rocks, which dip eastward. The strata are mostly shale, and are probably on the same horizon as the rocks on Protection Island. About one and a-half miles from the mouth of the river there is a seam of coal, of from nine to fourteen inches in thickness, dipping S. 19° E. $< 7°$. Between this and the mouth of the river, the rocks, which are sandstones, resemble those between Coal No. 2 and Coal No. 4 of Newcastle and Protection Islands, while about a quarter-of-a-mile higher up the river there are beds of sandstone interstratified with shale, containing plants, with some coal, and resembling Coal No. 5 of Protection Island.

Horizon of the coal bed.

Judging from the relative positions of the coal seams and the plant bed, I have little doubt that they represent coal No. 4 and 5 of Protection Island. Besides the remains of plants, a number of fossils were collected, among which Mr. Whiteaves has recognized:

Fossils.

Pyrula glabra, Shumard.
Cinulia obliqua, Gabb.
Gyrodes, Sp.
Fasciolaria N. Sp. (F. nodulosa W.—name pre-occupied.)
Inoceramus Vancouverensis, Shumard.
Axinœa Veatchii, Gabb.
Mactra Tripartita ? Sowerby.

Extent of coal measures south-east of Nanaimo.

The area of coal measures to the south-east is considerable, several folds causing the rocks to be repeated at the surface. The main anticlinal is traceable from Dodd Narrows on the north-west, whence it runs under the water to the west of the DeCourcy group; thence, between Thetis and Kuper Islands, on the south-west, and Reed, Indian and Secretary Islands on the north-east. The course is then along Trincomalee Channel to the north-east of Salt Spring Island; afterwards, between Prevost and Pender Islands on the south-west and Parker Island, the south-east end of Galiano Island and Mayne Island on the north-east. Between Pender and Mayne Islands, in Navy Channel, it turns more to the north, and gains Lyell Harbour on Saturna Island. Beyond this it was not traced eastward, but a well marked valley from the head of Lyell Harbour probably indicates its continuation eastward through Saturna Island to Deep Cove at the east end of this island.

Folding of the rocks.

By referring to the map it will be seen that there are also several minor folds which affect the measures between Boat Harbour and Chemanis Bay, as well as those of Thetis, Kuper and Salt Spring Islands. From about a mile to the west of the upper end of the gorge, on the Nanaimo River, the boundary between the coal measures and the underlying crystalline rock runs in an almost direct course south-east to the coast opposite the most northerly of the Shoal Islands. The south-east side of Horse Shoe Bay is occupied by black shale, while Bare Point is composed of grey sandstone, both dipping eastward. On the south shore of Oyster Harbour, the beds are vertical, and the alternations of sandstone and shale here exposed lead to the conclusion that the the same beds are repeated several times; otherwise the thickness would greatly exceed anything that has been observed in the distribution of the measures elsewhere. On the east side of Oyster Harbour the beds are more regular, and dip N. 51° E. < 3°. About half way up the harbour a seam of good coal, but only half-an-inch thick, was observed. It occurs in a bed of black shale from three inches to eight inches thick.

On the north and south sides of Boat Harbour the rocks are grey sandstone, with thin beds of soft, black shale, in one of which streaks and spots of good clean coal were observed. Northward from Boat Harbour, lower beds of black shale crop out along the shore, and in these *Conchocele Cretacea*, W., with fragments of *Baculites*, are abundant.

Proceeding towards Dodd Narrows, the shales pass beneath the water, and the upper sandstones and shales of Boat Harbour come out on the coast. In a bed of shale here, fragments of good coal were observed, no doubt corresponding to those at Boat Harbour. These beds also reappear in Mudge Island, on the other side of the main anticlinal, and also in the furthest north-west island of the DeCourcy group, where coal from two to three inches in thickness was seen in shale, probably representing that on the Boat Harbour side of the anticlinal.

Rocks of Mudge and De Courcy Islands.

The whole breadth of the Productive Coal Measures from the crystalline rocks south-west of Oyster Harbour to the north-east shore of the DeCourcy group of islands is nine miles. Pylades channel is supposed to be occupied by the overlying shales, the upper beds of which are seen along the base of the sandstone cliffs of Valdes Island. West of Gabriola pass the same shales occupy the shore of Gabriola Island to nearly half-way through False Narrows, where they have already been described.

Breadth of Productive Measures here.

From Shoal Islands south-eastward, the boundary of the coal rocks is beneath the water, but at a point on Salt Spring Island, which is in the direct course of the line already described as forming the boundary from near Nanaimo River to Horse Shoe Bay and Shoal Islands, the shales are again seen resting on the crystalline rocks, which here consist of very evenly bedded green, grey and black slates, dipping S. 23° W. $< 42°$. The overlying shales dip N. 8° E. $< 21°$ for about forty chains, giving a thickness of about 350 feet. They are followed by conglomerates and sandstones, and their trend to the south-east is marked by a well defined valley, which occurs between the mica schists below and the sandstones above. The upper portion of Mount Erskine, at about a mile from the shore, is formed of the sandstones, and rises to about 1,600 feet above the sea. From here the valley continues to be well marked for five miles to the south-east; the shales then sweep round the south-east end of a trough, and are affected by several sharp folds, bringing the base of the shales on the shore of Ganges Harbour opposite the Chain Islands. These folds are well seen to the west of Vesuvius Bay, and have already been mentioned as affecting the measures on Salt Springs, Kuper and Thetis Islands. Toward the top the shales are interstratified with calcareous sandstone, containing the remains of plants and bits of good

Boundary of coal rocks traced south-eastward.

clear coal. Immediately west of Vesuvius Bay, specimens of *Haminea* N. Sp. and of an undetermined species of *Tellina* were found.

Conglomerates.

The pebbles of the conglomerate, which, as already stated, overlies the sandstone, are well rounded, and from the size of a pea to a foot in diameter. They consist of white quartz, granite, diorite, and occasionally a piece of the underlying soft shale.

Coal Measures at Vesuvius Bay, Southey Point, &c.

A not very prominent point, on the west side of Vesuvius Bay, is formed of the conglomerate, and shales and sandstones dipping N. 25° W., apparently occur both above and below it. From the succession and character of these beds elsewhere, however, there can be little doubt that the shales and sandstones are really below the conglomerate, and are here repeated by an overturn dip. The shales are seen at the surface to the head of Vesuvius Bay; the strata dipping 80° to 90°, sometimes on one side, and then again on the other. They continue along the shore with no change in their attitude to the point south-east from Dock Point, where a few beds of sandstone come in. Between the shale and sandstone, good coal is met with in irregular beds from half-an-inch to one inch thick. Inside the point, the shale is again seen on its edge along the coast to Dock Point, where the overlying sandstones reappear. The cove inside is formed of the shale, which here dips N. 33° E., < 71°, and is overlain by sandstones and conglomerates. These continue to the north-east side of the island, and along the shore, to Southey Point, and occupy the greater part of the north-east coast of the island. The inclination of the beds gradually lessens to within half-a-mile south-west of Southey Point. Though somewhat variable, it is mostly to the south-west along the whole of the north-east side of the island. As already stated, the main anticlinal passes outside Salt Spring Island—and Narrow, Secretary, Hall, Indian and Reid Islands would present the summit of the Productive Coal Measures on the north-east side of the anticlinal; while Thetis, Scott, Hudson and Tent Islands would all belong to a lower portion of the measures.

Coal Measures at Ganges Harbour and south-eastward.

From the head of Ganges Harbour the coal measures are traceable south-eastward, and along the south-west side of the Harbour as far as the Channel Islands are seen, occasionally, resting upon and filling up hollows in the crystalline rocks.

The folds, already mentioned, are continued from the head of Ganges Harbour, south-eastward, along the south-west side of Prevost and Pender Islands, beyond which the rocks are concealed under the water.

The axis of the main anticlinal, in its continuation through Trincomalie Channel, strikes eastward through Navy Channel to Lyell Harbour; thence, through Saturna Island to Deep Cove, where it passes beneath the sea. The whole of Prevost and Pender Islands and part of Saturnia Island, therefore, lie on the south-west side of the anticlinal, and are occupied by the lower beds; while on Parker Island, a portion of Galiano Island, and along the greater part of the south-west coast of Mayne Island, the upper beds only are exposed. This is indicated by the overlying shales, which have been traced from Montague Harbour, across Galiano Island, to Active Pass, and from the south corner of Miners' Bay, across Mayne Island to the coast opposite the north end of Curlew Island, which, together with Samuel Island, is occupied by the upper beds of the coal measures.

Sucia Islands.

The Sucia Islands* are six miles south-east of East Point, on Saturna Island; the whole of which latter, as well as of Tumbo Island, is occupied by the coal measures, embracing rocks on both sides of the main anticlinal axis. On the south-west side of the largest of the Sucia Islands is a soft, arenaceous clay-shale, in which very few bedding planes are visible. The dip is, generally, N. 25° E., $< 52°$; but there are some places where it is at a high angle in an opposite direction. Some of the beds are crowded with fossils, which become liberated from the matrix by the action of the weather on the cliff, at the base of which they can easily be collected in large numbers and often in excellent preservation. The greater portion of the island, including the whole of the north-eastern shores, consists of massive grey sandstone, which, apparently, overlies the fossiliferous shales.

Overlying Shales and Sandstones.

Areas covered by overlying rocks.

The base of these shales and sandstones has already been partly indicated in describing the run of the Productive Coal Measures. On the north-west end of Gabriola Island the shale occupies nearly the whole of the shore of Rocky Bay, from which it strikes north, and comes out on the coast, extending from Berry Point westward for half-a-mile, towards Schooner Cove. From the southern shore of Rocky Bay it skirts along the south-west side of the island, but does not reach the shore until about opposite the middle of Mudge Island. Thence it occupies the shore to the entrance of Gabriola Pass, where it is overlain by grey sandstones. To the south-east it passes beneath the water, through

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* These Islands now belong to Washington Territory, having been ceded to the United States in 1872, under the San Juan arbitration award.

Pylades Channel, the upper beds only being occasionally exposed at low water along the south-west side of Valdes Island, where they are overlain throughout the whole length by grey sandstones, forming high, sometimes perpendicular, cliffs. Mexicana Hill, about the middle of the island, rises to a height of 600 feet, and is entirely composed of sandstone. The summit of the shale is seen in a similar position along the south-west side of Galiano Island as far as the low promontory on the north-west side of Montague Harbour, which is altogether shale. A curious feature observed here in the shale is the occurrence of what may be called dykes of sandstone. The shale dips N. 32° E. < 9°, while one of the so-called dykes is quite vertical, seven feet thick, and strikes N. 73° E. From the character of the walls of some of these dykes it is supposed that they are due to ditch-like excavations made in the shale by running water, which have subsequently been filled with sand by the same agency. The exposed breadth of the shale here is about half-a-mile. This, according to the angle of dip, would give a thickness of 530 feet, but as some of it lies under the water, the whole volume is, probably, between 700 and 800 feet. Both shales and sandstones often show lines of false-bedding, and on their run south-eastward they become almost altogether a dark coloured sandstone. This change in character is best seen between Montagne Harbour and Active Pass, when they form part of the high promontory, in marked contrast to the low land, or long deep channels by which the shale is commonly indicated throughout the length of Galiano Island.

Sandstone "dykes."

Boundary of overlying rocks traced south-eastward.

Further to the south-east, the shales being more arenaceous, their run is not so well marked as it is to the north west, but following the strike, the base runs from Miners' Bay, in Active Pass, through the centre of Mayne Island, and passes under the water just outside Curlew and Samuel Islands.

The overlying sandstones, in Galiano Island, are similar to those of Valdes Island, but in two places they rise to a height of 900 feet, and a good opportunity is here afforded of estimating the thickness. On a line, about two and a-half miles long, from Montague Harbour north-east to the open strait, the average of dip taken at nine localities is about 18°. This would give to the sandstones a thickness of 3,290 feet, which added to that of the shales—660 feet—and that assigned to the Productive Coal Measures—1,316 feet—gives the total thickness of the entire formation as 5,266 feet.

Total thickness of measures.

This is only 354 feet more than the whole thickness assigned to the seven divisions in the Comox Area, and thus, notwithstanding the

From Photo. June 15th, 1875.

HAREWOOD MINE, NANAIMO, B.C.

First opening on the Seam.

PHOTO LITH. BY THE BURLAND DESBARATS CO. MONTREAL.

marked difference in the succession of the sediments in the two areas, the total thickness is nearly the same in both.

What the attitude of these rocks, on their extension to the north-east, under the Strait of Georgia, may be, it is impossible to say with certainty; but the distribution, as shown on the map, would indicate that a synclinal axis, the north-western end of which is in the vicinity of the Wellington Mine, passes through Gabriola Island, and would run thence south-eastward beneath the Strait of Georgia, in which case the Productive Coal Measures might rise to near the surface beneath the alluvial and Tertiary deposits which occupy the flat country of the estuary of the Fraser River.

The Cowitchen Area.

Boundaries of Cowitchen area.

The south-western, or what may be termed the Cowitchen area, is wholly occupied by the Productive Coal Measures. From the head of Cowitchen Harbour into Somenos, it extends north-west for a distance of six and a-half miles to the base of Mount Prevost, which rises to 2,687 feet above the sea. In a south-west direction from the steamboat wharf, in Maple Bay, it extends five and a-half miles to the flanks of the hills on the south-west side of Cowitchen River, and thence south-eastward to the shores of Saanich Inlet, south of Hatch Point, reappearing south of Coal Point, and forming an irregular belt on the north end of North Saanich. It leaves Saanich at the south side of Shoal Bay, but occupies Piers, Knapp, Pym, Coal, Russell, Jones, Domville, Hill; Comet, Gooch, and Stuart Islands, the latter in Washington territory. A narrow strip, lying on crystalline micaceous rocks, skirts the east end and north side of Portland Island, while another strip skirts the north-east and north-west shores of Morseby Island, lying on rocks similar to those of Portland Island.

Localities in which coal observed.

At the undermentioned localities coal has been observed. The most westerly is at Coal Point, on the south side of Deep Cove, at the entrance of Saanich Inlet. From a seam here a few tons of coal have been excavated, but it appeared to be a good deal mixed with shale. The seam is thirty inches thick, and dips N. 22° E. < 18°. I was unable to trace it beyond the opening. At the same locality, about forty feet lower in the beds, there occurs an argillaceous shale, which appears to be from thirty to forty feet thick. Near the top of these beds there are many fragments of tree stems; six of these stems are upright, and appear to be in position in which they grow. The outside portion of the stems, representing the bark, consists of good, clear coal. On Mr.

Cloakes farm, three-quarters of a mile eastward, following the strike of the beds, an opening had been made, and a seam was observed in it which, however, did not appear to be more than the eighth-of-an-inch thick. In a similar bed, on the north shore of Shoal Bay, stems and also impressions of viened leaves and root-like forms occur. *Inoceramus* is also found here and on Coal Island in places. Similar beds are again exposed at the head of the Bay, on the opposite side of a sharp synclinal fold, which here affects the measures. An exposure, near the centre of the south shore of Coal Island, shows abont thirty feet of dark-grey argillaceons shales, overlain by seventy or eighty feet of grey sandstone. The uppermost two feet of the shales enclose many fragments of tree stems, which have been converted into carbonate of iron. Impressions of well-formed, broad, distinctly veined leaves, were abundant on the surfaces of the shale layers. In one place what appeared to be roots were observed extending from five to sometimes ten or twelve feet along the surface of the bed, with a thickness of one inch at one end, and gradually tapering to a quarter-of-an-inch at the other. These were wholly composed of good coal.

About the middle of the south-west side of Domville Island, at the base of a cliff of grey sandstone, similar stems of trees and leaves, with some good coal in irregular, thin seams, were observed.

Horizon of Cowitchen rocks.

From the character of the measures in the Cowitchen area, as above described, they would appear to be on the same horizon, and to represent the same period of deposition as those do which contain the workable seams of coal in the Nanaimo area. The total thickness, however, is probably much less than in the latter area, and the evidence, from the exposures so far observed, which are often continuous for a considerable thickness, does not favour the probability of the existence of workable seams of coal in this area.

COAL-BEARING ROCKS OF BURRARD INLET.

Rocks of Burrard Inlet probably Tertiary.

Rocks somewhat resembling those of the Cretaceous coal series were also observed on the south side of the entrance to Burrard Inlet, where they form cliffs of from seventy to eighty feet high. They consist of grey sandstones and arenaceous shales, both of which decompose readily on exposure to the weather. In some beds, fragments and lenticular seams of lignite were met with; but no fossils were observed, so that we have no guide as to their age. Judging, however, from the nearly horizontal attitude of the strata, and their resemblance to those of Sooke (page 190), in which Tertiary fossils have been found, it is not improbable that they are also Tertiary, and may spread over a great part of the flats at the mouth of the Fraser River, and for many miles up its valley, as well as southward into Washington Territory.

Section in bore-hole.

The details in the following section are from a bore-hole put down by Mr. John Dick, who kindly furnished me with the information. The bore is on the sea beach, about three-quarters of a mile west of the Company's saw mills.

Journal of No. 1 bore on the British Columbia Coal Mining Company's land at Burrard Inlet. The beds passed through are as follows, in descending order:—

	FT.	IN.
Surface (clay)	8	10
Light grey sandstone and shale	9	11
Parting	0	6
Light-grey sandstone	27	7
Do. do.	8	6
Do. do.	6	2
Dark-grey shale, with coal plies (that is, thin seams of coal)	0	5
Light-grey shale, with sandstone plies	7	8
Light-grey sandstone	7	2
Do. do. harder	3	0
Parting with pebbles in it	0	7
Hard, grey sandstone	0	11
Soft, light-grey sandstone	12	3
Very hard, grey sandstone	1	10
Soft, grey sandstone	13	0
Hard, grey sandstone	1	2
Soft, grey sandstone	15	4
Do. do.	3	0
Light-blue shale	9	10
Light-brown shale	16	5
Light-grey sandstone	2	0
Light-brown shale and sandstone	21	7
Dark-red shale	10	2
Light-grey shale and sandstone	3	0
Dark-grey sandstone	5	1
Light-blue shale and sandstone	11	10
Light-grey sandstone	8	0
Do. do.	6	3
Light-blue shale and sandstone	9	0
Light-grey sandstone	6	5
Dark-red shale	14	4
Light-brown shale	9	9

	FT.	IN.
Light-blue shale	16	4
Dark-grey sandstone	1	2
Soft coal	0	8
Dark-blue shale	1	11
Soft coal and shale	1	4
Light-blue shale	3	8
Light-grey sandstone	14	4
Hard, light-grey sandstone	50	0
Light-blue shale	0	3
Hard, light-grey sandstone	16	2
Dark conglomerate	8	7
Light-grey sandstone	3	1
Dark-blue shale	9	3
Dark-grey sandstone	2	3
Dark-blue shale	0	10
Soft, blue shale, mixed with brown	0	7
Light-grey sandstone	14	0
Light-blue shale	39	0
Dark-grey sandstone	2	9
Hard, grey sandstone	0	10
Dark-blue shale mixed with coal	0	4
Light-blue shale	7	8
	466	6

TERTIARY ROCKS OF SOOKE.

Limits of rocks.

Sooke is situated on the north side of Juan De Fuca Strait, the bearing, from Victoria to the mouth of the Sooke River, being S. 72° W., and distance seventeen miles. The rocks to be described occupy a narrow strip on the north-side of Sooke Inlet. Commencing at Cooper Cove, on the north-side of Sooke Basin, they extend to Sooke Bay, a distance of nearly five miles, east and west. At Sooke River they are a little less than a mile in breadth, and at Parson's Point half-a-mile wide.

Exposure at Parson's Point.

The only exposures are seen about a-quarter of a mile up Sooke River, and in the cliffs of Parson's Point. At the former place the base consists of soft, greyish-brown sandstone, interstratified with conglomerates, and overlain by about twenty feet of green, porous sandstone, in beds of from two to four feet thick, succeeded by conformably overlying beds of clay and sand, of from 150 to 200 feet thick. This very considerable mass of rocks is bounded by a ridge of grey diorite, which rises above the highest beds immediately on the north.

Whiffin Spit.

At Wiffin Spit the lowest beds in the natural section are exposed in the cliffs of Parson's Point, and here a bore was put down by Mr. Dick to a depth of 139 feet 1½ inches. The beds seen in the cliff, and those penetrated in the boring at the point, are given in the following section in descending order. For the details of the boring I am indebted to Mr. Muir, of Sooke.

Natural section.

The following is the section seen in the cliffs:—

	FT.	IN.
Clay, sand and conglomerate occurring in very irregular layers. The conglomerate more compact than either the clay or sand. These beds form the cliffs of Parson's Point, which rise to a height of from 140 feet to	160	0
Brown sandstone, interstratified with beds of conglomerate of from five to ten feet thick. The sandstone beds hold pieces of wood partly converted into lignite	50	0
Conglomerate	4	0
	353	1

Section in bore-hole.

The cliff section is continued downward by the boring as follows:

	FT.	IN.
Conglomerate	2	0
Grey sandstone	8	6
Fire clay, mixed with sand	0	6
White do.	9	0
Blue sandstone	9	9
Bituminous shale	0	4
Blue sandstone	14	8½
Sandstone, with flakes of silvery mica	2	0
Bituminous shale	7	3½
Hard, close-grained sandstone	0	5
Grey sandstone	9	8½
Hard, close-grained sandstone	0	5
Fine-grained sandstone, fit for building purposes	21	2½
Bituminous shale and sandstone	0	11
Hard, close-grained sandstone	1	0
Fire clay	5	5
Bituminous shale	3	2
Hard, close-grained sandstone (nodular)	0	10
Do. do. do.	0	3
Conglomerate	26	10½
Bituminous shale	8	10
Blue sandstone	6	0
Depth of bore-hole	139	1½

When this depth was reached, the hole was accidentally filled up during a storm with sand and gravel, and has not since been continued.

About a mile inland the upper beds at Sooke River come against diorite rocks. These appear on the coast at Sooke Bay. The rocks on the south and east sides of Sooke Inlet and Basin are all dioritic, showing that the Tertiary beds are confined to a narrow strip on the north-side; but to the south-west of Wiffin Spit they probably extend under the water of Juan De Fuca Strait.

Rocks at John River.

Following the coast westward from Sooke Bay to nearly a mile beyond Otter Point, a distance, in a straight line, of three and a-half miles, the rocks are crystalline; but from nearly a mile beyond Otter Point to Sherringham Point, a distance, in a straight line, of nearly four miles, rocks of a similar character to those at Parson's Point form the coast, in cliffs of from twenty to eighty feet high. At the mouth of John River the lowest beds are grey sandstone, in some places crowded with fossils, belonging apparently to three or four species. These are referable to the genera *Ostræa*, *Pecten* and *Saxidomus*, and are either of Tertiary or Post-Tertiary age.

Fossils.

Succeeding these are other beds of sandstone containing much fossil wood and thin seams of lignite, overlain conformably by beds of clay and sand. Following John River northward, for about two and a-half miles, similar strata are met with, bounded on the north by crystalline rocks, which extend thence southward to Sherringham Point, and south-eastward to the coast near Otter Point.

GEOLOGICAL SURVEY of CANADA
Alfred R C Selwyn F.R S., F.G.S Director
MAP
OF A PORTION OF
BRITISH COLUMBIA
showing the
COALFIELDS
of COMOX NANAIMO & COWITCHIN on
VANCOUVER and adjacent ISLANDS
and the distribution of the
CRETACEOUS COAL BEARING ROCKS
also the tertiary rocks of
SOOKE & BURRARD INLET
To illustrate the Report of
Mr James Richardson
1876.7.
Compiled & Drawn by
F. Barlow Ch. Draftsn Geo. Sur.
BRITISH COLUMBIA
STRAIT OF GEORGIA
VANCOUVER ISLAND
MALASPINA STRAIT
NANAIMO COALFIELD
Burrard Inlet
Boundary B.
JUAN DE FUCA STRAIT
Sketch Section No 1 From two miles S.W. of Deep Bay to Gillies Bay Texada Island.
N. 41° 30' E.
Section No 1 Contd
N. 51° 30' E.
Strait of Georgia
Section No 2 From N. side of Departure Bay to 2½ miles E. of N.E. side of Gabriola Island
S. 30° 45' E.
N. 50° 50' E.
Scale for Sections
INDEX
Crystalline Rocks
A Productive Coal Measures
B Lower Shale
C Lower Conglomerate
D Middle Shale
E Middle Conglomerate
F Upper Shale
G Upper Conglomerate
Tertiary
Scale for Map
125°
124°
123°
49°
Longitude West from Greenwich

REPORT

ON

GEOLOGICAL RESEARCHES NORTH OF LAKE HURON AND EAST OF LAKE SUPERIOR,

BY

ROBERT BELL, C.E., F.G.S.,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—I beg to report the results of the investigations carried on in the country north of Lake Huron and east of Lake Superior during the season of 1876, in pursuance of the instructions which I had the honour of receiving from you last spring. In these operations I was assisted by Messrs. G. F. Lount and Frank Adams, and for a part of the season by Mr. Willis Chipman, B.A.Sc.

Regions examined.

A great part of the north-east shore of the Georgian Bay, which had hitherto been visited only at a few points by officers of the Geological Survey, was examined in greater detail. The labradorite rocks and crystalline limestones of the Laurentian Series were more especially looked for. Towards the close of the season I returned to Parry Sound, and followed some bands of the limestones northward, as far as Lake Nipissing.

In going westward, the Huronian rocks are first met with in the vicinity of Shibaonaning ("Killarney"). A few days were spent in explorations in this locality, and some new and interesting facts discovered in regard to these rocks. Westward of this neighbourhood, Mr. Murray has examined the whole north shore in considerable detail.

Victoria Mine.

The discovery of argentiferous galena to the north of the mouth of Garden River, near Sault Ste. Marie, appeared to be of economic importance. I, therefore, visited the Victoria Mine and examined the rocks of the surrounding country, with a view to ascertaining the geological relations of the vein.

Specimens for Museum.

As you were desirous of improving the suite of rock specimens representing the tpyical Huronian Series in the Museum, I left Messrs. Lount and Adams to collect good examples of all the varieties described by Mr. Murray, and any others they might meet with, while I proceeded to Lake Superior. They were directed to confine their attention to the region between Sault Ste. Marie and the Thessalon River, as being the most accessible for obtaining such a collection, and as embracing examples of the principal sub-divisions of the series as it occurs on Lake Huron. I also instructed these gentlemen to explore the country northward of Echo Lake, which had not hitherto been done, but which promised to be of economic importance as lying within the great Huronian area, and as containing deposits of copper, lead, iron and antimony ores, and of other useful minerals.

Echo Lake.

East shore of Lake Superior.

The geology of the east shore of Lake Superior was investigated in detail, from Batchawana Bay to a point some miles beyond the Michipicoten River. In 1860 I assisted Mr. Murray in making a careful topographical and geological survey of this bay, and a geological examination of the country lying between it and the Sault Ste. Marie. During the past season, being favoured by fine weather, I followed the contour of the land within an oar's-length of the shore all the way from Batchawana Bay to Michipicoten, landing frequently to make notes on the rocks, and going some miles inland at a number of places.

Parry Sound and Nipissing Districts.

As already stated, the latter part of the season was devoted to some further explorations in the Parry Sound and Nipissing districts. In returning home from Lake Nipissing, by way of the Ottawa, some observations were made on the rocks of the route by way of Lake Talon, Mattawa River and the Ottawa.

The trimmed specimens of sizes suitable for exhibition in the Museum, collected by myself and assistants during the season, amount to 434 in number.

I shall now proceed to give an account of the geology of the regions examined during the season, arranging them in their order from east to west.

GEOLOGY OF THE NORTH-EAST COAST OF GEORGIAN BAY.

The rocks of the whole of this coast from the head of Matchedash Bay and Shibaonaning, a distance of about 125 miles, belong to the Laurentian series, and consist principally of varieties of gneiss. About Parry Sound and the mouths of French River the gneiss is interstratified with bands of hornblendic and micaceous schists, which are largely developed in these regions. In addition to these, crystalline limestones, lime-feldspar rocks, stratified diorites, trap dykes and granite veins are also met with, and will be described further on. The strike of the gneiss and its interstratified rocks has no uniform general course throughout the whole length of this coast-line. Besides the smaller contortions, the numerous anticlinals and synclinals which come out upon the coast cause the strike in different parts to run towards every point of the compass. Northward from the shore there appears to be more regularity, and the general structure of the country would seem to tend to run a little east of north. Locally, the run of the stratification is often indicated by the form or direction of the points and bays, the larger islands and the chains of smaller ones. The curving outlines of the islands, channels and inlets opposite to Penetanguishene, the twisted appearance of Parry Island, and of the channel on its south-east side, as well as the singular straightness of Partridge Bay, the Long Inlet, the points on the west side of Parry Island and about Shibaishkong Island, all correspond with the local strike of the rocks, and are due to the effects of denudation, which has formed channels along the course of the more yielding strata, and left ridges or higher ground where the rocks resisted decay and erosion. Along this shore there is, however, a class of channels and inlets due to another cause, namely, the existence of dykes of trap and breccia, and of granite veins, and also of parallel joints or cracks, along which the rocks have been rendered more decomposable; or these latter may have acted merely as starting points or guiding lines for the action of glaciers or other denuding agencies, which constantly enlarged and deepened the depressions once they had been commenced. The channels and inlets of this class usually run nearly east and west, and have steep sides, while those which follow the stratification have usually some other course, and are not so abrupt.

Varieties of rocks.

Strike.

Relation to natural features.

Dykes, veins and joints.

The vast numbers of islands, varying in size from mere rocks up to nine miles in diameter, along this coast constitute the most remarkable feature in its topography. Although Admiral Bayfield's chart of the

Islands.

coast represents, with considerable accuracy, the size, form and position of several thousands of these islands, yet it was either impossible for him, or not required for the purposes of navigation, to map an immense number of others which exist. The general outline of the coast represents a comparatively abrupt descent from a sort of plateau in the country behind, to the bottom of the Georgian Bay in front. In approaching the land from the bay, in most places one first passes over numerous sunken ridges and rounded knobs of Laurentian rock; then similar ridges and knobs begin to rise above the surface of the water; next small and then larger rocky islands, with stunted trees are passed; further in, the islands become more closely crowded together, and by and by the area of the islands is greater than that of the water amongst them; peninsulas now jut out among the Islands, but it is often a work of time to find out whether one is on a peninsula or an island; finally, the islands are mostly replaced by peninsulas, separated from each other by irregular bays and inlets, which send a labyrinthe of branches to various distances into the land. Unless well acquainted with the locality, one can never be certain when he has gained a point from which he may reach the interior of the country, without interruption from some arm of the lake. This broken margin of land and water is of a very rocky character, and it is seldom that much good land is found near the shore. In a general way, the country may be said to improve constantly in going from the Georgian Bay towards Lake Nipissing, although there is also much good land around Lakes Muskoka, Rosseau and Joseph, and in the neighbourhood of Parry Sound.

Character of coast.

Quality of land.

Varieties of gneiss.

Around Matchedash Bay the gneiss presents many varieties as to texture and the relative proportions of its constituent minerals, but none of them appear to be deserving of special description. The prevailing colours are different shades of red. The stratification is usually considerably disturbed. The occurrence of a curving band of crystalline limestone in Dog's Cove Inlet, off Robert's Bay, will be noticed further on in connection with a description of other bands of limestone in the district. The rock of the outermost chain of islands, which runs almost straight in due north-west course from Prince William Henry, for a distance of thirteen miles, consist of distinctly banded red gneiss, dipping north-east at angles, varying from 30° to 90°. On the islands of this chain, which lie midway between the Giant's Tomb and the mainland, the gneiss holds veins of greyish granite, running with the strike. In some places the weathered surfaces of the gneiss present small basins and crescent-shaped holes or deep pits, which have evidently resulted from the weathering-out of patches of crystalline limestone, portions of which are still found adhering to their sides and bottoms.

Granite veins.

On the mainland between Bushby Inlet and Partridge Bay, much of the gneiss is of a very micaceous character, and is cut by numerous but rather small veins of coarse granite, composed of red feldspar, lilac-coloured quartz and black mica. They run in all directions, but more of them in a course approaching east and west than in any other. The veins resist denudation better than the matrix, and are frequently found standing out about a foot above the surface of the latter, and still retaining the glacial striæ upon their tops. A few of the islands off this part of the shore consist of massive, reddish gneiss, resembling coarse syenite, sometimes conspicuously marked by spots of a dirty-green colour. On the group of islands opposite to the entrance of Partridge Bay the gneiss is partly of a massive, red, feldspathic character, and partly grey and quartzose. It is very much disturbed, and presents numerous fine examples of anticlinals and synclinals on a small scale. On one of these islands the grey gneiss is full of isolated nodule-like crystals of white feldspar, which, on splitting, show very distinctly striated surfaces. One of these nodules, about five inches in diameter, was crusted all round with a layer of white quartz. The crystalline faces of this feldspar have a lustre ranging from vitreous to slightly pearly. Its hardness is ·6, and its specific gravity 2·68. Before the blowpipe it fuses at ·4 to a colourless transparent glass, and gives a strong soda flame. A complete analysis of this feldspar has been carefully made by one of my assistants, Mr. Frank Adams, who finds its composition to be as follows:

Labradorite crystals.

Silica	53·864
Alumina	27·725
Ferric oxide	·047
Lime	11·766
Magnesia	Trace.
Alkalies	6·969
	100·371

Its composition would, therefore, cause it to be classed as a labradorite. All the alkalies have been calculated as soda, although a little potash is probably present.

On the north side of the entrance of the narrows leading into Partridge Bay there is a point of dark-coloured hornblendic rock with calcspar in the joints, and a similar rock occurs, on a mall, low, wooded islet, about one-third of a mile before coming to the mouth of the brook, at the head of the inlet which forms the eastern extremity of the bay. The slope of the hill on the north side of this brook is composed of a peculiar white-weathering diorite, very distinctly mottled white and black. The occurrence of this diorite, which is elsewhere found with Laurentian limestones, and of the calcareous hornblende rock along the north side of the long, straight depression which exists here, point to a limestone band running in the bottom of its course. The rocks were examined all the way across the head of the peninsula between this bay and the Long Inlet, and found to consist of many varieties of gneiss, which are often, locally, much contorted, but have a general east and west strike.

Mottled diorite.

Long Inlet.

On both sides of the Long Inlet itself the strike is, generally, very straight, and corresponds with the course of the inlet; the dip being uniformly to the northward. The length of the inlet, from Moose Deer Point to its head, is ten and one-half miles. The channel is comparatively free from obstructions, and narrows constantly, finally terminating in a small brook at the head of the inlet. This inlet lies in a depression which has been excavated along the course of a band of very light-grey gneiss, composed chiefly of lime-feldspar, but containing also a little white quartz and a few specks of black mica. It decomposes rapidly under the weather, leaving a snowy-white surface after the vegetable matter has been burnt off. On fresh fracture it has very much the appearance of crystalline limestone. It is underlaid by a rather hard, reddish gneiss, and overlain by a banded red and grey variety. The gradual narrowing of the inlet is caused by the rocks increasing in their inclination from about 20° towards the entrance, to about 60° at the head.

Moose Deer Point to Parry Island

Between Moose Deer Point and the southern extremity of Parry Island the gneiss is usually close-grained and massive. In some places it is red and feldspathic, and in others grey, and more silicious. It is associated with great quantities of dark-coloured, crystalline, horblendic and micaceous schists, which, as well as the gneisses, are generally thickly studded with small red garnets. The strike in this section varies from north-east to only a little north of east, and the dip is to the south-eastward at angles varying from 60° to 80°. The hornblende schists are cut by irregular and rather small veins composed, of coarse-grained quartz, mica and bluish or lilac-coloured striated feldspar and sometimes crystals of hornblende; and more regular small veins of quartz and striated feldspar were observed traversing the grey gneiss, with a bearing a little to the north of west. In several instances the rock on the north side of these veins was observed to be thrown slightly to the west. Numerous veins of rather coarse red granite cut the red variety of gneiss. On the eastern side of an island, just off the southern extremity of Parry Island, the hornblendic schists were in one place stained brownish-red by oxide of iron. Some of the numerous small granite veins which cut the garnetiferous, horblendic, mica-schists in this vicinity, have a central band of feldspar with a layer of quartz on either side; while in others this arrangement of the two minerals is reversed. Along the south-east side of Parry Island the strike of the gneiss is east of north, following the general course of the channel The dip is at high angles, sometimes to the eastward and sometimes in the opposite direction.

Village of Parry Sound.

Around the village of Parry Sound the rocks consist of thinly-bedded, harsh-looking micaceous and hornblendic gneiss or schist, interstratified with fine-grained, granular quartzose beds; the whole being considerably contorted and very much cut up by granite veins of all sizes, and running in every direction. The latter are, usually, very straggling and irregular, and as they weather to a light colour the larger ones contrast very strikingly with the dark matrix. They consist of a very coarse aggregate of white quartz, light-red, cleavable feldspar, and large scales of black mica. These rocks are also cut by smaller veins of quartz and feldspar in separate leaves, which are variously arranged parallel to the walls. The schistose matrix holds small red garnets, thickly disseminated almost everywhere through the mass. On Rosetta Island, about a mile south of the village, each of the garnets is surrounded by a yellowish border. When the rock is sliced and examined under the microscope, this border is found to consist of crystaline quartz, and the otherwise transparent garnets are observed to contain black specks. The hornblende schist, which holds three garnets, is cut on the western side of the island by small veins, filled entirely with black mica, the foliation of which is parallel to the walls of the veins, which cross the cleavage of the schist almost at right angles.

Straggling granite veins.

Mottled diorite and crystalline limestone.

Eastward of the village of Parry Sound, along the road of the same name, dark hornblendic gneiss or schist prevails for a distance of about a mile and a-half. A band of crystalline limestone, and one of the mottled white and black diorite, occur in association with these rocks, where this road crosses Lot 28, Concession I, Township of McDougall. These will be more fully described along with the other limestone bands of the district. On Lots 147 and 148, Concession A, of the road range, or rather more than a mile east of the village; and again on Lot 29, in the 11th Concession of Foley, about a mile to the southward of the last named lot, the hornblendic rock contains a good deal of magnetic iron. Mr. Frank Adams has made an assay of some of the specimens from Lot 148, and finds the iron is not in sufficient quantity for the rock to be properly called an ore. The general strike of the rocks in the vicinity of Parry Sound Village would appear to be a little east of north.

Parry Sound.

On the largest island in the northern part of Parry Sound, the rock is a grey, fine-grained, granular, silicious gneiss, with garnets and scales of mica. It runs about south-south-east, and is cut at all angles by veins of very coarse, reddish granite, some of them being nearly horizontal. In addition to quartz, feldspar and mica, they hold occasional spots of black magentic iron, half-an-inch and less in diameter. On the opposite shore of the Sound, about the middle of the northern side of Parry Island, the gniess dips S. 20° W. < 45°, while further west on the same side of the island or opposite to Kill-bear Point, it dips with considerable constancy about due south, at angles of 40° to 60°. Around the extremity of Kill-bear Point, the gniess is mostly grey and thinly bedded, and dips S. 10° E. < 40°.

Shibaishkong Island.

The large island, midway between Parry Sound and Franklin Inlet, is called Shibaishkong. Around the southern entrance to the channel, between this island and the main shore, the gniess dips north-eastward at an angle of 40°, but beginning at a short distance after entering the channel, and continuing for about two miles, it runs N. 15° W., while the dip is at a high angle to the eastward on the outside, and westward on the opposite shore. On the north end of the island the run of the bedding is very straight, and bears N. 22° W., with a westward dip at an angle of 80°. Here the rock is interstratified with beds, less than one foot thick, of hornblendic and mica schist, which have decomposed to some extent, leaving long, straight, ditch-like channels, a few inches deep, in the otherwise even glaciated surface of the ordinary gneiss. These channels are of the same depth when they occur under the water of this lake as when at an elevation of several feet above its surface, which appears to show that Lake Huron has not stood long (geologically speaking) at its present level. In the small bay, due north of this end of Shibaishkong Island, the gneiss runs N. 20° W., and dips westward at a high angle. Veins of coarse, reddish granite, from a foot to two feet in thickness, which here run with the strike, weather-out and stand a foot or more above the general level of the surface of the gneiss. At this locality parallel ridges, often lying close together, but none of them exceeding three or four inches in height, run nearly at right angles across the strike of the lamination of the gneiss. They appeared to me to be due to some indurating effect, following minute cracks or joints in the rock; but from the investigations of yourself and Professor Ramsay in North Wales, in regard to the phenomena of cleavage, lamination, etc., among altered rocks, it appears quite possible that these parallel ridges may really represent the run of the original bedding, while the usually better marked lamination of the gneiss is the result of subsequent structural change and metamorphism.

Shawanaga.

Franklin Inlet of the charts is called by the Indians, Shawanaga (or the straight north and south shore), in allusion to the course of the east side of the main channel. The largest of the islands on the west side of this channel has received the name of McKay's Island. The gneiss, on the island and opposite side of the inlet, is generally massive, of the ordinary reddish and greyish varieties, and runs north-west and south-east; but, on the conspicuous bare island in the middle of the channel, opposite the site of the old trading post, the strike of the massive gneiss, is N. 25° W. On the smaller islands lying around the northern part of McKay's Island, the run of the gneiss varies from east and west to east-south-east and west-north-west, while the dips are at comparatively low angles to both the north and south. The inner bay which opens off the northern part of Franklin Inlet is called Sturgeon Bay. Its shores consist of gneiss, cut by veins of coarse reddish granite. The Shawanaga River falls into the head of a smaller or branch inlet, running eastward from the northern part of Franklin Inlet; and which appears to have been excavated in a band of crumbling grey gneiss, which is continued in a direction a little south of east, in a small valley beyond the head of the lesser inlet, and dips northward at an angle of 30° to 35°. At the first fall of the Shawanga River, which lies a little to the south of the run of the above band of crumbling grey gneiss, the rock is a compact, reddish, silicious gneiss, having also an eastward strike. North-westward from Franklin Inlet, or towards Byng Inlet, the average strike of the gneiss would be about south-west for the first few miles.

Shawanaga River.

Byng Inlet.

Byng Inlet has a length of seven miles from the open lake to the proper mouth of the Meganatwan River, with an average breadth of less than a-quarter of a mile. Its course is about east, or nearly at right angles to the general strike of the gneiss, which is about N.N.W. Along the western half of the inlet the greater part of the gneiss is reddish and compact, while along the upper or inner half much of it is micaceous and hornblendic, and contains disseminated red garnets.

Meganatawan River.

On the south side of the Meganatawan River, just below the first fall, about two and a-half miles from the head of the inlet, a dyke of dark, reddish-brown breccia occurs. It crops up close to the edge of the river, and very little of it is exposed; but it appears to run eastward or with the course of the stream. The matrix is amorphous and very brittle; while some of the fragments consist of a dark, reddish-brown opaque, cherty rock, and others of a dark variety of syenite. The mass holds a little calcspar and specks of iron pyrites. Between the mouth of the river and this fall, especially along the north side, the gneiss, which runs in various directions, is of a dry, crumbling character along a set of joints which run parallel to the stream and are lined with oxide of iron. The course of Byng Inlet, and of the Meganatawan River, is remarkable in being comparatively straight, and crossing both the general course of the gneiss and mica and hornblende schists, as well as that of the lakes and the numerous smaller streams of the district. This would appear to indicate that the formation of this channel has had something to do with the existence of the brecciated dyke or the joints above described.

Brecciated dyke.

Mouths of French River.

About the mouths of the French River the prevailing rocks are dark, hornblendic and micaceous schists, or schistose gneiss, with compact reddish gneiss, and some of a grey colour and medium texture. The schistose portions are cut by numerous veins of coarse granite, and usually hold abundance of disseminated, reddish garnets. The average strike is about N.N.E., and the prevailing dip is to the eastward at high angles. On the Bustard Islands, however, in front of the mouths of the French River, the gneiss, which is interstratified with hornblendic schist, dips southward.

CRYSTALLINE LIMESTONES OF THE REGION BETWEEN GEORGIAN BAY AND LAKE NIPISSING.

Several bands.

The crystalline limestones of the above region belong to at least three distinct bands, and it is probable that some of the exposures belong to a fourth, and others, possibly, to a fifth band. With the exception of one locality, mentioned by Mr. Murray more than twenty years ago, these limestones have not hitherto been noticed in any of the reports of the Survey, and their existence does not yet appear to be generally known by the inhabitants of the district itself, although for many reasons they are of much importance in relation to the settlement of the country. I shall now give the principal facts ascertained in regard to each of these bands during the short time at my disposal near the end of the season. The greater part of this region is still in a state of wilderness, and difficult to explore for geological details, but towards Parry Sound itself it is becoming settled, and the roads which are being made in that vicinity gave us facilities which did not exist a few years ago.

Burton Band.

Western band.

The most western band of limestone of which I could get any information is reported to be well developed in the vicinity of Wa-wash-kaise (Little Deer) Lake in the townships of Burton and McKenzie, and Ka-wa-shaig-amog (Clear Water) Lake, the position of which is not yet definitely located, but which appears to be near the north-east corner of Wilson. On Iron Island, in Lake Nipissing itself, Mr. Murray has described a crystalline limestone of Laurentian age which would lie in the course of the northward continuation of the band under consideration. About a-quarter of a mile west of the southern expansion of Lake Wa-wash-kaise, the limestone of this band is said to come out in great force around a small lake in the eastern part of the township of Burton, from which circumstance I propose to give the band this name. It is stated to be nearly white in this locality, and to be worn into numerous caves. An exposure of crystalline limestone was reported to exist on the southern part of Shibaishkong Island, a few miles north-west of Parry Sound, and if this be a fact it may represent a southward continuation of the Burton band.

Parry Sound Band.

Course for forty miles.

The band of crystalline limestone, on which the most exposures were found, was traced from the south-west corner of the Township of McDougall, near Parry Sound village, in a general bearing of N. 14° E. (ast.) for a distance of about forty miles, or into the township of Ferrie. The courses of the other Laurentian limestone bands of this region appear to be nearly parallel to this, which, I may mention, is also the general bearing of many of the similar bands which have been traced out by Sir Wm. Logan, in the country north of the Ottawa. The band under consideration, which I propose to call the Parry Sound band, must have a thickness of upwards of one hundred feet in many places. It consists, for the most part, of a very pure, coarsely, crystalline limestone, which is usually white or very light grey, but is often tinged

Pure limestone.

Associated minerals.

pink, green or yellow. On burning it yields an excellent lime. Among the minerals which I found associated with it were graphite and serpentine; the former as scales, disseminated through the mass, and on Manitouwabin Lake occurring in lumps of two or three inches in diameter; and the latter in grains and masses of an inch or two in diameter, on Lot 32, Concession A, Hagerman, at the east end of Lorimer Lake. Along with the serpentinous portion of the limestone at this locality there is a fine-grained semi-crystalline rock, having, on fresh fracture, very much the appearance of a dolomite, but which Dr. Harrington finds, on examination, to consist of fine grains of quartz in a matrix of lime feldspar. This rock contains spots a few inches in diameter, stained to a beautiful purple tint by some compound of iron. Its position appeared to be near the western limit of the band, which is flanked on this side by gneiss, composed principally of quartz and lime-feldspar. The limestone near the junction of the gneiss contains crystals of pyroxene and specimens of yellow mica, having the laminæ arranged in a radiating form, or at right angles to the greater diameter of the mass. About the line between Lots 33 and 34, of the Northern Road in this vicinity, a natural culvert, excavated in the limestone, passes under the road, and conveys a small stream which runs into the head of Lorimer Lake. The rock is here coarsely crystalline and nearly white, and does not crumble under the influence of the weather.

Lime-kiln near Parry Sound.

On Lot 28, Concession I, McDougall, about one mile east of Parry Sound village, where this band is quarried for lime-burning, it is very much reduced in thickness, and appears to be pinched out entirely a short distance to the northward. At the lime-kiln it dips westward at a high angle, and consists of twelve feet of pure friable light pink and green, coarsely crystalline limestone, underlaid by twenty or thirty feet of similar limestone, interstratified with gneissic beds, and holding pebbles and concretions. The latter appear to be made up principally of pyroxene, while the pebbles, which are partly rounded and partly angular, consist of quartz, with layers of crystalline hornblende. The largest pebble observed was about a foot in diameter, and most of them were under three inches.

Mottled diorite.

The rock which is here immediately associated with the limestone is a remarkable looking diorite, consisting of a white ground, thickly mottled with patches of dark-green or blackish hornblende, having their longer diameters arranged parallel to the general bedding. This appears to be the rock which Mr. Vennor has described in the Hastings, Lanark and Renfrew region, under the name of "blotched diorite." I found the same rock along the face of the hill on the north-side of the brook, at the head of Partridge Inlet, which runs parallel to Long Inlet, at a distance of two or three miles south of it, both inlets being between the two northern mouths of the Muskoka River. I should not be surprised if it should be found that it forms the western flank of a band of limestone concealed in the valley of the brook.

Township of McDougall.

Crystalline limestone is said to occur at the head of the bay, about one mile west of the Indian village on the south side of Parry Island, which would be the most southern known exposure of the Parry Sound band. It is reported as occurring next, on Lot 30, Concession XI, of Foley. The lime-kiln. above mentioned, is a mile further to the northward. The next locality at which it is seen, is said to be on the northern part of Lot 22, Concession I., of McDougall. It is well exposed on Lot 18, Concession II., of the same township, on a small peninsula at the east end of Mill Lake, where it consists of about sixty feet of creamy-white and light-pinkish, coarsely crystalline limestone, with some included lenticular bands and smaller masses of hornblende. The dip is eastward, at an angle of 35° to 40°. It next appears at the edge of the water of this lake, under a cliff on Lot 18, Concession III; and again forming the face of a hill on Lot 17, Concession III, and dipping eastward at an angle of 60° to 70°. Here it is full of pebbles and concretions, like those at the lime-kiln, and it is underlaid by the mottled diorite above described. The latter rock is cut by veins of coarse granite, holding masses, a few inches in diameter, of black magnetic iron ore, which contains traces of manganese and titanium.

Exposures on the Parry Sound band.

The coarsely crystalline limestone of this band is largely exposed about the outlet and eastern extremity of Manitouwabin Lake, in Concessions VI., VII., and VIII., McKellar. Between this lake and the localities which have been described about the eastern extremity of Lorimer Lake, it is said to occur on Lot 19, Concession I., Hagerman, and beyond the latter lake, about Lots 43 and 44, Concessions A and B, on the Northern Road in the same township. Mr. D. F. McDonald, of Parry Sound, to whom I am indebted for many useful facts in reference to the Parry Sound District, informed me that a coarse, whitish, crystalline limestone, which would be on the run of this band, is well developed on Lot 60, Concession B, and Lots 59 and 60, Concession A, in Hagerman, and I have been assured that a similar limestone is found on Lot 35, Concession XI., Croft. This brings us close to Maple Island, on the Meganatawan River, in the south-eastern part of McKenzie from which Mr. Murray traced this band for three miles to the northward. He describes it as dipping eastward at a high angle, and as holding graphite, yellow mica and iron pyrites. The thickness is not stated, but, according to his accompanying plan, it would be at least 300 feet. Further on, the limestone occurs on the Northern Road, about the centre of the Township of Ferrie, and at the intersection of this road with Deer River. Beyond this, crystalline, whitish limestones, in which caverns are formed, are known to occur abundantly in the rear of Ferrie and in the unsurveyed township to the north of it, and also on Lake Minisegog; but it is uncertain whether these represent a continuation of the Parry Sound band or not. It is possible that the band, which appears to run in the same course from the eastern part of the township of Pringle to the South Bay of Lake Nipissing, is a continuation of the band under consideration; although it is equally probable that it belongs to the one to be next described.

Nipissing Road Band.

Nipissing Road band.

A band of crystalline limestone is traceable by numerous exposures on and near the Nipissing Road, from the township of Chapman all the way to South Bay, on Lake Nipissing, a distance of about thirty miles, the bearing of its general course being about N. 6° E. (ast.) I propose to call this the Nipissing Road band. Its whole width was not seen at any of the exposures which came under my notice, but it is, probably, not less than one hundred feet. In general character it is a light-grey or whitish, moderately coarsely crystalline limestone. It crops out at the following localities, (stated in order from south to north), which are given partly from my own observation and partly from information which appeared reliable:—

Character of limestone.

Exposures.

Lot 24, Concession IX., township of Chapman, on the Distress River. Lots 110, 112, 114 and 120, Concession B, in the same township. Opposite the west ends of Lots 126 and 129, Concession B, township of Lount. Lots 137 to 142, Concessions A and B, in Lount. On the road between Concessions VI. and VII. on Lot 6, Pringle. Lot 202, Road Range, township of Nipissing, near Muckwabie Lake. About Lot 215, Road Range A, Nipissing. About the western corner of Lot 218, Road Range B, Nipissing. On the peninsula between Namannitigong River and South Bay, Lake Nipissing, opposite "the landing" or the termination of the Nipissing Road. Similar limestone is said to occur on one of the Manitou Islands in the eastern part of Lake Nipissing, which lie in the continuation of the strike of this band to the northward.

Southward this band may, perhaps, be represented by an exposure of crystalline limestone, said to occur at Goff's Mill, in the Township of Foley; and it is not impossible that the limestones of Robert's Bay (about to be described) may belong to the same band.

Robert's Bay Band.

Robert's Bay limestone band.

Robert's Bay lies to the north-east of Prince William Henry or Beausoleil Island, opposite to Penetanguishene. A narrow curving inlet runs northward from the bay, which the Indians call Anim-wa-shing or Dog's Cave. The convexity in the course of the inlet is to the south-eastward. In this inlet I discovered a band of light-grey crystalline limestone, which is exposed on the points and islands along its course for a distance of about three miles, beginning at a-quarter of a mile from the head of the inlet. The band has a thickness of at least fifty feet, and is overlain by thirty or forty feet of light-grey granular gneiss, mostly thinly bedded, followed by an unknown thickness of very massive, close-grained, hard, brittle, silicious gneiss. Its dip is to the east and south-eastward, at an angle of about 70°, the strike following the curve of the inlet which, no doubt, owes its origin to the existence of the limestone. In this part of its course, the band is evidently passing round the south eastern end of an anticlinal. Near the head of the Inlet, and again on one of the small islands at its entrance, the limestone is rich in several of the species of minerals which often characterize the Laurentian limestones of the Ottawa valley. Among them are brown idocrase in very fine crystals, salmon-coloured garnets (well crystallized, but very brittle), dark wine-red garnets, hornblende, graphite, quartz, pyroxene in very numerous, small, transparent, bright-green crystals; iron pyrites and mica.

Crystalline minerals.

Lake Talon Band.

Lake Talon band.

In connection with the crystalline Laurentian limestones of the region under consideration, I may mention the band which makes its appearance at the foot of Lake Talon, and which I examined while on my way from Lake Nipissing to the Ottawa. It consists of whitish crystalline limestone, with specks and patches of green serpentine. It has a considerable thickness, dips southward at an angle of about 40°, and is traceable for 400 or 500 yards down the Mattawa River. It reappears under the timber-slide at the first rapid below the outlet of the lake, and is again seen on an inlet in Moon Lake, the first below Lake Talon.

Mr. Murray mentions the reported occurrence of crystalline limestone on Cedar Lake, on the Petawawa River, which lies about eighteen miles to the southward of the foot of Gaudin's Lake.*

GEOLOGY OF THE NEIGHBOURHOOD OF SHIBAONANING.

Shibaonaning.

The village of Shibaonaning ("Killarney") stands upon red granite, which also forms the bulk of George's Island in front of it, and extends northward from it for a distance of rather more than a mile. The same rock appears to continue north-eastward along the shore as far as the entrance to Collin's Inlet. Its position is along the junction of the Laurentian with the Huronian series, and it appears to belong to the latter rather than the former. It has a medium texture, and is composed of reddish feldspar and bluish-white quartz, with a little hornblende, which, however, is often wanting. Excepting at the sides it has a massive homogeneous structure, but in a few instances a single reddish or yellowish-green shaly streak, an inch or two in thickness, was observed running in a north-easterly direction, with a dip to the south-eastward of about 50°. Towards each side, the "grain" of the rock begins to assume a sort of parallelism or a gneissoid structure. This may be seen at about a mile and a-quarter due north of the centre of the village, and again on George's Island, opposite to the eastern boundary line of the village-plot. The junction of the granite with the Huronian quartzite and hornblende schists occurs at the south-side of a rather elevated rocky island in a cove about one mile north of the western entrance to "the passage," on the north side of which the village is built, On the north east point of George's Island the granite is flanked by a stratified rock of a reddish-grey color, consisting of a fine-grained crystalline mixture of feldspar and quartz. The course of the bedding, which is about vertical, and which runs quite straight, is S. 50° W. Some irregular veins of white opaque quartz, holding occasional specks of iron pyrites, were found running in the direction of the stratification.

Granite.

Huronian rocks.

iorite dyke.

A dyke of fine-grained, dark greenish-grey friable diorite, three to four feet in width, cuts the granite along the north side of George's Island, with a bearing of N. 70° W., or parallel to "the passage." The south wall, from which the dyke has crumbled away, is remarkably straight and even. The nature of this dyke and its direction suggest the probability of "the passage" itself being due to the erosion of a larger parallel dyke. The beautiful and appropriate name Shibaonaning, which has

Indian name.

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* See Reports of the Geological Survey for 1854.

belonged to this locality from time immemorial, means "the place of the clear passage" (between two open expanses of water;) and it is to be regretted that any other designation should be given to its post-office, especially without the consent of the inhabitants.

Township of Rutherford.

Huronian limestone.

Chert and conglomerate.

On the west side of the township of Rutherford, from the northern limit of the granite, already described, quartzites and hornblendic schists hold the shore as far as Lamiromdieres' Bay, in the north-western corner of the township. A blackish-green massive and rather coarsely crystalline hornblende-rock, having an exceedingly rough or irregularly pitted surface, is exposed on either side of the narrow entrance to this bay. Upon the slope of the hill, about one hundred yards in from the north shore of the bay, at a point about half-a-mile from the above named narrows, a band of finely-crystalline limestone occurs among the Huronian rocks. It has a vertical attitude, and runs about N. 70° W. at the part examined. Its total thickness is about seventy-five feet, of which the twenty-five feet along the northern side consists of a single solid band of nearly white finely-crystalline limestone, clouded with light greenish and greyish patches. The remaining fifty feet is mixed with shaley patches of hornblende, together with a little shining granular magnetic iron ore. Adjoining the limestone on the north side is a band only a few feet in thickness, of dark smoke-coloured chert-rock, ribboned with streaks of a dull red colour. It breaks easily with a fine conchoidal fracture, and appears to be identical with a rock which was used by the "mound builders" for making some of their arrow-heads. This is followed, to the northward, by a dark-coloured dioritic conglomerate in which the pebbles are mostly small and generally rather widely scattered, and further on by a very dark, grey, soft, massive-looking micaceous schist, most of which is full of small pebbles. Measured from the limestone band, a thickness of between one and two hundred feet of these rocks is exposed.

Hornblende rock.

Quartzite.

On the north shore of Lamirondieres' Bay, a few hundred yards eastward from the outcrop of limestone above described, are two exposures of very tough, massive hornblende rock, and between the two arms of the bay is a more fissile variety, interstratified with a reddish-grey quartzite, which also overlies the mixed rocks. The dip is here north-westward at an angle of 60° to 70°, and the series is underlain by granitoid gneiss. The long and narrow, but elevated peninsula which runs south-westward from the mainland in the vicinity of Lamirondieres' Bay to within two or three miles of Heywood Island, consists of fine-grained quartzite, of a light-grey to a milk-white colour. The beds vary from about an inch to many feet in thickness. At the part of the peninsula due west of Shibaonaning the strike is S. 85° W., and the dip southward at an angle of 80°, but at its extremity it is S. 70° W., with a northward dip of 70° to 80.° Here, some of the beds are separated by thin, greenish, slaty partings. Beds of fossiliferous, grey limestone, belonging to the Trenton formation, here lie uncomformably upon the southward slope of the surface of the quartzite at the water's edge. On the east side of the peninsula, about three miles north-west of Shibaonaning, a promising deposit of magnetic iron ore occurs in these quartzites. This peninsula points towards the head of Sheguaenda Bay, on the Grand Manitoulin Island. In my report for 1865 I have described a ridge of fine-grained, very light-grey Huronian quartzite, which runs westward into the island from the head of this bay.

Magnetic iron.

Geology of the Country northward from Echo Lake.

Echo Lake

While I was making an examination of the east shore of Lake Superior, I had instructed Messrs. Lount and Adams, to explore the region for a few miles around the head of Echo Lake, which had not been visited by Mr. Murray, and to collect specimens of the rocks which they might find. They traversed it in various directions to a distance of about six miles to the north-east and five to the north of the head of the lake. Judging from their notes and the specimens collected, as well as from Mr. Murray's remarks, a dark greenish-grey crystalline diorite appears to run from the northern side of the township of McDonald past the south-east side of Echo Lake, and northward as far as Mr. Lount went. In the north-eastward continuation of the valley of Echo River and Lake were found dark-grey, finely crystalline, slaty felsite; dark bluish-grey or smoke-coloured argillaceous slate, and rather massive very dark greenish-grey ribboned felsite slate, with even planes of bedding, which correspond with the cleavage. This last named rock occurs at what is called Stobies' Slate Location, about five miles north-east of the head of the lake. At one mile and a-half north of the most northern bight of Echo Lake, the rock is a dark, smokey-grey, compact, silicious slate, with smooth conchoidal fracture. At two miles, in a straight line north-east of the head of the lake, on Stobies' Location, there is a vein of white quartz and calcspar, holding copper and iron pyrites, and also masses of somewhat foliated, highly crystalline, magnetic iron, any piece of which forms a natural magnet. If a line be drawn north-north-eastward from the limestone point on the north-west shore of

Copper pyrites.

Natural magnets.

Echo Lake, through Fairy Lake, for a distance of at least six miles, it will be found that the rocks for ten miles to the westward of it, including part of the valley of Garden River, as far as they are yet known, consist mainly of different varieties of Huronian quartzites. Around the northern part of Fairy Lake, and for a mile or two to the northward, the quartzite is rather coarse-grained, of a dark colour, and has the interstices of the grains filled with decomposing feldspar. Some varieties are of a reddish-grey colour. On Garden River, opposite to "Mr. McDonald's Shanty," or about a mile and a-half north-west of the head of Fairy Lake, the quartzite is fine-grained, and of a very dark purple colour, with surfaces coated by purplish hematite. At the "Antimony Mine," about one mile west of Fairy Lake, a vein of white quartz occurs in felsitic, grey quartzite. This vein is said to carry sulphide of antimony, of which specimens were given me by Captain Weeks. At the "Boulder Mine," close to Garden River, or between two and three miles west of Fairy Lake, numerous large angular masses of white quartz and calcspar, carrying a good deal of galena with iron pyrites, have been dug up, but the vein from which they had been derived has not yet been discovered.

Quartzites.

Antimony.

Galena.

Geology of the Vicinity of the Victoria Mine.

Victoria mine, Garden River.

The above mine, which was opened last summer for the first time, is situated at eight miles from the mouth of Garden River, on a bearing a little east of due north. A new road leads to it from the mouth of the river, and a former trail from the north-east bay of Little Lake George, both of which follow rather sinuous courses, at a distance of a mile or two apart. The first rock observed on the new road occurs at a distance of about five and a-half miles in a straight line from the mouth of the river. It consists of a light reddish-grey, rather fine-grained quartzite. A mile further on, a glossy, greenish, chloritic, or soft hornblendic schist, was met with, running, apparently, east and west. At about seven miles a reddish-grey quartzite, resembling the first, reappears. Between this point and the mine, a fine-grained, reddish-grey granite makes its appearance. On the old or western trail, at distances corresponding with those on the other, similar quartzites are met with, having also a band of glossy green schist between them. About a mile and a-half west of the portion of the trail intersected by the latter rock, there is a dark-green, soft, finely-crystalline, glistening, calcareous mica-schist. At about three miles westward of the same part of the trail, a bluish-green, somewhat slaty felsite, with a rough, non-crystalline fracture, occurs a short distance west of a light, flesh-coloured imperfect gneiss, which breaks into rhombohedral pieces with smooth surfaces, due to a thin coating of a soft, non-calcareous mineral. A mile still further west, or on the shore of a second Fairy Lake, there was met with a dark-green calcareous hornblende-rock, containing grains of iron pyrites. From the brink of the hills overlooking Little Lake George, for a distance of more than three miles northward on the western trail, friable, ash-grey, granular, argillaceous or felsitic quartzites prevail. In two places they were observed to contain numerous small, rounded pebbles of white quartz. They usually weather to a bluish-grey colour. The general run of these rocks is west of north. At one place, about two miles and a-half from Little Lake George, a compact, slightly calcareous olive-grey, somewhat slaty felsite, occurs.

Rankin copper mine.

The Rankin Copper Mine is situated near Root River, at a distance of two or three miles north-westward from its mouth. The ore is the yellow sulphide, disseminated in a vein of white quartz, and between the laminæ of a soft chloritic schist, in which the vein occurs. The other rocks of the vicinity are slate conglomerate, more or less thickly studded with pebbles of all sizes, chiefly of light-reddish granite, massive, dark, greenish-grey, argillaceous slate, and a coarse crystalline, very dark-green hornblende-rock, with scales of mica.

Granite.

On the east side of the Victoria Mine there is a great volume of close-grained, reddish-grey, binary granite. Against the west side of this granitic belt are, first, a few feet of soft, glossy green schist, dipping S. 65° W., (ast.) < 80°, followed by a yellow-weathering band, about nine feet thick, of a tough, green, dioritic rock, some of which approaches the character of an amygdaloid. This is followed by thirty-six feet of soft, glossy-surfaced green schist, which cleaves in all directions, so that it is difficult to break out a hand-specimen. Galena, in strings, small bunches and grains, is disseminated throughout the whole of this band, but is chiefly concentrated in a vein, five feet from the east or foot-wall, and a smaller one, eight feet from the western or hanging wall. On each of these veins a shaft had been sunk to a depth of fifteen feet. The eastern vein consists of solid galena, with some dark-coloured blende, and a little copper and iron pyrites. In the galena, and accompanying it, are parallel and transverse streaks of quartz, made up of opaque white crystals, projecting from the walls into empty druses along their centres. The galena lode is only three inches thick at the surface, but at the depth of fifteen feet it had widened to nineteen inches. Its underlie

Galena.

is westward, parallel to the walls of the slaty band in which it is contained, and at the rate of one in five from the perpendicular. The western vein is ten inches wide, and interlaminated with white quartz, but over half of its mass is galena, with blende and a little copper and iron pyrites. Adjoining the slaty band on the west, or forming its hanging wall, are, first, four or five feet of reddish-grey, hard, silicious felsite, mottled by broken and lenticular fragments of green schist, followed by quartsiferous felsite, which resembles somewhat the fine-grained granite east of the mine, but has a smoother fracture. Along the east side of a brook, which flows southward, at a distance of two or three hundred yards west of the mine, there is a band of dark-green, rather coarsely-crystalline, hornblende-rock, of which a thickness of thirty or forty feet is exposed. It runs in a northerly course, and is flanked to the west by a fine-grained, light-reddish or pinkish-grey granite. Dr. Harrington has assayed three samples of the ore from the Victoria Mine. The first was taken from the ore pile, and it is not certain which of the two veins it came from, but it probably belonged to the eastern. The galena, which was rather coarsely crystalline, with curved cleavage planes, was separated from the blende and copper pyrites which accompanied it, and found to yield 168·4375 ounces of silver to the ton, of 2,000 pounds. The second sample was broken by myself from the east vein at the bottom of the shaft, and consisted of mixed coarse and fine-grained galena, with a small quantity of other sulphides and some earthy matter. The sample—after crushing these constitutents all together—gave, at a rate of 12·3959 ounces of silver to every 2,000 pounds. The third sample was broken, also by myself, from the western vein at the surface. It consisted of galena and other sulphides, mixed with a good deal of stony matter. The assay of a portion, representing an average of the whole sample, showed silver at the rate of 2·1875 ounces to every 2,000 pounds of the mass.

Assays of galena.

Silver.

GEOLOGY OF THE EAST SHORE OF LAKE SUPERIOR FROM BATCHAWANA BAY TO MICHIPICOTEN RIVER.

East shore of Lake Superior.

The point between Batchawana and Pancake Bays is comparatively low and tolerably level. It appears to be underlain by sandstone, but the rock is almost everywhere covered by a deep sandy soil. The whole of the promontory of Namainse (Little Sturgeon) is occupied by rocks of the Nipigon or " Upper copper-bearing" series. They consist principally of a great variety of amygdaloids, volcanic tufas, felsites, cherts, crystal-

Nipigon series.

line diorites, sandstones and coarse conglomerates. On the north-western side of the peninsula, the strike is nearly south, while on the south side, behind Pancake Bay, it is about south-east, the whole mass having curved round with a general dip toward the lake. Parallel bands of the same class of rocks form reefs and islets in the lake for half a-mile beyond the south-western extremity of the promontory. From the outermost of these bands, the breadth of the series in a north-easterly direction at right angles to the strike, appears to be at least six miles, and it may be seven and a-half. With the exception of some local irregularities of little consequence, the dip is pretty uniform, and would probably average upwards of forty-five degrees. But supposing it not to exceed this inclination, and taking the breadth at only six miles, the thickness of these strata would be 22,400 feet. The coarse conglomerate bands form one of the most striking features in the series. Between the little islands, eight miles southward of Point aux Mines, and a cove three miles south of the same point, five of these bands occur among the amygdaloids, tufas and diorites. They measure respectively, in descending order, about 260, eighty-five, seventy, eighty and 450 feet. In the last named thickness, two short intervals of concealment are included. From the large size of the masses which constitute the bulk of these beds, they may properly be called boulder-conglomerates. The boulders are closely crowded in a sandy matrix, and all sizes are mixed together. The largest one which I measured was three feet eight inches in diameter, but comparatively few approach this size, the majority being under one foot. Nearly all of them are well rounded and smooth, and far the greater number consist of a dull-reddish granite and of greenish and greyish, more or less crystalline schists, like those of the Huronian series, but in addition to these, are a few small ones, of white quartz, amygdaloid, and occasionally a larger one of gneiss. On some of the latter I observed small grooves like glacial striæ, but they were not well marked. The mass is generally cemented together sufficiently firmly to break with a straight fracture in any direction, through pebbles and matrix alike. The dip throughout the whole of the above five miles of coast, averages about S. 80° W. < 45°. At the northward termination of this stretch of the shore, several dykes of trap cut the amygdaloids, etc. Two of these were observed to run about east-north-east and east-south-east respectively.

Thickness of strata.

Coarse conglomerates.

Overlooking the little bay three miles south-south-east of the extremity of Point aux Mines, and rising abruptly from the edge of the water, is a hill about 400 feet high, of reddish granite, which, although apparently massive on the large scale, is full of irregular joints. The foot of this hill divides the bay into two coves. On the south side of the southern cove, a bluish-grey, finely-arenaceous flagstone and shale occurs, in perfectly even and straight beds, dipping N. 30° W. < 20°. The lowermost twenty-five feet of the exposure includes three thick beds of bluish shale. These strata are followed by a bed of greyish sandstone (showing diagonal stratification) eighteen inches thick, which is full of angular pieces of granite and white quartz of the size of beech nuts. This is followed by about fifteen feet more of shale, which is bright greenish-blue at the bottom, but brownish towards the top. The surfaces of the flaggy beds are often covered with scales of mica, and some of them show fine examples of small ripple marks. On the opposite side of this cove the dip is south-westward, and the angle gradually increases in approaching the foot of the granite hill, at which it is very high, and the strata much disturbed. In the cove, on the north side of the hill, are similar flaggy, argillaceous, fine-grained, soft sandstones with much shale, some of which is red, but most of it is of a chocolate colour. One layer of the latter is full of concentric concretions, which only differ from the rest of the shale in being more indurated. The stratification is somewhat undulating, but the total section exposed in this cove may be about seventy feet. The relation of these rocks, which appear to be totally devoid of fossils, to the great series which forms the Namainse promontory was not determined, as they were not found in contact, but they probably belong to a higher unconformable group. A bed of coarse conglomerate, like the bands above described, was seen in the bottom of the water opposite the foot of the granite hill.

Flagstones and shales.

A small section of similar shales and argillaceous sandstone occurs in the bottom of the next cove to the northward, but with the exception of this, the shore for the next two miles, or to within a mile of the extremity of Pointe aux Mines, consists of a fine-grained, red granite, and a very dark greenish trap or diorite. They are mingled in a confused manner. Generally the granite is present in greater quantity than the trap, but in some places the latter prevails. Occasionally the two rocks are broken down to the size of angular boulders and mixed together into a huge breccia. When they occur separately the masses of each kind are rudely parallel to each other, as if numerous great dykes of the trap cut the granite parallel to each other and close together, or as if the two rocks were interstratified. The course of this arrangement is nearly north and south, especially towards Pointe aux Mines, and the inclination eastward, at high angles to the horizon. Under the

Granite and diorite.

microscope the granite is seen to consist of equal quantities of colourless transparent quartz and light-red crystalline feldspar, with a few specks of dark mica.

Pointe aux Mines.

Around the south shore of the bay, on the south side of Pointe aux Mines, these rocks have merged into mica schist, running north-eastward, and having incorporated with it a good deal of granite, in the form of more or less regular veins. At the point on the south side of this bay a shaft was sunk some years ago on one of these veins, the layers and scales of beautiful yellow mica which it contained having, apparently, been mistaken for copper ore. In the material which had been thrown out of the shaft I could not detect a trace of any kind of metallic ore. The arrangement of the constitutents of the granite here prove it to be a true veinstone. Along the south side of Pointe aux Mines, the rock is a dark greenish-grey, hornblendic, mica-schist, much mixed with twisted layers and lenticular patches of granular quartzite, and of granite, which is usually fine-grained. The run is S. 45° W., and the dip in most parts nearly 90°, but always to the south-east.

On the extremity of Pointe aux Mines, the same kind of mica schist is cut by great masses of nearly white granite, which is usually very coarse-grained, with a banded arrangement of the crystallization, such as obtains in ordinary veins. Their general course is about east, but many of them, although large, do not run far.

Basaltic dykes.

Immediately on rounding Pointe aux Mines the thick beds of tufa, amygdaloid, etc., like those of Namainse, reappear with nearly the same dip (westward < 45°) as where they were last seen, three miles to the south. About a mile north-eastward of the extremity of the point, three dykes of basalt, all close together, and nearly parallel, come out upon the beach. They underlie to the northeast at an angle of 30° or 40° from the perpendicular, and their columns are at right angles to the walls. Pointe Brulé (one of several points of the same name met with around Lake Superior) is about three miles north of Point aux Mines. About the middle of Mica Bay, which lies between the two points, some beds of grey argillaceous flagstones, like those above described, are met with, dipping north-westward at an angle of about 20°. A band of calcareous grey gneiss forms the small point a-quarter of a mile south of the brook falling into this bay. It stands in a vertical attitude, and may be traced as a ridge running up the side of the burnt hill which rises above the bay.

Calcareous gneiss.

Pointe Brulé.

Pointe Brulé, on the north side of Mica Bay, is a bold cape, about 600 feet high, consisting of granite with patches of mica schist, which although apparently isolated from each other, all strike S.S.W. The mass is cut by some great dykes of trap, running a little south of west, and underlying to the north at angles not far from the perpendicular. These dykes are deeply weathered out, so that the tops of trees of the ordinary size, growing in the bottoms of the gorges thus left, do not reach the surface of the granite on either side. From Pointe Brulé northward to the Montreal River, the granite forms a high, rugged ridge, running parallel to the shore. At three miles there is a point at which the granite is cut by three trap dykes from fifty to one hundred feet thick, all running a little south of west, and underlying to the north at angles of from 10° to 20° from the perpendicular. The next point, nearly a mile further north, is faced by a dyke of trap, running parallel with the shore, in which masses of the granite are incorporated. The point projecting into the lake on the south side of the mouth of the Montreal River consists of a mass of nearly black, compact trap, resting on the granite, with an inclination to the northward of 60°. The granite forming the high ridge between Pointe Brulé and the Montreal River is of a very mixed character. The surface is rugged and "hummocky" on a large scale. No regular joints, such as often break granite into rectangular blocks, are to be found; but it is much divided in all directions by irregular cracks, and has a very dry or harsh appearance. Portions of every degree of texture, colour and composition, are mixed confusedly together, yet none was observed of a handsome shade for ornamental building. Large sound blocks could not apparently be obtained from any part of it. It is, likewise, all much mixed and divided by dykes of close-grained blackish trap.

Excavated dykes.

Montreal River.

Rugged granite ridges.

The granite on both sides of the Montreal River becomes gneissoid in spots. In some parts of it a gneissoid appearance results from the occurrence of parallel veins of different texture lying close together. A resemblance to gneiss is also produced locally, by short, thin, twisted bands, or mere partings of white quartz with black mica. But in the vicinity of this river the granite becomes gradually replaced, both on the coast and in the interior, by true gneiss. The country, for ten miles to the north-east of the mouth of the Montreal River, was found to consist of gneiss and granite like those of the coast, together with some micaceous and silicious schists. Between the Montreal and Agiwa Rivers the rocks of the coast consist of Laurentian gneiss, having a general north-eastward strike, mixed with a good deal of granite, and cut by numerous dykes of trap.

Gneiss.

I examined the country for a distance of about sixteen miles inland in a north-easterly direction from the mouth of the Agiwa River, and found nothing but Laurentian gneiss, cut by a few dykes of trap. The prevailing dip of the gneiss is north-eastward.

Agiwa River.

From the Agiwa to the Rivière Charon, the shore is occupied by gneiss, of which the dip is generally north-westward at high angles, but towards the latter stream it becomes about west, at an angle of 30°. From the Charon to a point which bears north-east of the northern extremity of the Lizard Islands, a distance of three or four miles, the rock consists of a massive, even and rather finely-grained, grey granite, with a slight tinge of pink. Between the Agiwa River and this point, both the gneiss and granite are cut by numerous large dykes of dark-coloured, close-grained trap, one of which was observed to be cut by another of a similar character. Their prevailing course is north-eastward, but some of them run nearly north, and others nearly east. Similar large dykes, with corresponding bearings in most cases, were observed frequently all the way to Michipicoten.

Opposite Leach Island.

Leaving the granite, and proceeding north-westward for seven or eight miles, or to within about a mile of the high cape north of Leach Island, dark-coloured, micaceous and hornblendic gneiss was found to hold the shore all the way. Its general strike is west, becoming west-north-west towards the end of the above distance, and the dip northward, at angles which are usually over 45°. In some places, beds or veins of crystalline red feldspar run with the stratification. Around this cape, and thence to the bay on the south side of Cape Gargantua, the gneiss is much disturbed and mixed with masses of granite of all textures, from very coarse to very fine, and comprising various shades of red and grey.

On the shore due north of Leach Island, are several patches of a red, shaly, volcanic breccia, resting upon the gneiss, and dipping southward and westward at angles of 20° to 30°. The outermost part of Cape Gargantua consists of a variety of amygdaloids and tufas, with some sandstone and conglomerate layers and a few thin, cherty beds; all dipping south-westward, or into the lake, at an angle of about 60°.

Cape Gargantua.

From the north side of this cape to the south side of Cap Choyyé the rocks consist of red and grey gneiss and dark, hornblendic mica-schist, which is usually mixed with coarse red granite, often to the extent of more than half the mass. About Cape Gargantua the strikes are, locally, in many different directions, but at two or three miles northward the run becomes more regular, and is S. 75° E. From this point to the commencement of the gravel beach on the bay on the south side of Cap Choyyé, the strike gradually changes, till it has become S. 45° E. at the last named place.

Cap Choyyé.

With the exception of a low patch of thinly-bedded, red and grey sandstone at its north-west extremity, Cap Choyyé is composed of Huronian rocks. They consist of glossy green mica and hornblende schists, yellowish-grey, slaty quartzite, massive, crystalline, green diorite. On the south side the strike is S. 60° E.; on the west, S. 30° E.; while on the north side it is from S. 20° to 15° E., with an eastward dip of 70° to 80°. In the high hill overlooking the cove on the north side of the cape, the rocks are rather coarsely crystalline, dark-green diorite, but at the cove itself, they consist of green dioritic schist, soft, calcareous, grey mica-schist, and brittle reddish-yellow silicious or cherty schists. The latter are divided by calcareous and ochrey partings, into small angular pieces. Northward from this cove, a red granite of medium texture is exposed more or less continuously for some distance near the water's edge, from which circumstance this part of the shore has received the name of Les Roches Rouges. The granite, which is much mixed irregularly with patches and large masses of a brittle, slaty diorite, with which it is associated, does not extend more than one quarter of a mile north of La Rosseau Rouge, where it passes under the water of the lake, and is replaced by green, slaty diorite, which continues to Rivière de la Vieille, forming a perpendicular cliff in one place about 600 feet in height. At the base of this cliff, a little islet of the red granite, cut by a small dyke of compact, dark-green trap, rises out of the water. Some of the slaty diorite has glossy surfaces on fracture; but most of it is dull or earthy. Much of it has a twisted structure and a very irregular surface. Parts of it are full of reticulating strings of calcspar and quartz. In some places there are irregularly lenticular curving veins of calcspar and milk-white quartz, from one foot to three feet wide. Iron pyrites was the only other mineral which I found in these veins, but I was informed that copper ore had also been detected in one of them. Near Rousseau Rouge the strike of the diorite is north-westward, but towards Rivière de la Vieille it appears to curve round with the shore till it becomes north-eastward, in which direction it seems to be continued in a range of hills running into the country. Between the last mentioned stream and Burnt Point Harbour, the rock is a massive, medium-grained granite, most of which is reddish, but some of it is of a grey colour. Two small trap dykes were observed to cut it in an east-north-easterly course.

Les Roches Rouges.

Rivière de la Vieille.

On the west side of Burnt Harbour, the rocks observed consist of slaty diorite with an earthy fracture, and a massive, coarse, crystalline, green variety of diorite. At the west side of the entrance to this harbour, there is a soft, probably, magnesian rock, part of which is grey and very calcareous, approaching the character of limestone; while another portion is greenish and of a dioritic appearance. Spots of copper pyrites with green carbonate of copper occur in these rocks. The extremity of

Burnt Harbour.

Copper pyrites.

Burnt Point is formed of massive, green dioritic slate, which continues northward almost to the mouth of the Michipicoten River, where the rocks consist of dark-coloured hornblendic mica-schist.

Michipicoten River.

Gros Cap.

The rocks of Gros Cap, three or four miles west of the mouth of the Michipicoten River, appear to be mostly greyish, slaty diorite, interstratified in thick beds with a reddish, silicious rock, all having a general strike to the north-eastward on the eastern side and north-westward on the western. Two exposures of hematite occur on the southern part of the cape. At the first of these is fifteen or twenty feet of very impure, purplish-red hematite, interstratified with thin, drusy, grey, silicious beds. The band dips S. 30° W., $< 70°$. The second exposure is near the south-west extremity of the cape. Here the deposit, which was worked to some extent a few years ago, consists of about twenty feet of thin and very distinct and regular ferruginous beds. The best layers appear to be a sufficiently rich iron ore; but it is questionable whether the earthy beds do not form too large a proportion to make it profitable to mine the whole mass in order to obtain them.

Hematite.

Rocks of Gros Cap.

At the point two miles west of Gros Cap, the rock is a soft, green, dioritic slate, finely ribboned with wavy lines. It holds layers and lenticular patches of felsite, and also rounded pebbles of reddish granite; the largest of which would measure nine inches in diameter. A small boulder of a fine quartz conglomerate was also observed amongst the others. The strike is N. 80° W., and S. 80° E. A trap dyke, over fifty feet in width, here cuts these rocks in a north and south direction. It is cut transversely by short veins of white quartz, holding iron and copper pyrite, specular iron, calcspar, chlorite and crystalline epidote.

Veins.

Granite.

At a point three-quarters of a mile west of the last, or nearly eleven miles from the mouth of the Michipicoten River, a light-red granite begins; its junction with the slaty rocks to the east, running inland, apparently in a north-easterly direction. The granite is of a medium texture, and has incorporated in it, near its eastern boundary, bands of greenish-grey hornblende schist, running N. 20° W., with a westward dip of about 45°.

Return to Parry Sound.

This was the most westerly point which I could reach in the time at my disposal. After returning to Parry Sound the remainder of the season which was devoted to field-work was spent in tracing the crystalline limestones from Georgian Bay to Lake Nipissing. An account of these rocks has been given in a previous part of this report.

THE GODERICH SALT REGION

AND

MR. ATTRILL'S EXPLORATION,

BY

T. STERRY HUNT, LL.D., F.R.S.

(*From the Proceedings of the American Institute of Mining Engineers, Vol. V.*)

The deposit of rock-salt which is known to exist along the eastern shore of Lake Huron, in the Province of Ontario, has lately been more completely explored than before, by a boring with a diamond drill, put down by Henry Attrill, Esq., of New York City, and the results obtained are so important in every way that I make no apology for presenting them to the Institute of Mining Engineers. I may be permitted to preface an account of this remarkable exploration, and of its results, with a historical sketch of the discovery and development of this salt region.

Discovery of salt at Goderich.

It was in December, 1865, that a boring was begun near the town of Goderich, in the hope of finding petroleum. In this the adventurers were disappointed, but, after passing through ahout 800 feet of limestone, they encountered a series of variegated marls, in which, at a depth of 964 feet from the surface, a bed of rock salt, thirty feet in thickness was met with in May, 1866. The boring was carried to a depth of 1,010 feet, ending in hard rock, and yielded, by pumping, a very pure saturated brine when examined by me in August of the same year. In the report of the Geological Survey of Canada for 1863-66, published early in 1867, I described this salt-well, with many geological details, and gave an analysis of the brine.

Further explorations.

In the next three years a considerable number of wells was sunk in and around Goderich, and numerous trials were made in various other parts of the region. Salt was found at Kincardine, thirty miles north-north-east from Goderich, at a depth of about 900 feet, and also at Clinton, thirteen miles south-east, at 1,180 feet. Records of these wells, Reports on Goderich salt.

with analyses of the brine from them, were given by myself in a subsequent Report of the Geological Survey, 1866-69, published in 1870, (pp. 211-244,) together with accounts of various unsuccessful borings in the neighbourhood, analyses of the brines from the various wells (including one analysis by Dr. Goessmann,) with many details of the salt manufacture at Goderich, at Syracuse, New York, and at Saginaw, Michigan. The geological character of the region was there discussed at length, and it was shown that the salt here occurs in the Onondaga or Salina formation, which is also the source of the Syracuse, though not of the Saginaw brines.

Further discoveries.

Since that date some further discoveries have been made in this region. At Kingstone's Mills, in Warwick, about fifty miles a little west of south from Goderich, a boring, begun for oil, in the black shale at the summit of the Hamilton formation, was carried down 1,200 feet, when salt was met with. This was found, alternating with marls and harder beds, for 130 feet, beneath which seventy feet of hard rock were penetrated, making 1,400 feet in all. From this well a very pure and saturated brine was raised, which was analyzed by me, and the boring described, in 1870.

Report of J. L. Smith, 1870 to 1874.

The observations from that date to the end of 1874 are to be found in the report of Mr. J. Lionel Smith to the Director of the Geological Survey of Canada, dated November, 1874, and published in 1876. Rock-salt had been found at Port Frank, in Bosanquet, a little to the north of Warwick, and also, at a depth of 1,100 feet in an oil well in the Township of Dawn, south of Enniskillen. Another well had been sunk at Kincardine to a depth of 1,007 feet (being 110 feet below the previous boring,) from which it appeared that beneath twelve feet of rock-salt, and thirty-six feet of alternating marls and salt, was another bed of sixty feet of pure salt. Similar results had been obtained at Goderich, where, in the International well, were found, in descending order—salt, nineteen feet; rock, thirty feet; salt, twenty-four feet; rock, three and a-half feet; salt, thirty-two feet; rock, eight feet; the boring ending at 1,175½ feet. Besides the wells at Kincardine, Goderich, and Clinton, salt had also been met with at Seaforth, about thirty miles south-east of Goderich, where it was found at 1,035 feet. The boring was carried 100 feet further, and, according to Mr. Smith, a third layer of salt was reached here as at Goderich. At Carronbrook, five miles further to the south-east, a well sunk 1,396 feet showed no salt, and at Mitchell, eleven miles south-east from Seaforth, a boring was carried down 2,008 feet. No salt was there met with, and after passing through the Salina marls, and the underlying Guelph and Niagara limestones, the boring was carried 300 feet in the red shales of the Medina formation.

North and east limit of salt region.

At Inverhuron, on the lake shore, nine miles north of Kincardine, marls but slightly impregnated with salt were met with at 895 feet, and the boring was abandoned in hard limestone at 1,007 feet. At Teeswater, some twenty miles further to the eastward, a well was bored to 1,180 feet, traversing somewhat saliferous strata, but no rock-salt; and similar negative results were obtained by a boring of 1,200 feet at Ainsleyville, about fifteen miles north of Seaforth. These observations serve to show the limit, to the north and east of the salt deposit. It occupies but a small area in the great extent of the Salina formation, which underlies and bounds on two sides the shallow basin of Corniferous limestone through which the borings of Teeswater, Ainsleyville, and Mitchell have been sunk. To the southward, however, the same salt deposit, or perhaps a distinct one, would appear to have a considerable extension.

In 1873 Mr. J. Gibson published in the American Journal of Science an account of this salt region, which he subsequently embodied in a communication to a committee of the Canadian House of Commons in 1876. His account is little more than an unacknowledged compilation from my official report of 1869, together with records from the borings of some of the newer wells just mentioned, and some curious errors on the part of its writer.

Purity of brines.

The brines obtained from the various wells of Goderich, Clinton, Seaforth, and Kincardine are, as appear from my published analyses, of great strength, varying from 90° to 100° of the salometer (the latter degree indicating saturation), and hold a much smaller proportion of earthy chlorides than those of either Saginaw or Syracuse. The manufacture of salt by artificial heat is carried on at all these Canadian wells, and in 1873, according to the data obtained by Mr. Smith, the production from them was over two and one-third million bushels, of which very nearly one-half was sent to the United States, notwithstanding an import-duty of 34c. per barrel, and 8c. per 100 lbs. of salt in bulk; making $1.60 per ton of 2,000 pounds, or very nearly 4½c. for the bushel, estimated at fifty-six pounds.

Salt produced in 1873.

Market for salt in Canada and United States.

The Canadian demand for salt is limited, while that of the United States is large and rapidly increasing. This country imports large quantities of salt from the West Indies, Southern Europe, and Great Britain, the latter country sending us 6,000,000 bushels in 1872. The interior States are, however, in great part supplied from local sources. The total salt production of the country, according to the census of 1870, was equal to 17,606,105 bushels, of which 17,063,405 bushels were made from the brines of New York, Michigan, Ohio, Pennsylvania, and West Virginia. I have not the amount of salt imported in 1870, but for the fiscal year 1868-69 it is set down at 19,331,591, and in 1874-5 at 26,885,948 bushels. The salt production of New York reached its highest point in 1870, when it was 8,748,115 bushels, since which time it has fallen off, and was only 5,392,677 bushels in 1876. Michigan, on the other hand, which, according to the census, produced only 3,981,316 bushels in 1870, attained 7,313,645 bushels in 1876.

Mr. Attrill's boring.

Impressed with the great future offered by the interior salt market of the United States, Mr. Attrill resolved to ascertain whether this vast deposit of rock salt in the Goderich region was of a nature to be advantageously extracted by mining. Having acquired a large tract of land on the lake shore, commanding the port of Goderich, and affording the necessary facilities for shipment, he proceeded, by the aid of a diamond drill, to determine the nature of the salt beds beneath. This work was begun and successfully completed in the course of the year 1876. Previous to its completion, however, in September last, Mr. Attrill consulted me professionally in the matter, and placed in my hands the whole of the results of the operation for study, analysis, and description. The principal results of my inquiries were embodied by me in a letter published in the *Globe*, of Toronto, on the 9th of January, 1877, and I am now indebted to the generous courtesy of Mr. Attrill for permission to lay the details of the whole operation, and the results of my studies, before the Institute of Mining Engineers.

Examination of cores.

Having previously been furnished with a copy of the record or log of the well, I received, on the 14th of November, a selection from the cores extracted, to the depth of 1,295 feet, and, on the 16th of December, those from the continuation of the boring down to the point at which it was abandoned, 1,517 feet from the surface. The cores were sent me from Goderich to Boston, and on each occasion I was visited by Mr. W. S. Fritz, of Pottsville, Pennsylvania, the very intelligent and skilful foreman of the drilling, who carefully went over the collection of cores with me, and gave many verbal explanations, besides leaving with me the diary of the operations from the beginning. The work was commenced at Goderich, on the 10th of March, 1876, by sinking a well through gravel and clay to a depth of thirty-five feet, after which a wrought iron pipe was driven ten feet further. The annular diamond drill was then used for about ten feet more, passing through what is described as "a

Commencement of boring.

Superficial deposits.

broken sandy rock," yielding but a few inches of core. Below this a gravel bed was reached, through which iron pipe was again driven to a depth of fifty-nine feet. Drilling was once more resorted to, and, after passing through what seemed to be boulders or loose masses of limestone, to a depth of seventy-two feet, a stratum of sand and gravel, with some clay, was reached, through which iron pipe was again driven until, at a depth of seventy-eight feet nine inches, what was regarded as the bed rock was reached on the 15th of April. The record up to this point is as follows:—

	FT.	IN.
Gravel	14	0
Blue Clay	31	0
Loose stones or boulders	10	0
Gravel	4	0
Loose stones, as before	13	0
Sand and clay	6	9
Total of superficial deposits	78	9

Progress of the boring and length of cores obtained.

For the next fifteen feet boring was effected partly by a steel drill and partly by the diamond drill, passing through what was described as a porous limestone. From this portion only two feet of core were obtained. Beyond this the drilling proceeded regularly, with an annular diamond drill of two and a-half inches diameter, up to July 10th, when a depth of 349 feet had been reached. From the 270 feet of solid rock thus bored, only 103 feet of cores were extracted. At this point the work was interrupted from the loss of tools in the bore-hole. It was, however, resumed on the 20th July, this time under the direction of Mr. W. S. Fritz, who, after extracting the tools, recommenced the boring on the 10th of August. An influx of water was perceived, it is said, at 135 feet, and another and more considerable one having been met with at about 360 feet, an iron pipe of two three-eights inches was driven down to a depth of 365 feet, thus excluding the water.

Below this point the boring was made with a two-inch annular diamond drill, and was carried on without any interruption (except the loss of a week from the breaking of a drum of the lifting-machinery) up to the 6th of December, when the work was stopped at a depth of 1,517 feet from the surface, making a distance of little over 1,438 feet drilled in the sold rock.

Up to 349 feet we have seen that the cores preserved measured only 103 feet, but for the succeeding 936, or to a depth of 1,295 feet reached on the 10th November, there were extracted 853 feet 7 inches of cores. From this point to the bottom, a distance of 222 feet, there were obtained, according to the record, only ninety-eight feet of cores, which were in an exceedingly soft and crumbling state. Of this distance, the last 125 feet (below the lowest salt bed) yielded only about twenty-three feet of cores; the average day's boring, of about ten feet here giving, in many cases, only one or two feet of solid core, and in one instance none at all, the whole portion removed breaking up into a soft incoherent mud.

Of the cores down to the vicinity of the salt-bearing rock, or to 910 feet from the surface, I received only a selection of fragments from one to six inches in length, each duly labelled, and, in addition to these, portions of the clay, gravel and boulders. I had, for the 830 feet of solid rock, ninety-three specimens, measuring in all about thirty feet, judiciously chosen with a view to give examples of every variety of rock met with in this part of the boring. Below 910 feet the whole of the cores extracted, amounting, for the 617 feet penetrated, to 443 feet in length, were sent me, arranged and labelled, in twelve boxes. These materials were, at the request of Mr. Attrill, submitted to a careful chemical and mineralogical investigation, in order to determine whatever might be either of economic or scientific importance. The results of the examinations already made are embodied in the present communication.

General section of boring.

The salt-bearing strata at Goderich, as will be shown in the sequel, are nearly horizontal, so that the measurements given below may be taken as representing the actual thickness of the beds traversed. The entire rock-section, as shown in the cores from the boring, may be conveniently described in seventeen divisions, as follows:

Boring, by Mr. Attrill, at Goderich, Ontario.

				Total	
		FT.	IN.	FT.	IN.
I.	Clay, gravel and boulders	78	9	78	9
II.	Dolomite, with thin limestone layers	278	3	357	0
III.	Limestone, with corals, chert, and beds of dolomite	276	0	633	0
IV.	Dolomite, with seams of gypsum	243	0	876	0
V.	Variegated marls, with beds of dolomite	121	0	997	0
VI.	Rock-salt, 1st bed	30	11	1,027	11
VII.	Dolomite, with marls towards the base	32	1	1,060	0
VIII.	Rock-salt, 2nd bed	25	4	1,085	4
IX.	Dolomite	6	10	1,092	2
X.	Rock-salt, 3rd bed	34	10	1,127	0

				Total.	
		FT.	IN.	FT.	IN.
XI.	Marls, with dolomite and anhydrite......	80	7	1,207	7
XII.	Rock-salt, 4th bed.....................	15	5	1,223	0
XIII.	Dolomite and anhydrite................	7	0	1,230	0
XIV.	Rock-salt, 5th bed....................	13	6	1,243	6
XV.	Marls, soft, with anhydrite..............	135	6	1,379	0
XVI.	Rock-salt, 6th bed.....................	6	0	1,385	0
XVII.	Marls, soft, with dolomite and anhydrite..	132	0	1,517	0

Strata met with in International well.

With this it is interesting to compare the record of the International well, already noticed, drilled in the ordinary way in the town of Goderich, one mile south from the above, and about 105 feet over the level of the lake, Mr. Attrill's boring being about twenty-two feet over the same level. The top of the first bed of salt was found at 1,064 feet, as compared with 997 feet above; and the thickness of the divisions penetrated below this were as follows: VI., nineteen feet; VII., thirty feet; VIII., twenty-four feet; IX., three feet; X., thirty-two feet. These measurements of the total depth, and of the successive divisions, are, from the manner in which they are got, less certain than those obtained by boring with the diamond drill.

Description of section.

I now proceed to describe, in descending order as numbered, the several divisions of the section. Passing over Division I, which consists of the superficial deposits already noticed, we come to:

Dolomite with thin limestones.

Division II.—This, extending from seventy-eight feet nine inches to 357 feet, consists almost wholly of dolomite or magnesian limestone, varying in colour from pale-grey and buff to a dark-grey, passing into chocolate-brown. This latter colour is due to a little bitumen, the odor of which is very marked in the specimens. These dolomites are in some parts fine-grained and compact, and other parts coarsely granular and crystalline. In many beds the cut surface of the compact rock, as seen in the cores, is marked with numerous small, round, shallow pits, from one to two-tenths of an inch in diameter, apparently formed by the dissolving-out of some subtance. These give the rock a worm-eaten aspect, which led the late Prof. Eaton to call similar beds, belonging to the same geological horizon in the State of New York, *vermicular lime-rock.* In other beds the surface of the cores is marked from the removal, by solution, of thin-bladed crystals, which has given rise to what appear like small gashes or incisions in the compact rock. These are sometimes half-an-inch in length, and occasionally intersect each other at right angles. Some portions of the rock are porous or cellular throughout, and in other parts the mass is made up of thin curved or waved laminæ, alternating of lighter and darker colours.

The compact vermicular rock was met with in several specimens from between 100 and 150 feet, that with thin-bladed crystals between 260 and 300 feet, and the finely laminated variety at 189 feet, while from this to 217 feet the specimens were coarsely granular, and often cellular. The chocolate-coloured bituminous beds were at from 320 to 351 feet. These various rocks scarcely effervesced with an acid, unless previously crushed to powder, and were evidently proper dolomites. Layers of a more calcareous rock, effervescing like a true limestone, were, however, detected between ninety-three and 102 feet, and between 181 and 183 feet.

Limestone with chert and dolomite.

Division III; from 357 to 633 feet. The separation of this from the divisions above and below was determined by the following reasons: The record of the boring between 351 and 357 feet gives "fossiliferous limestone," and two specimens of cores sent me from 357 and 360 feet, hold, imbedded in a grey dolomite paste, small white calcareous masses, which are very probably organic, inasmuch as organic remains of recognizable forms are found abundantly in the next 170 feet. Again, flint or chert was noticed in the boring at 379 feet, and abounded not only throughout the fossiliferous portions, but as far as 633 feet; from which lower limit up to 428 feet it was described in the record as a hard white and opaque rock. Below the partially calcareous stratum, noticed at 360 feet, varieties of dolomitic, compact, laminated, granular, and bituminous, resembling those found in Division II., were seen in six specimens to 374 feet, from between which point and 383 feet came two specimens of grey mottled carvernous limestone. Following these were dolomites, sometimes with more or less calcareous admixtures, in six specimens to 417 feet. In a specimen of grey crystalline dolomite from 402 feet were numerous cavities from two to five millimetres in diameter, left by the removal of stellate groups of bladed crystals. From between 417 and 428 feet were sent me two specimens of grey limestone, one holding a calcareous coral (*Favosites,*) and another a similar coral silicified, together with a portion of chert. Below this, at 438 feet, was a layer of cellular dolomite with crystals of carbonate of lime, after which, from 444 to 500 feet, were six specimens of grey fine-grained limestone, in three of which were corals, as before, in one case silicified. Between 500 and 509 feet was a layer of fine-grained dolomite, and between the latter and 528 feet gray limestone with corals. From between this point and 535 feet came a finely granular laminated dolomite, having white chert above and below, in immediate contact with it; while from 547 to 594 feet were two specimens of grey limestone, with patches and layers of white chert.

In this last interval, the rock just above 535 feet two inches is described as rather hard, and from thence to 547 feet 7 inches—probably on account of the hardness of the rock—the drilling was effected by a solid bit. From this point to 557 feet ten inches the annular drill was used, beyond which, to 573 feet ten inches, the solid bit was again had recourse to. There is thus, in this part of the boring, a little over twenty-eight feet from which no core was obtained. Between 594 and 633 feet were two specimens of dolomite, finely laminated and including chert, while the last portion, from 633 feet, was from a bed of white opaque chert or flint, said by the foreman to be the lower limit of this rock.

Dolomite with seams of gypsum.

Division IV.; from 633 to 876 feet. Of this division, the lower limit of which was marked by the marls of Division V, I had twenty-six specimens, all of which were dolomites, varying in colour from buff to light and dark grey. In texture they were finely or coarsely granular, or compact, and often thinly laminated. Near 726 and 745 feet, and again near 840 feet, were seen casts of thin-bladed crystals, like those noticed in Division II., which were either vertical or oblique to the stratification. In four specimens, from 726 to 803 feet, thin layers of gypsum, never more than half-an-inch in thickness, were interstratified in the dolomites. No mention is made of gypsum in the record of the boring, but it is probable that an inspection of the whole of the cores from this division might show more of this substance. From 780 to 834 feet the records describe the rock as intermixed with slate, none of which appears in the specimens sent me.

Variegated marls with dolomites.

Division V; from 876 to 997 feet. Of this division, the lower limit of which is the top of the first bed of rock-salt, the first sixty-six feet, or to 940 feet, are described in the record as "fire-clay slate," from their resemblance in texture to strata with which the borer had been familiar in the coal regions of Pennsylvania. From 894 feet the rock is said to have been salt to the taste, and below 940 feet crusts of salt formed on the cores in drying; so that this lower portion of the division is described in the record as "salt rock," with the exception of some harder layers, designated as "limestone." Of the first thirty-four feet I received four specimens, which are clayey rocks, best described as variegated marls. They are bluish-grey, dark-red, greenish, and nearly white, the colours being banded and mottled in their arrangement. Below 910 feet the whole of the cores were sent to me; they consist of marls, as before, including, at 922 feet, a layer of one foot six inches of granular dolomite. Below this, much of the marl was of a dark reddish-brown, and inclosed, to the base of the division, numerous beds of dolomite, which were porous or compact in texture, and often banded.

These marls are apparently intimate mixtures of clay with dolomite, and when tried, in a great many cases, with warm chlorhydric acid, never failed to effervesce freely. Similar rocks from the same geological horizon, near Brantford, in Ontario, were examined by me many years since. One of them, a green crumbling marl, contained 45 per cent., and another, darker and more compact, 75 per cent. of dolomite: the remainder, in both cases, being a clay. Some of these dolomite marls are well adapted to the manufacture of hydraulic cements.*

Rock-salt, 1st bed.

Division VI., from 897 feet to 1,027 feet 11 inches; being the first bed of rock-salt. Until reaching this the drill had been supplied with water, which was now replaced by a brine, made fully saturated for the purpose, by the use of which the solution of the salt in the boring was prevented, and cores of it were obtained. The first two and a-half feet of this division were, however, extracted, while fresh water was still employed, and showed a solid grey, finely granular dolomite, from which masses of rock-salt, presenting no regular forms, and amounting to perhaps one-third of the bulk, had been dissolved. To this succeeded seven feet eleven inches of salt, holding a small proportion of earthy matter, and including layers of dolomite; then three feet nine inches of porous dolomite, with some marl, holding irregular masses of salt, as before, and finally sixteen feet nine inches of salt, in parts colourless and transparent, and in part stained by earthly impurities, and including layers of fine-grained dolomite; the whole making for this division, composed chiefly of rock-salt, a thickness of thirty feet eleven inches. This stratum, as displayed in the boring, is not pure enough for mining.

Dolomite with marls toward the base.

Division VII; From 1,027 feet 11 inches to 1,060 feet. The upper four feet of this division consist of a grey dolomite, often finely laminated, with disseminated masses of salt, followed by a grey, porous dolomite, holding salt in frequent veins or transverse seams, to 1,052 feet. The remaining eight feet of the division consists of a marl, resembling those described above.

Rock-salt, 2nd bed.

Division VIII; From 1,060 feet to 1,085½ feet. This, the second bed or rock-salt, has, at the top, nine inches of perfectly colourless and transparent salt, to which succeed six feet nine inches of salt mixed with some rocky matter; then seven feet one inch of salt with very little stain or discolouration, followed by ten feet nine inches of pure white crystal-

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* See Geology of Canada, 1863, pp. 625, 807.

line salt, inclosing a layer of dolomite one inch in thickness, near the base. The whole of this division, measuring twenty-five feet four inches, is fit for mining, and in some parts, as will be shown, is of remarkable purity.

Dolomite.

Division IX; From 1,085 feet 4 inches to 1,092 feet 2 inches. This bed, of six feet two inches, consists of dolomite, holding salt both in interstratified layers and in thin vertical seams.

Rock-salt, 3rd bed.

Division X; From 1,092 feet 2 inches to 1,127 feet, makes the third bed of rock-salt, thirty-four feet ten inches in thickness, and consists throughout of solid salt, with a very small proportion of impurities, which give it a slight shade of colour. With a little sorting it might probably be used for all ordinary purposes, It should here be remarked that of the lower five feet five inches of core from this bed, only about one-half was received.

Marls, dolomite and anhydrite.

Division XI; From 1,127 feet to 1,207 feet 7 inches. This portion, of eighty feet seven inches, consists, for the first forty-three feet, of grey marls, inclosing much red salt in layers and in vertical veins, and including, moreover, numerous thin, dolomitic beds. Below 1,170 feet there is found, for a distance of four feet, granular dolomite, with several layers of greyish-white, translucent anhydrite, each about an inch in thickness, followed by porous dolomite beds, with some marls, the whole inclosing vertical veins of rock-salt, which are reddish in colour and fibrous in structure, the fibres being transverse to the sides of the veins.

Rock-salt, 4th bed.

Division XII; From 1,207 feet 7 inches to 1,223 feet. This is the fourth bed of rock-salt, from which, as appears from the record, only the upper two feet and the lower two feet nine inches of cores were preserved. Of these the former was somewhat impure and the latter was a white salt, including thin layers of dolomite.

Dolomite and anhydrite.

Division XIII; From 1,223 to 1,230 feet. This division of seven feet consists, at the top, of one foot of porous dolomite, followed by two feet of granular anhydrite, holding irregular masses and grains of salt, beneath which are four feet of dolomite and marl.

The anhydrite, or anhydrous sulphate of lime, from this division, resembled closely that found in Divisions XI., XV. and XVII. It was finely granular, crystalline, very tough, bluish-grey in colour, and subtranslucent. A specimen free from included salt had a specific gravity of 2·90, and lost by ignition only ·62 per cent. of its weight.*

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* This anhydrite, when placed in fresh water or in saturated brine at ordinary temperatures, gradually becomes hydrated from the surface inwards, and changes into gypsum. It is worthy of enquiry whether the mechanical effect of great pressure may not serve to explain the existence of anhydrous rather than hydrated sulphate of lime in deep-seated deposits, and the conversion of the latter into anhydrite.

Rock-salt, 5th bed.

Division XIV; From 1,230 to 1,243½ feet is the fifth bed of rock-salt, measuring thirteen and a-half feet. Of this core, by an accident, the greater part was dissolved in the bore-hole, but five and a-half feet, from above 1,241 feet, are preserved, and are impure salt, though clear and white in portions.

Marls with anhydrite.

Division XV; From 1,243½ to 1,379 feet. From this division of 135½ feet only 109⅓ feet of cores were preserved. They consisted of red, bluish and greenish marls, banded and variegated, holding throughout layers of reddish salt of from a few inches to a foot, and at about 1,300 feet, from one to two feet in thickness, Below this are several thin layers of bluish anhydrite, followed by soft exfoliating marls, chiefly reddish in colour. No beds of hard dolomite were found in this division.

Rock-salt, 6th bed.

Division XVI; From 1,379 to 1,385 feet. This, which is the sixth bed of rock-salt, measures six feet, and is pure white and translucent.

Marls with dolomite and anhydrite.

Division XVII; From 1,385 to 1,517 feet. This division, extending to the bottom of the boring, was exceedingly soft, so that, from the 132 feet, only twenty-eight feet three inches of cores were preserved. At the top were six feet of porous dolomite, holding layers of from two to four inches of bluish anhydrite. The portions preserved from below this consisted of soft exfoliating, variegated marls, chiefly greenish and greyish in colour. The ten feet at the base, however, consisted of a dark-grey dolomitic rock, somewhat harder, but crumbling, and exhibited cavities from the dissolving-out of salt. These lower portions also included thin layers of anhydrite. The boring at this point was abandoned, because it was considered that no practical good results were to be expected from its continuance.

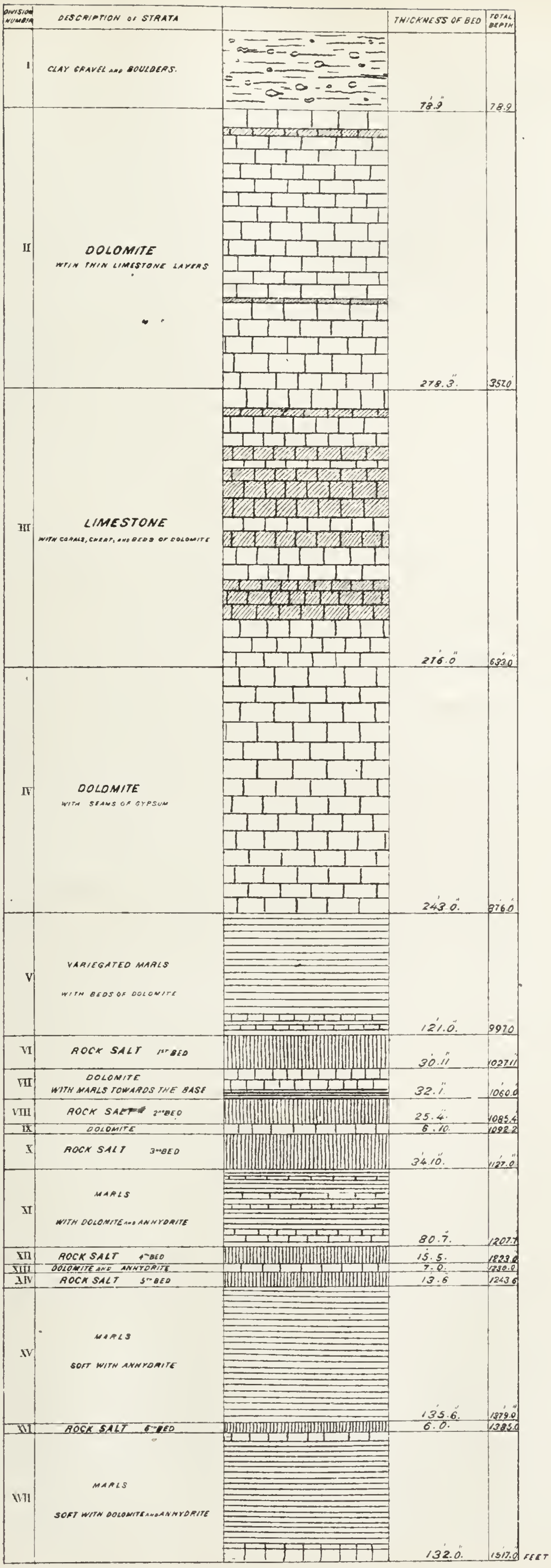
Total thickness of salt.

The above-described section shows, in the 520 feet of strata below the top of the first salt bed, six layers of rock-salt, measuring in all 126 feet, without counting the considerable amount of salt present in thin layers, and in veins, throughout the rocks.

Purity of the rock-salt.

These beds of rock-salt, as we have seen, are not alike in purity. The first is scarcely suitable for mining, while the second is remarkably pure, and the third approaches it in this respect. The latter two beds, which measure together over sixty feet, are separted from each other by a layer of less than seven feet of rock, and for practical purposes may be regarded as one great workable mass of rock-salt. It was desirable to determine the composition of this salt, and especially of the purely white and translucent portion of the second bed (Division VIII), measuring, as has been shown above, ten and three-quarters feet. The quality of this portion, as seen in the cores, was apparently uniform, but in order to

PLATE XI.



DIVISION NUMBER	DESCRIPTION of STRATA	THICKNESS OF BED	TOTAL DEPTH
I	CLAY GRAVEL and BOULDERS.	78.9	78.9
II	DOLOMITE WITH THIN LIMESTONE LAYERS	278.3.	352.0
III	LIMESTONE WITH CORALS, CHERT, and BEDS OF DOLOMITE	276.0	633.0
IV	DOLOMITE WITH SEAMS OF GYPSUM	243.0.	876.0
V	VARIEGATED MARLS WITH BEDS OF DOLOMITE	121.0.	997.0
VI	ROCK SALT 1ST BED	30.11	1027.11
VII	DOLOMITE WITH MARLS TOWARDS THE BASE	32.1.	1060.0
VIII	ROCK SALT 2ND BED	25.4.	1085.4
IX	DOLOMITE	6.10.	1092.2
X	ROCK SALT 3RD BED	34.10.	1127.0
XI	MARLS WITH DOLOMITE and ANHYDRITE	80.7.	1207.7
XII	ROCK SALT 4TH BED	15.5.	1223.0
XIII	DOLOMITE AND ANHYDRITE	7.0.	1230.0
XIV	ROCK SALT 5TH BED	13.6	1243.6
XV	MARLS SOFT WITH ANHYDRITE	135.6.	1379.0
XVI	ROCK SALT 6TH BED	6.0.	1385.0
XVII	MARLS SOFT WITH DOLOMITE and ANHYDRITE	132.0.	1517.0 FEET

DIAGRAM OF STRATA MET WITH IN MR ATTRILL'S BORING, GODERICH.

insure an average of the mass, portions of equal size were broken from each foot of the core, and the ten specimens thus got were crushed up together, to get a sample for analysis. This was chemically examined under my supervision, by Mr. Gould, the determinations being made in duplicate, and found to agree very closely. The results were as follows, the chloride of sodium being determined by difference :—

Analysis of colourless rock-salt.

Chloride of sodium	99·687
Chloride of calcium	·032
Chloride of magnesium	·095
Sulphate of lime	·090
Insoluble in water	·017
Moisture	·079
	100·000

Comparison with other salts.

From the above analysis it appears that, deducting the adherent moisture, the amount of foreign matters in this salt is 0·234, or less than a-quarter of one per cent. Its remarkable purity will appear when this result is compared with the analyses of the best commercial salts, the impurities of which are essentially of the same kind. In the case of the rock-salt of Cheshire, in England, I copy from a report printed by the British House of Commons in 1873, an analysis of "Crushed Marston rock-salt," made by Dr. Grace Calvert for Messrs. Fletcher & Rigby, as follows: Chloride of sodium, 96·70; chloride of calcium, ·68; chlorides of magnesium and potassium, traces; sulphate of lime, ·25; insoluble matters, 1·74; moisture, ·63 = 100.00. This gives of foreign matters, deducting the moisture, 2·67 per cent., or more than eleven times as much as the Goderich rock-salt. Another analysis of Cheshire rock-salt, cited by Watts in his Dictionary of Chemistry, gives 1·70 per cent., and one of the famous rock-salt of Cardona, in Spain, 1·45 per cent. of foreign matters.

Comparison with salts from brines.

The salts got by evaporation from sea-water and from brines, with which our markets are in great part supplied, contain nearly as much impurity. From data gathered by me, and published some years since in a report of the Geological Survey of Canada, already referred to, it appears that the amount of foreign matters in Turk's Island salt is 2·34; in Saginaw salt, 2·00; in Syracuse solar salt, 1·15; and in the boiled salt from the same locality, about 1·50 per cent. Of the salt made at Goderich from the brines pumped from the salt-bearing strata of the region, three samples, analysed by me in 1871, gave for coarsely crystalline salt, 1·097; flaky medium salt, 1·282; and fine salt, 1·625 per cent. of foreign impurities. The fine salt, which is the least pure, is made by boiling, the others by slower evaporation. The analysis by Dr. Goessmann of another sample of Goderich boiled salt gave 1·50; while the rock-salt from the layer of ten and three-quarters feet in Division VIII. of the section, as we have seen, contains only 0·234 per cent., or less than one-sixth of the amount of foreign matter found in the boiled salt made from the Goderich brines.

Nature of impurity.

A considerable portion of the impurities in the commercial salts which we have thus compared with the Goderich rock-salt, consists, it is true, of sulphate of lime (gypsum), which is not actively injurious; but the brines of Saginaw and Syracuse, and, to a less extent, those of Goderich, contain (as I have shown at length in the report of 1869, already quoted), chlorides of calcium and magnesium, which, in the ordinary methods of salt-making, accumulate in the pans or kettles, and give to the salt very objectionable qualities, unless they are removed by chemical processes, as is done in the superior quality of dairy-salt made at Syracuse.

Less pure salt from 2nd bed.

The less pure salt, which overlies the pure white layer in the second bed, was examined, like the preceding, by taking small portions from each foot of the core, and making from them an average sample. It was analyzed, as before, with the following results: chloride of sodium, 91·24; chloride of calcium, ·57; chloride of magnesium, ·05; sulphate of lime, 2·81; insoluble in water, 5·33 = 100·00. The impurities, consisting of gypsum and marl, are very irregularly distributed through the layers; and it would appear, from an inspection of the cores, that by a proper selection it would be easy to get a large proportion of salt much purer than this, and probably equal to the Cheshire salt, of which the analysis has been given above. The same is true of the greater part of the third bed (Division X.) These great masses above and below the white salt would yield, in abundance, salt for agricultural and manufacturing purposes, and probably for the salting of provisions; while the layer of pure white salt, when ground, would give a product which for the dairy, and for table use, would be unequalled in purity and in beauty.

Examination for potash salts.

The saliferous strata of Stassfurth and Douglasshall, in Germany, and of some other regions, contain, as is well known, soluble salts of magnesia and of potash, which, in the localities named, have been found of great economic importance. A careful examination of the cores from the Goderich boring was accordingly made, in order to determine in these the presence or absence of such compounds. Samples were taken not only of the solid salt of the various salt-beds, but of that found in veins and thin layers, or disseminated throughout the saliferous strata.

The following is a description of these samples from the various divisions of the section :—

Specimens selected for examination.

Division V; marls; saline efflorescence on the core; from 983 feet.

Division VI; first bed of salt; glassy salt, 1,000 feet; granular salt, 1,026½ feet.

Division VII; dolomite and marl; white granular salt in vein, 1,031 feet; red fibrous, at 1,057 feet.

Division VIII; second bed of salt; dark-coloured glassy salt, 1,085 feet.

Division X; third bed of salt; white glassy, 1,092½ feet; white opaque, 1,095 feet; white transparent, 1,100 feet; white, with marl, 1,116½ feet; reddish, 1,121 feet.

Division XI; marls, etc.; reddish salt in marl, 1,127 feet; reddish, irregular lumps in marl, 1,134 feet; white granular in marl, 1,142 feet; white, like the last, 1,152 feet; white, vertical, vein in dolomite, 1,178 feet; small grains in dark porous dolomite, 1,180 feet; grains, like the last, 1,183 feet; thin layers of dark-brown salt in porous dolomite, 1,192 feet; reddish salt in vertical seams in dolomite, 1,201 feet; reddish salt, as before, 1,205 feet.

Division XII; fourth bed of rock-salt; colourless and transparent salt, 1,208 feet.

Division XV; marls; red granular salt, 1,272 feet; red granular salt, 1,283 feet; red fibrous salt, 1,294 feet; red fibrous salt, 1,314 feet.

Division XVI.; marls, granular salt with anhydrite, 1,420 feet; white glassy, 1,500 feet; brine from 1,500 feet.

Traces only of potash present.

Of each of these specimens, twenty-eight in number (without counting the brine from the bottom,) there were taken a gramme or more, which was dissolved in a little water and examined for potassium, by the addition of platinum-chloride and alcohol, but in no case was there found an appreciable quantity of potash-salt, the soluble material being in every instance nearly pure chloride of sodium. The brine from 1,500 feet, tested in like manner, contained only traces of potash-salt, with small portions of the chlorides of calcium and magnesium.

Determination of specific gravity.

In calculating the results of mining rock-salt it is necessary to know its specific gravity, and upon this point there are found great discrepancies, the determinations by different observers worthy of confidence varying from 2·00 to over 2·25, so that Prof. Henry Wurtz has been led, from a comparison of a great number of observations, to conclude that these differences correspond to different degrees of chemical condensation. In the present case I sought to fix, with as great care as possible, the specific gravity of selected specimens of pure rock-salt from the white layers of the second bed (Division VIII.) of the Section. For this purpose freshly distilled oil of turpentine, having a specific gravity of 0·863, was used, and the determinations were made at 15° C. Two fragments of the transparent colourless salt, weighing, respectively, a little over four, and ten and a-half grammes, gave each a specific gravity of 2·172; a third fragment of about ten grammes, 2·168; and a fourth of nearly five grammes, 2·133. This last was imperfectly transparent, and was seen, under a small magnifying power, to contain numerous little cavities filled with brine, to which its lower specific gravity is to be ascribed. We may, I think, accept 2·172 as the density of the pure pellucid rock-salt of this bed; but for the purposes of calculation in mining, the lowest figure, or more conveniently 2·125, being two and one-eighth times the weight of water, may be safely assumed for the great mass of salt.

Yield per acre.

A layer of rock-salt, one foot in thickness, with a specific gravity of 2·125, will contain for each acre of superficies (4,840 square yards) 2,873 tons of 2,000 pounds, or 2,582 gross tons of 2,240 pounds; which gives for the layer of white salt ten and three-quarters feet thick, 27,751 gross tons, equal to 1,110,280 bushels (estimated at fifty-six pounds each) to the acre. As regards the loss in mining, from pillars left behind, etc., the average in coal-mining in England is estimated at twenty per cent., and as the finely broken salt is, unlike the coal, merchantable, the loss in mining solid undisturbed ground at Goderich should not exceed this. If then we suppose eighty per cent. of the salt from the white layer of ten and three-quarters feet, to be got in a merchantable shape, it will be equal, for each acre, to a little over 22,200 tons, or 880,000 bushels, so that the product from mining twenty acres of this layer of rock-salt would be equal to the entire salt-production of the United States in 1870.

Market for the salt.

It is scarcely necessary to enlarge upon the vast economic importance of such a salt-deposit as this, or upon its value to the industry and commerce of the country. In place of the comparatively laborious and costly process of manufacturing salt from brines, in a region remote from coal, where wood is yearly increasing in price, we have offered to the miner a deposit practically inexhaustible in extent and, in large part, of exceptional purity. While the finer qualities of salt may here be cheaply obtained for the supply of the vast and populous regions which are readily accessible by the great lakes, the opening of such mines would yield, at lower rates, salt somewhat less pure, which would be well adapted for the wants of the chemical manufacturer and the agriculturist.

Rock-salt known in North America before Goderich discoveries.

In conclusion, it remains to notice some points relating to the geology of this deposit, and to the occurrence of salt in North America. To the east of the Rocky Mountains, previous to its discovery at Goderich in 1866, rock-salt had been found only in two localities; one of these being at Petite Anse Island, near New Iberia, upon the Bayou Teche, in Western Louisiana, and the other at Saltville, Washington County, in Southwestern Virginia. This latter deposit, where rock-salt is associated with gypsum and marls, although situated in the midst of Palæozoic rocks, is, by Prof. Lesley, regarded as probably of Tertiary age, and as occupying a very limited basin. The sources of the brines in the salt-wells of the Ohio valley, and of Saginaw, in Michigan, are supposed to be near the base of the Carboniferous series; the Michigan salt group of Winchell being above the Devonian sandstones, but beneath the limestone which there underlies the coal measures. Rock salt has never, so far as I am aware, been detected in the borings at this geological horizon.

Distribution and thickness of Salina formation.

The saliferous formation of New York was called by Vanuxem the Onondaga salt group, but to prevent confusion with the Onondaga limestone (a sub-division of the overlying Upper Helderberg group,) the synonym of the Salina formation, from the town of Salina (named for its salt-works,) near Lake Onondaga, is to be preferred. The Salina formation has a position in the geological column in the upper part of the Silurian series. It rests conformably upon the magnesian limestone of the Niagara formation, and, in Western Ontario, upon a similar rock, which, although apparently an upward continuation of the Niagara, has, for palæontological reasons, been separated from it, and designated the Guelph formation. At its northern outcrop, in Montgomery County, New York, the Salina is only a few feet in thickness, but westward, along its northern outcrop, it rapidly augments in volume, and attains, in Wayne County, a volume of 700, and even in parts, it is said, of 1,000 feet. Where it crosses the Niagara River this thickness is reduced to less than 300, and in Ohio, according to Newberry, to less than twenty feet, while Winchell found in Northern Michigan only thirty-seven feet of strata representing the Salina formation. Here, however, the formation is characterized, as in New York and in Ontario, by the presence of gypsum. In its greater development, in New York, it consists, in the lower portion, of variegated red and green marls, overlaid by grey or drab dolomites and shales containing beds of gypsum, sometimes accompanied by native sulphur in small quantities. Crystalline plates of specular iron ore, as pointed out to me by Dr. Goessman, are also sometimes found in druses in the dolomites of this formation.

Water-lime and Helderberg formations.

Overlying the Salina formation are found the Water-lime beds, which are dolomites, like the underlying strata, and contain the remains of *Eurypterus* and some other crustaceans. This division, united with the Lower Helderberg by Vanuxem, is separated alike from it and from the Salina by Professor James Hall, who, however, shows that the Water-lime is more closely related to the Salina, from which it is not always easy to distinguish it. The Lower Helderberg, consisting, at its base, of dark-blue non-magnesian limestone, with tentaculites, succeeded by divisions characterized by pentameri, spirifers, and crinoids, indicates conditions of deposition which were very different from those of the two preceding periods, and did not extend further westward than the centre of the State of New York; beyond which the Lower Helderberg limestones are absent, and those of the Upper Helderberg rest directly on the Water-lime beds, sometimes with and sometimes without the interposition of a thin stratum of silicious rock, representing the Oriskany sandstone. This appears to have been spread over portions of Ontario, but to have been partially removed by erosion before the deposition of the succeeding limestones.

Of the extension of the Salina formation southward beneath the overlying strata, nothing is known until we reach Central Pennsylvania, where, immediately beneath the well-characterised Lower Helderberg (Lewiston) limestone, appears a series of thin-bedded, more or less argillaceous limestones, 580 feet thick, which have been referred to the Water-lime formation. These rest upon 375 feet of fossiliferous limestone and shales, which, in their turn, repose upon the strata of the Clinton formation. Mr. Ashburner, of the Second Geological Survey of Pennsylvania, to whose recently published valuable section we are indebted for these details, suggests that these 375 feet may "represent equally or conjointly" the Niagara and Salina formations of New York. (Trans. American Philosophical Society, February 16th, 1877,) It is clear that the conditions which give rise to the gypsiferous, saliferous, and non-fossiliferous beds of the Salina, did not extend to this region.

No rock-salt in New York.

No rock salt has as yet been discovered in the Salina formation in New York, which is nevertheless regarded as the source of the brines of Syracuse and its vicinity. Hopper-shaped cavities, supposed to be due to the removal, by solution, of crystals of salt, are, however, found in marls at the outcrop of this formation, both in New York and, further westward, in Ontario. It is not, perhaps, generally known that the

Brines at Syracuse from overlying gravels.

numerous salt-wells of the Syracuse region, though occurring along the outcrop of the Salina formation, do not peneterate into it, but are sunk in a deposit of stratified sand and gravel, which fills up a valley of erosion, measuring nearly four miles from north to south by two miles from east to west. The marls belonging to the base of the formation crop out to the northward, and are found in the various borings beneath the ancient gravel deposit, which is itself covered by thirty or forty feet of more recent loam or sand. The bottom of the basin is very irregular, the marls being met with at depths of from ninety to 180 feet in some parts, and at a depth of 382 feet in the middle of the basin, the greatest depth of which, according to Mr. Geddes, is not less than 414 feet below the surface-level of Onondaga Lake, and fifty feet below the level of the sea. (Trans. New York State Agricultural Society, 1859.)

Distribution of Salina and Water-lime groups in Ontario.

We have seen that the outcrop of the Salina formation, passing from New York, with a thickness estimated at less than 300 feet, crosses the Niagara River above the cataract, and enters the Province of Ontario, where its distribution has been carefully studied by Mr. Alexander Murray, of the Geological Survey of Canada. By reference to the geological map of Canada, on which the Water-lime beds are included with the Salina formation, and represented by the same colour, the series may be traced between the underlying Guelph and the overlying Upper Helderberg (Corniferous) formation, nearly westward from the Niagara River to Brantford, and thence north-north-west to Southhampton, at the mouth of the Saugeen River, on Lake Huron, a distance of about 180 miles. From this point its upper limit stretches southward along the lake for fifty miles, to Goderich, where the higher beds of the series disappear, being overlaid to the eastward by the limestone of the Upper Helderberg, Beneath the waters of the lake the outcrop of the Salina turns again to the northward, and reappears in the Duck Islands, south of the Grand Manitoulin, and at the Straits of Mackinac. The arrangement of the strata north and east of Goderich shows the existence of a shallow synclinal dying out to the southward, and inclosing a tongue of the overlying limestones. These, from Goderich, extend for a distance of about forty miles to the eastward, and about the same distance to the northward; Ainsleyville and Teeswater lying nearly in the centre of the synclinal, which is surrounded east, north and west by the Salina series.

Outcrop dissimilar to character in borings.

The belt of this series, of which we have thus traced the distribution, has a breadth, throughout the whole distance, varying from eight to sixteen miles, and includes in its upper part, beds having the character of the Water-lime, (affording in some places near Lake Erie, the characteristic *Eurypterus*) underlaid by dolomitic strata, with gypsum, which is mined in several localities. Some greenish marly beds are found, but nothing is seen corresponding to the great mass of variegated marls which appears at the base of this formation in Central New York, and in the Goderich borings; neither are there any brine-springs known along its outcrop. The whole thickness of these nearly horizontal strata, along the north-east border of the Upper Helderberg limestone, is probably not great, but north-westward, towards Lake Huron, there is evidently a rapid thickening, and a development of saliferous strata in the formation, as is shown in the vicinity of Goderich. The results of the borings at Teeswater, Ainsleyville, Carronbrook and Mitchell (already mentioned) prove, however, that the eastern limit of this development lies between these places and the lake shore. Much further exploration by borings would be necessary before it would be possible to determine whether the salt found further south, in Bosanquet, Warwick and Dawn, belongs to the same area as that of Goderich and its vicinity, or whether, like the salt of Syracuse, it occupies a separate saliferous basin at the same geological horizon as these.

Salina formation in Michigan.

In strata underlying the saliferous rocks already noticed as occurring at the base of the coal measures, there exists in Michigan another salt-bearing horizon which, it may be conjectured, belongs to the Salina formation. A well, bored to a depth of 1,198 feet, in Port Austin, Huron County, Michigan, on the western shore of Lake Huron, nearly opposite to Goderich, has yielded a strong, though somewhat impure brine, marking 88° of the salometer, which has been analysed by Dr. Goessmann. This boring is sunk in the Devonian (Portage and Chemung) sandstones of the region, between which and the Salina formation there intervene, on the Canadian shore of Lake Huron, about 400 feet of strata belonging to the Hamilton shales, and 200 feet of the Upper Helderberg limestones. It would appear that we have at Port Austin a considerable diminution in thickness either of the overlying formations or of the Salina formation itself. This latter supposition would agree with the greatly diminished thickness found by Professor Winchell for this formation at its outcrop near Mackinac, where it is reduced to less than forty feet. A further discussion of this subject will be found in my report already referred to (Geological Survey of Canada for 1869). Since that time

Rock-salt at Caseville.

rock-salt has been detected in Huron County, in a boring at Caseville, and further northward, in 1872, at a depth of 1,164 feet, in a boring begun in the same strata at Alpena, on Thunder Bay, sixty miles or more west of north from Huron County. These occurrences of rock-salt were made known by Professor Winchell in 1874, but details with regard to them are still wanting. The existence of brines in the counties of Macomb and Iosco, which have a geological position similar to those of Huron and Alpena, has also been announced.

Rock-salt at Bay City.

[Since these pages were in print, a paragraph (in April, 1877) in the *Inter-Ocean* journal, of Chicago, states that a well has lately been sunk at Bay City, on Saginaw Bay, in Michigan, with a view of ascertaining whether salt exists below the present brine-producing horizon of that region (which is that at the base of the coal measures), and that a stratum of "rock salt," 115 feet in thickness, has been reached at the great depth of 2,085 feet from the surface. This, it may be conjectured, belongs to the Salina formation.]

Divisions of Upper Helderberg in New York.

The Lower Helderberg rocks, seen overlying the Salina in Eastern New York, disappear entirely to the west of Onondaga County, and the Oriskany sandstone, regarded as constituting a division between these and the Upper Helderberg, is not found continuously to the west of Cayuga Lake; beyond which, except where isolated patches of the Oriskany intervene, the Water-lime beds are directly overlaid, throughout New York and Ontario, by the Upper Helderberg limestones. These, in New York are divided by Professor James Hall into a lower member, the Onondaga, described as a grey, sub-crystalline, coralline limestone, and an upper member, the Seneca or Corniferous, consisting of compact limestones, dark in colour, often bluish or blackish, containing few corals, and generally less fossiliferous than the lower, but abounding in chert or hornstone, which sometimes exceeds the limestone in amount.

Corniferous in Ontario.

In Ontario these divisions of the Upper Helderberg have not been clearly made out, partly for the reason that the strata are much concealed by clays, but the whole mass of limestone, from the Water-lime below to the over-lying Hamilton shales, has been included, on the geological map of Canada, under the name of Corniferous, and has a thickness estimated at about 200 feet. On the Maitland River, near the town of Goderich, is a section in which grey, coralline limestones, supposed to represent the base of the Upper Helderberg, repose, with the intervention of a few feet of yellowish sandstone, upon grey bituminous dolomites, which have been regarded as the summit of the Water-lime formation.* The distribution of the Upper Helderberg limestones to the north and east of this has already been described. It will be remem-

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* Geology of Canada, 1863, p. 377.

bered that at Clinton, thirteen miles southeast from Goderich, it was necessary to sink to 1,180 feet, or 216 feet deeper than at Goderich, before reaching the rock-salt. This may probably be taken as representing approximately the thickness of the overlying Corniferous limestone.

Underlying fossiliferous limestone proved by boring.

We now come to the consideration of an unexpected result of the examination of the cores from the Goderich boring; namely, the occurrence beneath 278 feet of beds, chiefly dolomite, which, according to the Geological Survey, underlie the Corniferous limestone of the region, of not less than 276 feet, chiefly of grey, non-magnesian, coralline limestone, abounding in chert, and seeming like a repetition of the Corniferous. Beneath this lower fossiliferous limestone, it will be noted, are dolomites with gypsum, succeeded by variegated marls, with an aggregate thickness of not less than 364 feet before reaching the saliferous strata, which latter have been penetrated 520 feet without reaching the underlying Guelph formation. Professor James Hall, who has kindly examined such specimens of the corals as I have obtained from this limestone (Division III. of the section) recognizes in them two species of *Favosites*, *F. Winchelli* and *F. Emmonsii*, together with a section of *Acervularia* or *Diphyphyllum.*

Fossils.

Hypothesis to account for appearance of limestone, etc.

It might be supposed that these corralline limestones of Division III. correspond to the Onondaga (the lower member of the Upper Helderberg,) and that the dolomites of Division II. are but a locally intercalated mass, separating this from the proper Corniferous—the superior member. These dolomites have, however, been supposed to be continuous with those which, near the shore of Lake Erie, hold the fossils of the Water-lime formation, and are there overlaid in part by the Oriskany sandstone, thus occupying a position inferior to the whole of the Upper Helderberg series. Moreover, there is not, as far as known, any interposed mass of coralline limestone along the belt of magnesian strata, believed to represent the Salina and Water-lime formations, which has been traced from Lake Erie to Lake Huron.

A second hypothesis may be suggested to explain this seeming anomaly. If we suppose that at the time when the saliferous and magnesian strata of the Salina and Water-lime formations were in course of deposition in cut-off basins, the outer ocean already contained the fauna of the Upper Helderberg time, we may admit that the intercalated mass of coralline limestone of Division III. was deposited by a temporary influx of the waters of the open sea into a part of the evaporating basin.

The existence of such a saliferous deposit as the Salina, and the great variations in its thickness over adjacent areas, point to local irregularities of surface, which render either one of the above hypotheses not antecedently improbable. In the first, we suppose an intercalation of of magnesian deposits in the midst of the non-magnesian coralline limestones of the Upper Helderberg series; and in the second, the interposition of a non-magnesian coralline limestone among the dolomites of the Salina and Water-lime series. Further observations will be required before it is possible to determine which one, if either, of these hypothesis is admissible. It is to be hoped that the mining operations projected for the working of the rock salt at Goderich may furnish more extended palæontological evidence, which will be eagerly sought for by geologists.

PROGRESS REPORT

OF

EXPLORATIONS AND SURVEYS MADE DURING THE YEARS 1875 AND 1876,

IN THE

COUNTIES OF RENFREW, PONTIAC AND OTTAWA,

TOGETHER WITH

ADDITIONAL NOTES

ON THE

IRON ORES, APATITE, AND PLUMBAGO DEPOSITS OF OTTAWA COUNTY.

BY

HENRY G. VENNOR, F.G.S.,

ADDRESSED TO

ALFRED R. C. SELWYN, F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Collection of specimens for Philadelphia.

SIR,—A considerable part of the year 1875 was devoted to the collection of specimens for the Centennial Exhibition at Philadelphia. The remainder of the season, however, was spent in active field-work, in continuation of that in 1874 in Lanark and Renfrew Counties. A note, appended to my Report for that year, explains that the accompanying map had been added to considerably since the manuscript was handed in, and consequently, "is somewhat in advance of the Report." The additions embody much of the work done in 1875, which will now be described in detail, and, therefore, this portion of the last map may be consulted in connection with the description of localities in the present report.

Map.

Field-work in 1876.

The season of 1876 was altogether spent in the counties of Pontiac and Ottawa, in the Province of Quebec; but the investigations carried on

Geological examination completed from Madoc to Desert River.

were on the extension of the same bands of rock, which have now been traced continuously from Madoc, and adjacent townships in Hastings County, to the neighbourhood of the Desert River, on the Gatineau; a total distance of close upon 140 miles. The results of these explorations may be given under the following headings:—

Divisions of report.

I. Completion of work in Renfrew County, with some general remarks on the Geological Structure of Eastern Ontario.

II. Investigations in Pontiac and Ottawa Counties, Quebec, with notes on some of the Important Economic Minerals.

III. The Apatite and Plumbago deposits of Hull, Buckingham, Templeton and Portland Townships, with a Map (four miles to one inch) showing the position of the more important of these.*

I.

COMPLETION OF WORK IN RENFREW COUNTY, WITH SOME GENERAL REMARKS ON THE GEOLOGICAL STRUCTURE OF EASTERN ONTARIO.

Difficulties respecting age of rocks.

Up to the close of the year 1874, the geological structure of the region that had been examined was exceedingly perplexing, and no very clear or definite conclusions could be arrived at from the mass of facts collected, respecting the true succession and ages of the groups of rocks relatively to those in the Laurentian system, which had already been worked out at Grenville and neighbourhood. That they were something far older than the oldest of the Silurian deposits was evident from the fact that these, from the Potsdam upwards, rested upon them horizontally and unconformably; but whether they were to be considered as Cambrian, Huronian or Laurentian, was a still undetermined question. During 1875, however, a clearer light began to dawn upon this intricate field, and before the season closed, sufficient facts were collected to afford a satisfactory clue for the unravelling of the geological structure of the whole region from Madoc on the west, to Portage du Fort on the Ottawa, to the eastward. Among the most important results arrived at during 1875 was the determining of the limits, in a northerly direction, of all crystalline limestones in Renfrew County, and the fixing of the points where these respectively crossed the Ottawa River, into the counties of Pontiac and Ottawa. In my last report † I hinted at the probability of a north-westward change in the strike of the rocks in the vicinity of Arnprior, which, if correct, would carry these not across but up the valley of the Ottawa,

Important conclusions reached during 1875.

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* This map is the only one now published.

† Report of Progress, 1874-75, pp. 126-144.

Run of Arnprior limestones.

Lanark and Ramsay limestones.

Silurian patches.

Limestone quarried for Government buildings.

and along the shore portions of Horton and Ross Townships, and thus render their connection with the great bands of limestone, in Ottawa County certainly more remote, or, perhaps, altogether preclude it. Commencing at Arnprior, I shall now proceed to describe the very intricate windings of these rocks before they finally pass from the Province of Ontario to the Quebec side of the Ottawa River. In the report last cited, the great Lanark and Ramsay band of limestone with its associated black hornblende-rocks (Group IV.) was described and mapped as disappearing under the Silurian rocks in the eastern portion of Ramsay Township. Comparing the last strike and dip obtained here with those at Arnprior, and from a study of the general characters of the limestone in both places, it appeared almost certain that it was continuous between these positions, though concealed by the overlying Silurian, and such proved to be the case. An examination of the townships of Fitzroy and Torbolton, bordering upon the Ottawa below Arnprior, revealed some breaks in the flat Silurian beds, in which the inferior crystalline rocks again became visible. By means of these isolated exposures, we were enabled to trace the Ramsay band of limestone northward through Fitzroy, to Fitzroy Harbour, on the Ottawa. Here it was found to be immensely developed, and had been extensively quarried for use in the construction of the Government buildings at Ottawa. In the same direction was also traced the first belt of red gneiss in succession, or that known in Ramsay as the "Wolf Cove" belt,* which, likewise, projects through the Silurian sandstones at many points between Ramsay and the Ottawa River. As will be seen from the map, the strike of the rocks on leaving Ramsay has changed from north-easterly to northerly, carrying them to Fitzroy Harbour, while at the harbour they further turn, first to the westward of north and then westward. The dips, likewise, corresponding to this flexure, are in succession to the S.E., E., N.E., and N. at various angles. In the last two directions the angle of dip becomes small, and in some localities the bedding is even nearly horizontal.

Limestones cross to the Quebec side of the Ottawa.

From Fitzroy the limestone extends across the Ottawa River, and occupies a portion of the shore of the township of Bristol, Que., at and contiguous to the point where the Pontiac Horse Railroad comes out to the steamboat wharf, and almost immediately opposite Arnprior. In Bristol, the limestone is overlain by a volume of dark hornblendic and red granitoid gneiss, with epidote; above, or in the upper portion of which

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* Report of Progress, 1874-5, p. 155.

Magnetic iron ore.

Character of ore.

Other iron ore horizons.

there occurs an horizon of magnetic iron ore. On this horizon are situated the openings known as the "Bristol Iron Mines," and it is important and interesting to note here that the position of these corresponds closely to that of the "Foley Mine" openings in Bathurst Township, in Lanark County, which are likewise towards the summit of a belt of gneiss underlain by crystalline limestone. The character of the ore is also alike in both positions; occurring in large and well-defined crystals, as well as in the form of crystalline masses more ordinarily met with. The apatite, however, which characterizes the Bathurst horizon, appears to be wanting in Bristol, or, at any rate, has not yet been discovered. We thus feel pretty confident that the Fitzroy, Ramsay, and Lanark exposures of limestone are all parts of one band, and consequently should expect to find above this, as we eventually did in Bristol, a sequence of rocks corresponding to that in Bathurst and South Sherbrooke, in which some three or more horizons of iron ore might be expected to occur.

Bristol limestone.

Great spread of limestone through undulations.

Iron ores in Torbolton and Fitzroy on two horizons.

Magnetite in crystals.

The limestone along the Bristol shore of the Ottawa, is coarsely banded with darker and lighter layers. It dips to the northward, at an angle of from 15° to 20°, and clearly runs under the gneiss already alluded to. Consequently the trough form, assigned to the south-westward extension of the same band in the section accompanying my map and report for 1874-75, in Ramsay, Lanark and Dalhousie Townships, is, probably, incorrect, and its great spread in these townships may simply be ascribed to frequent repetitions of it in superficial but sharp and often overturned undulations. This is an important point, as if not a trough, this great band of limestone must be very low down in the series; in fact, almost at the base of the limestone-bearing portion of the Laurentian system. It should also be stated here, that magnetic iron ores are of frequent occurrence between the townships of Bristol and Ramsay, namely, in Torbolton and Fitzroy, and that though they occur for the greater part as straggling deposits in the run of a belt of gneiss, largely concealed by the Silurian sandstones, still there are sufficient exposures to indicate the existence of two or more horizons of ore. They are, undoubtedly, an extension of those heretofore traced through South Sherbrooke and Bathurst. The "Foley Mine" horizon in particular was clearly identified in Fitzroy, on the third lot of the twelfth concession, where an opening was at one time made on a mass of magnetic iron ore, of which a large part was in the form of distinct crystals.

Towards the centre of the front of Bristol the upper margin of the limestone is again crowded into the Ottawa valley by the overlying gneiss, which continues to occupy the shore for some distance. Towards Bristol Landing, however, further north-westward, the limestone again comes in, and occupies the whole remaining shore of Bristol Township, as well as one-third of Clarendon; the strike being here clearly to the north and south, and the dip almost vertical, but decidedly to the eastward. The whole valley of the river along the front of Bristol, and on the opposite side along the McNab shore, is occupied by the same banded limestones, and it is evident that in this direction their spread is something extraordinary. At and around Arnprior they are immensely developed, and lie at all angles from nearly vertical to horizontal. At this point an outlier of the Calciferous formation comes in, and extends in a long, narrow strip along the Ottawa shore through the whole of McNab, concealing much of the inferior crystalline rocks in this direction.

Great spread of limestones along the Ottawa valley.

Outlier of Calciferous.

(A.) *The McNab and Madawaska Trough.*

McNab and Madawaska trough of limestones.

A few days work around Arnprior, revealed the existence of a great synclinal of the limestones, extending westward up the general course of the Madawaska River, through McNab Township towards Burnstown, a little settlement and post office, some twelve miles up the river. Towards the centre of this township the limestone trough is upwards of six miles across in a north and south direction, and the bands or beds lie in a nearly horizontal attitude. No gneiss overlies the limestone here, and it is evident that it either does not cross the Ottawa River, or that if so, it merely touches upon the Arnprior shore. In this McNab trough, then, we simply have an estuary-like extension of the lower portion of this band of limestone on to the gneiss area, while its front or upper portion clearly continues along the Ottawa valley. Leaving this, however, for the present, we will proceed to follow its estuary-like extension, westward in its windings through the Ontario gneiss area.

Absence of gneiss in trough.

Map.

The spread of the limestones in McNab Township is clearly shown on the map accompanying the present report, to which, and to that also accompanying the report for 1874-75, I would now refer. These maps show that the McNab trough bifurcates toward the line of Bagot Township, and is thence separated into a northern and southern trough. The northern trough, considerably narrowed and occupied almost entirely by the massive and slaty black hornblende-rock which immediately underlie the limestones, follows the course of the Madawaska through Bagot to Calabogie Lake in Blythfield, and thence runs southward through Blythfield into Levant. The southern one passes to the south of White Lake, in Pakenham, and thence traverses the rear portion of

Bifurcation of limestones.

Darling, enters and runs southward through the south-eastern quarter of Levant. The mass of red gneiss seen between these troughs in Bagot and Levant was for a time somewhat of a puzzle. It first comes in abruptly at the eastern extremity of White Lake, and clearly alters the course of what are considered to be the overlying rocks. It occupies an extensive and broken area north of this lake in Bagot, and between it and the Madawaska River, but on leaving Bagot extends as a lengthened and comparatively narrow strip southward through Levant, and constitutes "Joe's Mountain" and the gneiss area around Robinson's Lake. Its course, from White Lake eastward, could not be made out, owing to the low and covered condition of the country along the valley of the creek from this lake to the Ottawa, but there are indications of a corresponding axis of elevation along the course of this stream and to the southward of it. This gneiss area, north of White Lake, in Bagot, was for some time regarded as the coming in of the overlying Bristol gneiss, and to establish this point, the iron ore horizon which should accompany it was carefully sought for, but without success; nor did the lithological characters of the gneiss in these two positions appear to correspond. Further on, following the Bagot gneiss southward through Levant and south-westward through Palmerston, it was found to be clearly connected with a great anticlinal axis of red gneiss, described in previous reports as occupying the south portions of Palmerston, Clarendon and Barrie, and north portions of Kenebec, Olden and Oso Townships. Thus I was led to conclude that the McNab limestone trough branched precisely as shown in the map. We may now proceed to give some further details respecting each of these troughs.

Levant trough.

Elevation of red gneiss separates limestone troughs.

Great anticlinal of gneiss.

The Northern Trough.

In tracing the northern trough through Bagot to Calabogie Lake, the limestone soon disappeared, and the immediately underlying black hornblendic slates and mica-schists came in in very great volume. This was clearly owing to these last rocks being sharply folded over upon themselves in a U shape, in which the limestones were pinched out. Immediately to the northward of this trough, the remaining part of Bagot is occupied by great rolling hills of gneiss, which form an elevated range of country westward to the western end of Calabogie Lake, in Blythfield, and which thence continue to mark out the western outline of the trough, south-eastward and again south-westward, through this and Levant Township respectively. Before arriving at the eastern end of Calabogie Lake the northern margin

Northern limestone trough.

Hills of gneiss.

Great development of slates and schists.

of the trough becomes deflected, and the slates and schists are largely displayed. The dip of these here is, in most instances, very slight, varying from about $< 20°$ to horizontal, or very nearly so. The southern margin, on the other hand, retains its almost vertical attitude, and in places even shows a slightly overturned dip. Thus, in tracing out these margins respectively, and while even carefully observing the general dip, the structure would not readily be regarded as a synclinal one, were it not shown to be so by more extended and detailed exploration. Where the schists are thus spread out in Bagot, their resemblance to the silvery-white mica schists of Levant* is striking. Interstratified with these are ferruginous dolomites abounding in tremolite, and some bands of crystalline limestone; these, however, are of secondary importance to the greater mass of black hornblende-slates, and glistening mica-schists. Entering Calabogie Lake these rocks, in their distribution, conform to the shape of the lake, and their northern and western outlines are well marked by the bordering gneiss hills. Along the shores the dip is very slight, and towards the immediate outlet of the lake (the Madawaska) the strata are nearly horizontal. The southern shore, through a portion of Bagot, and all the way through Blythfield towards the "High Falls" on the Madawaska, is occupied by an escarpment of black hornblende-slate, in which are interstratified several bands of brown-weathering tremolitic dolomite of very rough exterior—these last strongly resembling the dark-weathering tremolitic dolomites of Lanark and Ramsay Townships.

Silvery mica-schists.

Tremolite.

Horizontal strata.

"High Falls.

Overlying these rocks, and coming close up to the shore of Calabogie Lake, on both sides of the town line between Bagot and Blythfield, there occurs a large patch of horizontal Silurian sandstones, and some limestones, which again are covered by a deep drift of yellow sand. The exact outline of this patch could not clearly be made out, but an attempt has been made to represent it on one of the maps which accompany this report. This Silurian outlier was probably at one time continuously connected with the sandstones and dolomites (also Silurian) of Arnprior and Fitzroy, from which they have since been separated by extensive denudation. It certainly never had any connection with any mass of Silurian to the southward of Calabogie Lake, for in this direction the nearest lower palæozoic rocks occur in Drummond Township, some thirty miles distant, and these are of Potsdam age; while at Calabogie Lake, Arnprior, and Fitzroy, the rocks are chiefly Calciferous. Besides this,

Silurian sandstones.

Denudation.

Potsdam.

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* Group I., Report of Progress, 1874-75.

Silurian sandstones in synclinal of crystalline limestones.

at Arnprior we clearly see the sandstones extending for some distance up in the synclinal hollow of the crystalline limestones along the valley of the Madawaska, which would appear to have afforded some protection from the effects of the surrounding denudation. A similar feature, as we shall afterwards see, is observed on the course of the Bonnechere River to the northward of the Madawaska, where there occurs another synclinal of the banded limestone and hornblende-slates and schists, and in this, patches of Silurian run up from the Ottawa River Valley for some distance into the interior of the country. The land on the northern side of Calabogie Lake is very flat for some distance from the waters' edge, and here there are further indications of Silurian rocks, but beyond this the gneiss rises in a bold and barren range of hills. These run for a short distance in a north-westerly direction, then suddenly take a southerly course to the western end of the same lake, and form a high ridge along its whole western shore; and crossing the Madawaska, give rise to the leap of water so well known as the "High Falls." These Falls—for there are several—are the most picturesque I have yet met with in the whole region examined, and were it not for their very inaccessible position, could not fail to invite the attention of tourists. The lake, also, into which the waters fall, is very beautiful. It is about three and a-half miles in length, by about two miles in breadth, and abounds with fish. Game also is abundant through the adjacent mountains. From the "High Falls" similar gneiss mountains pass south-eastward through Blythfield, and veering round through the north-western corner of Levant, join the gneiss mountains of Canonto and Miller Townships, which have been already described.* In the last named townships these mountains form the northern boundary of the Palmerston, Clarendon and Barrie synclinals (which are, undoubtedly an extension of the *Hastings series* from Madoc) and it has now been shown that the same gneiss hills in a similar manner border the black hornblende-slates, mica-schists and banded limestones of the McNab trough. It, therefore, necessarily, or, at any rate, naturally follows:—first, that this trough or depression is a continuous one all the way from Arnprior to Madoc; and secondly, that it is occupied by rocks of the same age, although these differ somewhat, but not irreconcilably, in their extension to the westward. To establish this very important point, I proceeded to examine, in detail, that portion of the trough or depression lying between Calabogie Lake, in Blythfield

Other traces of Silurian.

Cause of "High Falls."

Fish and game.

Gneiss mountains.

Hastings Series.

Continuous trough from Madoc to Arnprior.

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* Report of Progress, 1872-73, pp. 144, *et seq.*

and Palmerston, Clarendon and Barrie. I found that at the western extremity of this lake, the black hornblende-slate rocks, mica-schists and tremolitic dolomites, with some crystalline limestones, rounded with the gneiss abruptly, and with it running southward through the eastern portion of Blythfield and western part of Bagot. They rest upon the gneiss at a very slight angle, and indeed in many places are nearly horizontal. The dip in Blythfield is invariably to the eastward or south-eastward, but in Bagot, on what I take to be the opposite side of the trough, it is generally vertical or overturned. Blythfield is a rough wooded township with few roads and no navigable streams, and consequently nothing like a clear succession of rocks could be made out. But the black hornblende-slates and associated mica-schists were found everywhere between *two fixed outlines*, and there can be no doubt but that these are arranged in a synclinal form connected with that at Calabogie Lake, and hence with that in McNab, where the synclinal is apparent, and the succession of the rocks clear. It was further evident that in this trough the great body of the striped or banded limestones (*e. g.* as at Arnprior) were pinched out near Burnstown, on the Madawaska, by the sides of the trough coming together, and that these, so far as investigations had then gone, did not again appear either in Bagot or Blythfield. Consequently, in these townships there are only the lowest beds of the synclinal resting directly upon the red gneisses. Entering Levant, the township immediately abutting Blythfield to the southward, we at once came upon the mica-schists*, and subsequently the dolomites and slates,† the one being separated from the other, geographically, by about half-a-mile of country, and geologically by the volume of gneiss which has already been alluded to on page 249 of this report, as separating in this direction the two synclinals at present being followed. It is thus proved that in reality these two groups of rocks, though differing in many respects greatly from one another, are simply the extension of the two branches or bifurcation of the McNab synclinal, a fact which will be readily understood from an inspection of the map which accompanies this report. But the limestones and schists of the McNab synclinal have been shown to be nothing more than a repetition of the limestones and schists of Ramsay and Lanark or Group IV. (same report as before cited); therefore, it follows that Groups I., II. and IV. belong to the same series of rocks. Again, in Levant, further investigation showed that beneath the silvery mica-schists there is a

Blythfield a rough township.

Narrowing out of limestones.

Levant mica-slates and dolomites.

McNab limestones same as those of Ramsay and Lanark.

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* Group I., Report of Progress, 1874-75.

† Group II. of same Report.

Rocks beneath the Levant mica-schists.

great volume of heavy, dark-green and whitish-speckled hornblende-rock, with some bands of limestone and rust-coloured gneiss or schist, which are similar in every respect to much of the rock in the diorite and hornblende schist (Group III., report before cited) as represented in Dalhousie and Darling Townships. These, likewise, rest upon the red gneisses, with, however, here and there intercalations of a grey or greenish-grey hornblendic and strongly epidotic gneiss, and a band or two of white dolomitic limestone, abounding in serpentine, and with obscure trace of Eozoon. Now, it will be remembered that with this diorite and hornblende-schist, Group III., in Dalhousie and Darling, there had also been found an *epidotic syenite* or *diorite** and crystalline limestone abounding in serpentine, with forms resembling Eozoon.† Consequently the further probability was suggested, that Group III. formed the base of the whole series of rocks represented by Groups I. to VI. of the report already several times cited. Thus, the true position of the Levant silvery mica-schists is not far from the summit of the diorites and hornblende-schists (Group III.) and in close proximity to the base of the banded limestones and hornblende rocks, (Group IV.)

Eozoon.

Epidotic syenite.

Lowest rocks of whole series.

The Southern Trough.

Levant dolomites and slates.

The dolomites and slates (Group II.) in Levant occur, as has already been shown, to the southward of the mica-schists. They are, undoubtedly, on the southward extension of the southern trough or bifurcation of the McNab synclinal, and appear to be nothing more than another form of the mica schists and tremolitic domolites. On tracing them northward and eastward into Darling and Pakenham they were found to run roughly parallel to the mica-schists and hornblende-slates of Calabogie Lake and the Madawaska, their course being dependent upon the outline assumed by the intervening gneiss. Finally, between Pakenham and McNab they were seen to unite with the McNab synclinal, and to pass conformably under the banded and wavy limestones of the Madawaska and Arnprior.

From Levant, both mica-schists, dolomites and slates (the northern and southern troughs) run westward into Palmerston, where they become much spread out, and form a great undulating basin-like sheet through this and the adjacent townships of Clarendon and Barrie. But here they have been already traced and described. I must, however, direct attention to the narrowing of these rocks again upon leaving Barrie, at the

Clarendon and Barrie basin of rocks.

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* Report of Progress, 1874-75, p. 137.

† Same Report, p. 138.

Addington Road trough.

Addington Road, and in their extension through Kaladar.[*] Here again the lowermost diorites and hornblende-slates—which everywhere form the rim or margin of the troughs—approach from opposite sides and join one another. The dip becomes vertical and, strange to say, the rocks become of a decided greenish colour on their weathered surfaces; this colour prevailing alike through both the massive and slaty varieties. We thus have heavy masses of greenstone, and of what I have described[†] as diorite, slate and schist. The silvery-white mica-schists are also represented here, but in the altered form of fine, glazed, nacreous—in places, even talcose—slates, and these, in Kaladar, Elzevir and Madoc, hold interstratified layers of pebbles, and become conglomerate.[‡] Now these rocks represent Division B, and a part of C, of the *Hasting series*[§] which have been compared, by some investigators, to the Huronian, but which I have now shown are really only the westward extension of the diorites hornblende-schists and mica-slates of Lanark and Renfrew counties, or, in other words, of Groups I., II. and III.[||] But these last, as we have also shown, are simply a low portion of the gneiss and limestone series[¶] which has always been looked upon as typical Laurentian. Consequently, we are finally led to the important conclusion that the *Hastings series* is not, as it has up to the present been considered, the most recent, but rather the oldest portion of the great system of rocks we have been investigating from the year 1866 to 1875 inclusive. Further, it was clear that this great crystalline, gneiss and limestone series rested upon a still older gneiss series, in which no crystalline limestones had yet been discovered. This series is referred to as Division A in the Report of Progress, 1866-69, where, however, limestones are, incorrectly, mentioned as occurring in it. It occupies many hundreds of square miles between the St. Lawrence and Ottawa Rivers, and is the rock which may be said to form the back-bone of Eastern Ontario, and the nucleous around which have been deposited all succeeding formations. This, then, is undoubtedly Archæan and Lower Laurentian, and consquently the crystalline limestones and gneisses constitute a series which would come in beneath Sir W. E. Logan's Upper Laurentian or Labradorite series. As regards the existence of this latter as a distinct formation, however, I entertain grave doubts, and for reasons which will be mentioned further on in the course of this report.

Change of colour in rocks.

Identity of rocks with some of the Hastings series.

Hastings rocks low down in series.

Red gneiss without crystalline limestone.

Doubts respecting the Upper Laurentian as a distinct formation.

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[*] See Report of Progress, 1872-73, p. 150, *et seq.*

[†] Report last cited.

[‡] See same report.

[§] Report of Progress, 1866-69, page 145.

[||] Report of Progress, 1874-75.

[¶] Groups IV., V. and VI. of Report of Progress, 1874-75.

Diorites and green slates in Kaladar.

In the second contraction or narrowing of the diorites and green slates in Kaladar (the first, as we have seen, occurring on the Madawaska, in Bagot and Blythfield) the dolomites and banded limestones become again pinched out, shortly after crossing the great Addington Road,* and are not again seen until we approach the neighbourhood of Bridgewater Village, in Elzevir. Here the margins of the trough again expand or diverge, the northern one striking in a north-westward direction through the eastern portion of Elzevir and western of Madoc, while the other and southern one tends south-westward to and along the northern shore of Hog Lake, to the southward of Madoc, as is clearly shown on the coloured geological map of the County of Hastings.† Now, it will be observed that no sooner do these margins of greenstone and green slate separate than the dolomites and grey micaceous limestones of Madoc and Tudor come in, in their respective basins, thus occupying precisely the geological position of the tremolitic dolomites and banded limestones of the Madawaska and Arnprior. And here I would direct special attention to the fact—the significance of which, however, will become more apparent in the subsequent part of this report—that in Tudor Township, immediately to the north of Madoc, there comes in, abruptly, a great mountain mass of a coarsely blotched and largely white-weathering diorite rock, which forms an almost complete barrier to waggon travel along the Hastings road in this direction. This is known as "The Hole in the Wall," ‡—a name probably suggested by the narrow and rocky defile through which this road passes over it. This mountain mass of rock separates the Tudor limestone basins, and for some time it was thought to represent an outlying portion of the Upper Laurentian or Labradorite series, which here rested unconformably upon the *Hastings' series*; for in the opinion of both Sir W. E. Logan and Dr. T. Sterry Hunt much of the rock partook of the general characters of this (Labradorite) series. Sir W. E. Logan, in a paper in the "Quarterly Journal of the Geological Society, for August, 1867," thus refers to it:— "Where it (the zone of grey micaceous limestone) thus spreads out in Tudor, it becomes suddenly interrupted for a considerable part of its breadth by an isolated mass of anorthosite rock, rising about 150 feet above the general plain, and supposed to belong to the unconformable Upper Laurentian, thus showing that the specimens of Eozoon of this neighbourhood, like those previously discovered and described, belong to the Lower Laurentian series" As, however, this mass of rock appeared

Map of Hastings County.

"Hole in Wall," Tudor.

Quotation from Sir W. E. Logan.

Eozoon.

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* See map, Report 1866-69.

† Report of Progress, 1866-69.

‡ See same Report.

to join both to the north-eastward and south-westward the diorites and green hornblende rocks of Division B., (Hastings' series), I did not feel justified in mapping it otherwise than as a portion of these rocks brought up on a transverse line of elevation across the limestone area; consequently, it was represented on the map by the same colour.* Subsequent investigations supported the correctness of this view, and showed that with the hornblendic and diorite rocks (Division B, and Group III.), beneath the synclinals of the limestones, there existed, in places at any rate, veritable grey, massive labradorites. To this important point, however, I shall again refer in this report, when facts will be brought forward proving, beyond question, the stratigraphical position of a mass of labradorite rock in the townships of Horton and Ross, on the Ottawa River.

Labradorite.

Recapitulation.—So far, then, we have been describing the westward extension of the Arnprior, McNab and Madawaska synclinal of rocks, and have seen that this trough is continuous all the way to Madoc and Tudor, in Hastings County, where it joins with the innumerable broad basins and narrow synclinals of the *Hastings series.* In other words, the wavy and banded limestones of Arnprior, and consequently of Ramsay, Lanark and Dalhousie Townships, are the same as the grey micaceous and but slightly altered limestones of Madoc and Tudor. The diorite and hornblende rocks, underlying the former, correspond to the massive greenstones, green slates and conglomerates (Division B, Hastings series) of Kaladar and Elzevir, and the silvery mica-schists of Levant, concerning which there has been so much discussion, are simply a portion of the same series. Therefore, the name of the *Hastings series* has no longer any significance unless it be retained to designate the slightly altered condition of the rocks in this particular county.

Recapitulation.

Hastings series a name no longer of any significance.

(*B.*) *The Horton, Ross and Bonnechere Trough.*

Concealment of inferior rocks.

As already described, the McNab and Madawaska trough of limestones and schists, towards the Ottawa, runs under and is concealed by an outlier of the Calciferous, and also, where this terminates, by extensive tracts of deep yellow sand. On crossing the river, however, a great volume of a similar limestone was met with in both Bristol and Clarendon, which undoubtedly is an extension of that in McNab. But being already aware of the existence of another large area of limestone further up the river,

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* Report of Progress, 1866-69.

in Horton township and along the Bonnechere River, I determined to continue my exploration on the Ontario side of the Ottawa, until the last of the crystalline limestones, in this apparently interminable series of troughs, should be reached. It was now clear that we were on one of the lowest of the limestone bands, and that wind as this might it must eventually cross the Ottawa, and start on its course towards one or other of those bands which had been already followed out in Grenville. I was not, however, prepared to find—as I afterwards did—another great limestone trough running back again into the great gneiss area of Ontario, and which obliged us to leave the shores of the Ottawa and journey for miles again in a westward direction; thus preventing us from doing much on the Quebec side of the river that season (1875).

Lowest band of limestone.

Between Arnprior and Castleford post office, at the mouth of the Bonnechere River, in Horton, the Silurian (Calciferous) skirts the Ottawa to the water's edge for at least two-thirds of the distance. Approaching the Bonnechere, clay and a deep drift of sand appear, concealing all rock. The Silurian appears to be confined to the Ontario side and a few islands in the river, and the opposite or Quebec shore is again Laurentian. Nor does the Silurian extend far to the westward. To ascertain this, a traverse was made from the shore of the river at Sand Point. Here, we first ascended a series of escarpments of flat rock, rising one above the other in the form of steps, to the height of from seventy-four to eighty feet from the water. The summit was then reached, and flat rock was crossed over for a distance of one and three-quarters or two miles. Here the escarpment abruptly terminated, and we descended to low, rolling, swampy land, through which are interspersed rounded knolls of flesh-red gneiss. Sand and clay also cover a large part of the country.

Silurian.

Drift.

Sand Point escarpments.

Sand and clay.

At and around the mouth of the Bonnechere the clay and sand is very deep, and continues so for a number of miles up the valley of this river, towards Renfrew. No flat rock was here seen in place, and it is my impression that the Silurian terminates shortly after passing the Horton township line. North of the Bonnechere, and on the road skirting the Ottawa shore, red gneiss was again observed cropping out in rounded knolls, and these appeared to extend in a westerly direction towards Renfrew. A short distance beyond Castleford post office, a road branches off from the Ottawa River road, and runs to Renfrew village. Immediately at this junction of roads, white crystalline limestone is again met with, striking to the westward, with distinct northerly dip. It rests upon a dark, whitish-speckled hornblendic gneiss, which again immediately overlies the red gneiss. Following the Renfrew road through Horton,

Red gneiss.

we for some distance kept upon the junction of the gneiss and limestone, and observed that the dip continued steady to the northward, and at an angle invariably high. Now, this dip being directly the opposite of that observed where the limestone was last seen in the McNab synclinal, it is clear that between the two outcrops there exists an anticlinal form of the underlying gneisses; and it is further probable, from the visible flattening of the gneiss hills towards the Ottawa, and from the indications all along the valley of this river, that the limestone forms a continuous outcrop from the one position to the other. A few traverses made in Horton soon revealed the existence of another great basin or synclinal of the crystalline limestone and associated rocks, running inland from the Ottawa valley, precisely as that at Arnprior, in McNab, had done; and it was evident that this extended for a considerable distance. The front of this great band of limestone, however—as in McNab—still retained its position in the valley of the Ottawa along the whole of Horton township. In examining the Horton and Bonnechere trough we first followed its southern margin. This commences with the limestones, already described as running along the road from Castleford post office to Renfrew village. These continue on a nearly due west course to within a short distance of Renfrew, when becoming suddenly deflected, they describe southward a U-shaped curve, which embraces the whole of this village. They then run for a short distance north-westward, and pass up through Admaston along the course of the Bonnechere River, their outline being clearly defined in this direction by a range of red gneiss hills, which also runs at a comparatively regular distance from the river. Beyond this point the limestones are lost sight of under the deep drift and Silurian outliers which occur along the valley of the Bonnechere, but their run in this direction is shown by isolated exposures, which were met with as far as Golden Lake, thirty miles up the river from Renfrew. Up to this point, also, the mountains of red gneiss form a continuous range all the way from Renfrew village, and were seen to continue in a west-north-west course beyond Golden Lake, and along the course of the river toward Round Lake, some twelve miles further up. Beyond Golden Lake, however, all traces of limestone disappear. The total distance from the Ottawa River, of the last exposure of limestone observed in the Bonnechere valley was about fifty-two miles. Between Golden and Round Lakes the whole country is occupied by gneiss, which appears to be in immense thickness, and on a traverse made from the first-named of these lakes to Brudenel post office, on the great Opiongo Road, gneiss was the only rock observed. Another range of gneiss hills or mountains runs

Anticlinal of gneiss.

Synclinal in Horton.

Rocks around Renfrew village.

Deep drift.

Golden Lake.

Round Lake.

Great spread of gneiss.

eastward from Round Lake towards Horton Township, along the northern side of the Bonnechere Valley. This forms the northern border or margin of the trough just described. These two ranges of hills—the northern and southern—diverge and converge in their run eastward to Horton, in some places being widely separated from one another, and in others approaching so closely that they may be almost said to connect. In one of these expansions Golden Lake is situated, and in another, Mud Lake, some miles further down the stream. The northern range reaches the Horton town-line at a point which is only about two miles distant from the outline or front of the southern range near Renfrew, and this may be said to be the average width of the intervening trough through Admaston. Beyond this position, in Horton, the northern margin of the trough becomes deflected to the northward, and forms a U-shaped curve, which corresponds to that at Renfrew village, on the opposite side of the trough. Thus, the rim or outline of the limestones is carried for a considerable distance into Ross Township, where again curving to the southward, it reaches the Ottawa, in proximity to the village of Portage du Fort. The widest part of this trough is, therefore, between the two opposing U-shaped curves just referred to, where a transverse measurement showed a total width of close upon eleven miles. Along the shore of the Ottawa crystalline limestone is largely displayed the whole way between the Portage du Fort bridge and Castleford post office, a distance of about seven miles, and this may be said to represent the mouth of the Horton and Bonnechere trough. At Portage du Fort, the northern margin of this trough, as represented by the lowest limestones, is clearly seen to cross the Ottawa, and start on a north-eastward course along the Calumet channel through Litchfield. In this direction these limestones reach the village of Bryson, some nine miles from Portage du Fort, where, after describing a very sharp V-shaped turn, they recross the Ottawa in a westerly direction, traversing the southern extremity of the Grand Calumet Island, and again enter Ross Township, at a point some four miles to the northward of Portage du Fort. Here they describe another U-shaped curve—this time to the westward—the extremity of which reaches Foresters' Falls in the ninth range of Ross, a point some two and a-half or three miles inland from the Ottawa. In this direction the margin of the limestones once more returns to the Ottawa (*Roche Fondu* Channel) in the neighbourhood of a creek, on the fourth lot of Ross, the mouth of which is situated about a mile and a-quarter from the line of Westmeath, and about nine and a-half miles from Portage du Fort. From this position the limestones cross on to the

Second range of gneiss hills.

Return of limestones to Ottawa River.

Limestones cross the Ottawa.

Return of limestones to Ontario side.

Grand Calumet.

Grand Calumet Island, and do not again return to the Ontario side. This singular and intricate winding of the margin of the trough, between Portage du Fort and the Grand Calumet Island, will be better understood from a study of the map in course of preparation, on which will be laid down the further course of the limestones, as investigated during 1876, and yet to be described. It will also be seen that this curve at Foresters' Falls is the last of these exposures of limestones on the Ontario side of the Ottawa.

Last exposure of limestones on Ontario side.

Having thus followed and described the general outline of this great synclinal of rocks through Horton, Ross and up the Bonnechere Valley, we may now give some further details respecting the rocks which occupy it, and the succession in which these occur. A glance at the map will show that in the great expanse of this trough in Horton and Ross, crystalline limestone is the most extensively developed rock. This, in its general character and relations, corresponds precisely with the limestone and hornblende rock (Group IV.) of Lanark County.* Overlying this, and towards the northern part of the Horton expanse, is an oval-shaped area of a very black hornblende rock which represents the summit of the synclinal form, or, in other words, the last rock deposited in it. This rock is in a position corresponding to the lowest portion of the gneiss and limestone (Group V., report just cited) of Lanark County, where a black hornblendic gneiss, in like manner, immediately succeeds the limestones. In Horton, however, this rock is not followed by the succeeding members of the group, but of itself occupies the whole area ascribed to it. But to this area we shall again shortly have to refer. About half way between the base of this black hornblende rock and the base of the crystalline limestones in Ross Township, and, indeed, everywhere around the basin, but at irregular distances in Horton, there occurs a zone of black hornblende-slate and mica-schist, much of which is of a strong rust-colour. This is clearly interstratified with the limestones, and separates them into two distinct volumes. Now, this is also precisely the case in Lanark, where, as has been described, † the great band of limestone is about equally divided by a belt of hornblende rocks, massive and schistose, which presents the four characters of rock described under the letters a, b, c and d. In Horton these subdivisions are also represented, with the addition of a grey massive labradorite, which clearly occurs in bands interstratified with the limestones. These labradorite rocks were traced continuously across Ross Township, on a course corresponding to the U-shapes

Horton and Ross trough.

Black hornblende rock.

Rust-coloured slates.

Labradorite.

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* Report of Progress, 1874-75.

† Report of Progress, 1874-75, p. 142.

of the limestones, and further were observed to be particularly well developed on the shore at the bend of the Ottawa, a short distance to the northward of the long bridge, connecting with Portage du Fort. From this position they strike into the river, but are again seen to occupy an area at the northern end of the large island, immediately opposite the place last named. Thence they follow the tortuous windings of the enclosing limestones, and run with these up the Calumet Channel of the Ottawa, and are lost sight of. In close association with these bands of labradorite rock, there almost invariably occur two or more belts of a very strongly rust-coloured schist or slate, which likewise are interstratified with the limestones. In the southern portion of the Horton trough, namely, on the Renfrew side, the labradorites were not observed, but the zone of hornblende-slate with which these are connected, as well as the strong rust-coloured bands of rock, are well defined. They are particularly well seen along the face and top of a hill known as "Pinnacle Hill," situated about one mile to the north-westward of Renfrew village. This hill rises abruptly to the height of 356 feet above the level of the Bonnechere, and it is entirely composed of alternations of the black hornblende-slate, rust-coloured bands, and crystalline limestones. Eastward of this point the country becomes covered by a heavy drift of sand, and the rocks are concealed along this horizon for some distance, but on approaching the road which skirts the shore of the Ottawa, and immediately to the north of the junction of roads alluded to on page 257 of this report, the rust-coloured slates again appear in considerable body, and are seen to strike due eastward, with northerly dip into the river. Westward from Horton, this zone of slates appears to terminate abruptly, and it is only natural to suppose they are completely pinched out in the narrowing of the trough through Admaston. Consequently, the limestones met with further westward along the valley of the Bonnechere must be regarded as representing the very lowest portion of these, or that which in Ross Township comes in beneath the slates and labradorites, and immediately at the summit of the red gneiss. Before leaving this horizon of black hornblende-slate and labradorite rock, I may state that a similar belt, and in a corresponding position, can be followed through the townships of Ramsay, Lanark and Dalhousie, and even still further to the south-westward. This is, perhaps, particularly well defined in the neighbourhood of Hopetown, in Lanark, and thence south-westward to the rear of Watson's Corners, in Dalhousie. In this section some of the bands are of the character of a coarsely-blotched diorite of which the feldspar is triclinic and closely

Course of labradorite bands.

"Pinnacle Hill."

Heavy drift.

Narrowing of trough.

Labradorites of Ramsay and Lanark.

Blotched diorite.

Labradorites and limestones interstratified.

related to labradorite; the rust-coloured zones are here likewise well represented, and both these and the former are clearly interstratified with the limestones.[*] Lastly, in this connection I would refer to the area of coarsely-blotched diorites in Tudor Township, in Hastings County, already briefly touched upon on a former page of this report. They are, undoubtedly, in the same stratigraphical position as those just described in Lanark and Renfrew Counties, but being here brought up on the crown of an anticlinal, in which the inferior volume of limestone does not come to the surface, it was some time before their relation was clearly understood. The limestones of Tudor, therefore, in which it will be remembered a remarkable form of Eozoon was found,[†] correspond to the upper portion of the Lanark and Horton limestones, or that immediately succeeding the black hornblende-slate and labradorite belt.

Identity of limestones in Tudor, Lanark and Horton.

But to return to the Horton and Ross trough. The upper volume of limestone is rendered peculiar by the curious forms of serpentine which it contains. These weather out in relief on the surfaces of the bands, and present the appearance of broken layers, cup and saucer shapes, circular concretions, and other forms difficult to describe. As a rule, the colour of the serpentine is grey and yellowish-grey, weathering white; but where the limestone has been exposed to the action of the water—as at, and a little below Portage du Fort, on the shore of the river—the enclosed fragments are of a brilliant red or orange colour on their surfaces, and where polished by the action of the water, might easily be mistaken for layers and lumps of jasper or yellow chert.[‡] In the lower portion of this band of limestone, almost immediately above the black hornblende-slates, there occur *eurites* or sandstones, quartzites, and some belts of a greenish pyroxenic rock, the whole of which are clearly interstratified; but these seldom exceed, in transverse measurement, two or two and a-half chains. Towards the summit again of this division of the limestone, there are frequent alternations of rust-coloured hornblende-rock (gneiss) and slate, these indicating the approach to the great mass of black hornblendic gneiss, or that already described as occupying the centre of the Horton trough. In this connection, and for the sake of comparison, I may again allude to the limestones of Group IV., in Lanark County. These, also, towards their upper portion hold interstratified heavy bands of rust-coloured slate rock—as, for example, along the northern side of Bennett's Lake, and north of the Fall River,

Serpentine.

Peculiar forms.

Eurites.

Rust-coloured slates.

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[*] Group IV., Report 1874-75.

[†] Report of Progress, 1866-69, p. 159.

[‡] This, on examination by Dr. Harrington, proved to be pyrallolite.

in South Sherbrooke—which are succeeded by a volume of very dark-weathering, hornblendic and thin-bedded red, granitic gneiss. Thus we have additional evidence of the identity of the limestones in these two positions. And further, we are led by this evidence to another important conclusion, namely, that in none of the troughs of rocks which occur to the northward of Lanark County, or between this county and Portage du Fort, in Litchfield, do we get much higher in the series than to the summit of Group IV.* and to the first of the subdivisions of the gneiss and limestone (Group V.) which immediately suceeds. What then becomes of the remaining subdivisions of Group V.? This question will be satisfactorily answered further on, when describing the progress of investigations during the year 1876, on the Quebec side of the Ottawa.

Thin-bedded gneisses.

I have, as yet, said little respecting the lowest subdivision of the Horton limestones, or that which immediately underlies the black hornblende-slate and labradorite zone. This clearly corresponds to subdivisions 1 and 2, of Group IV., in Lanark County.† Much of the rock is dolomitic, and abounds in tremolite and white quartz. It, however, but seldom presents that banded appearance so characteristic of the Lanark limestones, but in all other respects, including stratigraphical position, it is similar.

Quartzose and tremolitic dolomites.

Dolomite, tremolite and quartz, then, may be said to largely characterize the very lowest subdivision of the limestones in both Horton and Lanark. Now, this is precisely the case in Madoc, in Hastings County, where a compact drab dolomite, abounding in tremolite and quartz, is the base of the calcareous division of the Hastings' series of rocks; and further, these are here likewise separated from a second and upper volume of limestones by a subdivision of hornblende slate rock, precisely as we have just shown to be the case in Horton and Ross Townships. Thus, apart from the fact that the McNab synclinal—occupied by rocks corresponding to those in Horton and Ross—was traced continuously through into Madoc Township, we have additional evidence of the identity of the Hastings series in the close similarity of the sequence of rocks in two very widely separated positions.

Lowest division of limestones.

Madoc rocks.

Hastings series.

Thickness of the Limestone.

It now becomes an interesting point to endeavour to estimate, if possible, the thickness of this great band of limestone, inclusive of its

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* Report of Progress, 1874-75.

† Op. cit., pp. 141, 142.

central belt of hornblende-slate and labradorite rock. This was found to be an extremely difficult task; for in no place in these very long synclinals could I satisfy myself that it was not several times repeated. The thickness given to it in Lanark County was from 5,600 to 6,000 feet*, but there also the band was greatly plicated. Towards the close of 1875, however, I made a number of close and careful measurements in Ross Township, at the most favourable point the band presented for such measurement. This was in the Fifth Concession, and between Lots 19 and 23. Here, to the best of my belief, the bedding was quite regular, and there were no indications of repetition. The measurements were made at right angles to the strike, and from the summit of the gneiss which underlies the limestone to the base of the black hornblendic gneiss which immediately overlies it. To my surprise these resulted in still showing an average thickness of 5,600 feet. Immense, then, as this thickness may appear, it must be close upon the truth, unless, indeed, it can be proved that the identity of the figures, resulting from measurements made in two widely separated positions, is a mere coincidence.

Estimated thickness of limestone.

Rocks beneath the Limestones.

The sequence of rocks along the northern rim of the Horton and Ross trough is much clearer than that along the southern margin, the dip in the former position being very uniform to the southward, and there being no repetitions of the strata. Here, then, was afforded a favourable opportunity for studying the rocks which immediately underlie the great volume of limestones. By referring to the map it will be seen that underneath these is a body of gneiss which has a transverse measurement of about one mile, and a thickness estimated at close upon 3,500 feet. This gneiss clearly belongs to the series of rocks of the trough, and is quite distinct from the great fundamental gneiss system we have already several times alluded to in this report. This is underlain again by another calcareous division or group of rocks—the lowest I have yet met with—which consist of limestones, pyroxene rocks, granular quartz and orthoclase strata, with garnets and some bands of greyish and reddish gneiss. The limestones in this division are very different, both as to appearance and general lithological character, from the upper ones. They are often flesh-coloured, contain a great deal of silvery white and black mica in large scales, and graphite, and are generally coarsely

Thick volume of gneiss.

Lowest division of limestones.

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* Report of Progress, 1874-75, p. 143.

First appearance of apatite.

crystalline. Apatite also occurs in grains and crystals in some portions of them, and this is rather remarkable, for the true apatite-bearing limestones occur many hundreds of feet—at the lowest computation—above them. And a still more remarkable fact, is, that the granular quartz and orthoclase strata, with garnets and the greenish pyroxenic rock, are very similar to those met with in the apatite-bearing series. (*e.g.* as in North Burgess.) But this calcareous and pyroxenic division or group of rocks is, undoubtedly, low down in the series, while as certainly, the true apatite-bearing rocks are in its highest portion.

Lowest zone of limestones.

This *lowest* zone of limestones was traced continuously across Ross Township. Towards their lower portion they become very slightly inclined, and in places are nearly horizontal, but in this direction they are much concealed by a heavy drift of yellow sand, which covers a very large area, north-westward through Ross, Westmeath and Pembroke Townships.

Rocks concealed by sand.

It is evident, however, that these rocks rest immediately upon a great body of red gneiss, exposures of which were met with all the way across to Pembroke and the mouth of the Petewahweh River. In this gneiss no trace of limestone was observed, and I am confident there are no calcareous bands below this horizon.

Red gneiss region.

A further and more detailed examination of these limestones recalled strongly to my mind those observed at Golden Lake, in the Bonnechere Valley, and which at the time of their examination struck me as being unlike any I had heretofore met with. These were alluded to by Mr. Murray in his Report of Progress for the years 1853 to 1856, in which he writes as follows:—"Crystalline limestone was observed to extend along the eastern shore of Golden Lake, associated with coarsely crystalline beds or masses of flesh-red feldspathic rock, and a mixture becoming dark-green from the presence of pyroxene in very large quantity, with scapolite, graphite and mica disseminated."

Extract from Mr. Murray's report.

Now, this was the last calcareous exposure noted either by Mr. Murray or myself in the Bonnechere Valley, while beyond it, at Round Lake, and for miles around this lake, nothing but red gneiss was observed. The inference, then, seems clear, namely—that the Golden Lake limestones represent this lowest calcareous division of Ross Township, and that the upper, or Horton trough limestones, rapidly thin out in passing through Admaston, and probably terminate somewhere in the neighbourhood of Mud Lake.

Golden Lake limestones.

A singular fact connected with this lowest calcareous division is that it does not appear to be represented on the southern side of the Horton synclinal; but this may not unreasonably be accounted for by supposing the anticlinal form of gneiss which occurs between these two synclinals to represent the 3,500 feet of gneiss which overlies this division in Ross. It is, however, I think, represented in Darling and Dalhousie Townships by the limestones in connection with the coarse syenites and diorites of Group III.* These last contain a great deal of serpentine, but of a different colour, and differently arranged from that in the upper limestones, or those immediately above the 3,500 feet of gneiss. With this low calcareous division in Ross, there is further a great quantity of quartzite and feldspar, and quartzose rocks, in which garnets are abundantly disseminated. Many of the limestones strikingly resemble those in the Petite Nation Seigniory, at Cote St. Pierre, and like these last, are often associated with blotched diorites. No forms, however, in any way resembling *Eozoon*, were found in Ross, although as we have already seen, (report last cited and same page) obscure forms of this fossil were found in Dalhousie Township. Another noteworthy fact concerning these lowest limestones, is the conglomeritic or brecciated aspect which they present in some localities, the enclosed fragments being chiefly derived from the underlying gneisses; but to this, and to many other interesting points, I shall again have to refer when speaking of the distribution of this very low division of rocks in Pontiac and Ottawa Counties. Westward of the Ottawa Valley, this group or belt of strata is not often met with. In Hastings County, and in the Hastings series of rocks, its position should be between divisions A and B; † and although in one or two places I have found what I take to be its equivalent, yet, as a general rule, B rests immediately upon A, without any intervening series. This, however, is not surprising, for the thinning out of other bands in a westward direction from the Ottawa has been clearly established.

Serpentine.

Garnets.

Eozoon.

Brecciated aspect of limestones.

Hastings series.

Thinning out of limestones to westward.

In Ross, as already stated, a deep drift of sand covers a large tract of country, and consequently no clear view could be obtained of the underlying rocks in this direction. Judging, however, from isolated exposures which every here and there protrude through the sandy plains of Ross and Westmeath, the immediately underlying rock is a thin-bedded and very clearly stratified granitic and hornblendic gneiss. This appears to be of great thickness; but owing to the nearly horizontal position of the strata it was found impossible to estimate, even approximately, its volume. It overlies the great fundamental gneiss system, which, as we have already mentioned, constitutes the backbone of Eastern Ontario, as well as thousands of square miles in the region to the northward of the

Sand drift.

Granitic gneiss.

Fundamental gneisses.

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* See Report of Progress, 1874-75, p. 138.

† Report of Progress, 1866-69.

Ottawa River. Independent, then, of this ancient gneiss system, we have, in the Horton and Ross trough, the following sequence of rocks in ascending order :—

Sequence of rocks in Horton and Ross.

	ESTIMATE OF THICKNESS.
1. Red and grey, thin-bedded and clearly stratified granite and hornblendic gneiss. In this, mica is very sparingly distributed....................	Not known.
2. A calcareous division or belt, embracing crystalline limestones, white and flesh-coloured, quartzites, quartz and orthoclase strata with garnets, pyroxenic rocks, a few bands of gneiss and some diorites. The limestones contain serpentine, graphite and apatite; the last mineral sparingly. Whole division estimated at between..........	2,000 to 3,000 feet.
3. A belt of gneiss of varied colours and characters; dark-greenish, hornblendic gneiss and slates; fine-grained whitish gneisses, abounding in quartz and feldspar; red granitoid gneiss; coarse porphyroid gneiss with deep-red feldspar. In the hornblendic varieties, epidote frequently occurs as interstratified beds and layers. Some of the porphyroid bands have the appearance of a conglomerate...........................	3,500 feet.
4. Volume of white crystalline limestone with dolomite, tremolite, quartz and serpentine. This includes a subdivision of black hornblende slate, mica schist and labradorite. The limestone is often striped or banded, sometimes wavy, and towards its summit is thickly interstratified with rusty slates or fahlbands....................	5,600 feet.
5. Very black-weathering hornblende-rock or gneiss, largely rust-coloured, with a few small bands of crystalline limestone. Towards the summit of this there are indications of red granitic gneiss, but this rock does not come in, in body, in the Horton trough..............................	200 to 300 feet.

This last division we have already shown to consist of only the very lowest portion of the gneiss and limestone series of Group V.;* consequently, the thickness here given to it only applies to the volume represented in Horton and Ross Townships. It may be further stated that in this sequence Divisions 2 and 3 correspond to my former Group III. (report just cited); Division 4 to Group IV., and Division 5 to

Comparison of section with former groups.

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* Report of Progress, 1874-75.

subdivisions 1 and 2 of Group V., as given on page 152 of the same report.

Oldest stratified rocks of Ontario.

These rocks, then, are clearly the oldest of the stratified rocks of Eastern Ontario, and the commencement of the great series of gneisses and crystalline limestones of the Laurentian system. They, therefore, must correspond to some portion of Sir Wm. Logan's Grenville series, but to which it is at present difficult to determine. The Grenville sequence is given in the Geology of Canada, page 45. It is supposed to represent, in ascending order, all of the most important rock strata in the Lower Laurentian system, so far as then known; but whether Sir William's No. 1, namely—the Trembling Mountain gneiss (5,000 feet) is to be considered as representing my fundamental gneiss system, and the immediately overlying gneiss (No. 1 of foregoing sequence) or something very much higher, cannot yet be satisfactorily determined. We can learn nothing by comparing the respective thickness of the groups, for these of course vary greatly on their run through even limited areas. For instance, I can find nothing in the Grenville section to compare with the 5,600 feet band of limestone; yet, notwithstanding, this may be represented by the 1,500 feet displayed by the Trembling Lake limestone, or by the 2,500 feet which is given to the limestone of Great Beaver Lake and Green Lake. A clue, however, in this relation, and a most important one, is presented in the occurrence in Ross Township of labradorite rock. This, as we have shown, is connected with the second body of limestone, or No. 4 of section. Now, turning to Sir Wm. Logan's coloured geological map* illustrative of the distribution of the crystalline limestones in the counties of Argenteuil and Ottawa, we find, in intimate association with his lowest band of limestone, a great development of labradorite rock. This, from Sir Wm. Logan's description, overlies, unconformably, the gneisses and limestones of that section, and constitutes his Upper Laurentian or Labradorite series. Thus, we have, in two corresponding positions, and at widely separated points—but no where between—areas of labradorite rock; and these in one place conformable, and in the other unconformable. It will, however, be seen, from a further inspection of the map just alluded to, that this labradorite area occurs towards a portion of the country not yet thoroughly examined; and further, that the outlines or boundaries of this are but indefinitely laid down. Hence, a question naturally arises as to the correctness of the view then taken, touching its unconformity.

Grenville series.

"Trembling Mountain" gneiss.

Great Beaver Lake and Green Lake limestones.

Sir W. E. Logan's map referred to.

Upper Laurentian.

Labradorites conformable and unconformable.

Question as to correctness of view taken.

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* See Atlas accompanying Geology of Canada.

Further, it will be remembered (page 262 of this report) that in Tudor, Hastings County, a mass of anorthosite rock was for a long time regarded as unconformable to the adjacent grey limestones (with Eozoon) but was afterwards proved to be simply an anticlinal axis of a lower portion of the same series, and perfectly conformable. May not the same then, possibly yet be found to be the case with the Argenteuil County labradorites? But to this interesting point, as well as to others in connection with Sir Wm. Logan's series, I shall yet have to refer in this report, when describing the other important bands of limestone and strata of gneiss, which succeed the Horton and Ross limestones, in Ottawa County, and which clearly correspond in both stratigraphical position and lithological character to some in the Grenville section.

Anorthosite area in Tudor.

The investigations so far described represent the work done up to the close of 1875, in Ontario, and now before entering upon that of 1876, which was conducted upon the Quebec side of the Ottawa, and in the counties of Pontiac and Ottawa, I wish, in conclusion, to make a few general remarks on the singular troughs of rocks we have been describing, and the underlying great red gneiss system, the fundamental rock of Eastern Ontario.

General remarks upon investigations up to close of 1875.

During the year 1853 Mr. Alexander Murray examined a large portion of the country—then unsurveyed—lying between Georgian Bay, in Lake Huron, and the Ottawa River. This examination was effected by means of the Muskoka, Petewahweh, Bonnechere and Madawaska Rivers. His first traverse on the Muskoka and Petewahweh rivers carried him from Lake Huron to a point on the Ottawa, a few miles above Pembroke, whilst his second, by the Bonnechere, Madawaska and Gull Rivers, brought him back again to Balsam Lake, in proximity to Lake Simcoe. The results of these explorations will be found in his report for the year 1853.* Amongst the most important of these was the discovery of crystalline limestone as far inland as Golden Lake, on the Bonnechere, and on the Shawashkong or south-west branch of the Madawaska, subsequently included in the Township of Dungannon. On the Muskoka and Petewahweh, crystalline limestone was not met with, but *garnetiferous gneiss* occurred frequently on the first-named river. Excepting, then, the limited areas occupied by the crystalline limestones and garnetiferous gneiss, it was clear, from Mr. Murray's report, that gneiss alone (chiefly red) occupied the greater part of the region traversed. This fact is

Review of Mr. A. Murray's work in same region.

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* Reports of Progress for the years 1853-56.

confirmed by my subsequent investigations It, therefore, becomes certain that the Lower Laurentian system comprises two divisions, namely—a calcareous and a noncalcareous division. On this point, Sir Wm. Logan, in a paper read before the "Eleventh Meeting of the American Association for the Advancement of Science," held in the city of Montreal, in 1857, writes as follows:—

Calcareous and non-calcareous divisions in Lower Laurentian.

Extract from paper read by Sir W. E. Logan at meeting of American Association.

"The sub-silurian azoic rocks of Canada occupy an area of nearly a-quarter of a million of square miles. Independent of their stratification, the parallelism that can be shown to exist between their lithological character and that of metamorphic rocks of a later age, leaves no doubt in my mind that they are a series of very ancient sedimentary deposits in an altered condition. The further they are investigated the greater is the evidence that they must be of very great thickness, and the more strongly is the conviction forced upon me that they are capable of division into stratigraphical groups, the superposition of which will be ultimately demonstrated; while the volume each will be found to possess, and the importance of the economic materials by which some of them will be characterized, will render it proper and convenient that they should be recognized by distinct names, and represented by different colours on the geological map. So early as the year 1854, as will be found by my report on the Ottawa district (presented to the Canadian Government the subsequent year) a division was drawn between that portion which consists of gneiss and its subordinate masses, and that portion consisting of gneiss, interstratified with important bands of crystalline limestone. I was disposed to place the lime-bearing series above the uncalcareous, and although no reason has since been found to contradict this arrangement, nothing has been discovered especially to confirm it, while the complication which subsequent experience has shown to exist in the folds of the whole (apparent dips being from frequent overturns of little value) would induce me to suspend any very positive assertion in respect to their relative superposition until more extended examination has furnished better evidence."

Separation of Lower Laurentian rocks into two divisions.

Such evidence has now been obtained, and this clearly points to the separation of "that portion which consists of gneiss and its subordinate masses" from that "consisting of gneiss interstratified with important bands of crystalline limestone." At the date of Mr. Murray's investigations, and indeed for many years later, the exposures of crystalline limestone in the valley of the Bonnechere, at Golden Lake, and those on the Shawashkong or York Branch of the Madawaska, in Dungannon, were supposed to represent portions of two or more great bands of limestone which were interstratified with and formed a part of the great gneiss system; and it was thought further probable that as investigations progressed in this region, others would be discovered, which, with the former, would compose a series corresponding to that at Grenville, in Ottawa County. Such, however, has not been the case; for not only have no other bands of limestone been discovered in this particular gneiss area, but even those that had previously been discovered have been proved to have but superficial connection with it. Thus we have seen that the Bonnechere and Golden Lake limestones, are nothing more than an extension of the Horton trough in this direction, and beyond which they entirely disappear and give place solely to gneiss. In like manner it was subsequently determined that Mr. Murray's crystalline limestones on the Shawashkong or York Branch River were situated in Dungannon, in which township I had already traced out and mapped* the south-western half of a great trough of limestones, which is one of a series of troughs extending all the way up from Tudor and Madoc Townships. Thus, in each instance in which crystalline limestones have been found in the interior of the great gneiss country, these have been proved to occur in the superficial condition of shallow trough forms, and not as bands interstratified in the gneiss itself. Again, I observe in Mr. Murray's records of his explorations on the Petewahweh, Muskoka, Meganatawan and other rivers which traverse the great central gneiss area, that he is often puzzled to account satisfactorily for the opposing dips presented by the strata at many points. For instance, in describing the strata on the Meganatawan, he writes: "Above the junction of Doe River the rocks at the rapids were usually more or less garnetiferous, and presented southerly and easterly dips. At Wahuzke Lake the dip was sometimes a little to the west, at others a little to the east of south; but the general trend of the hills and ridges being nearly north-east and south-west, it is possible the strike of the strata corresponds, and that the average dip is south-east." Again, on the Muskoka, where garnetiferous gneisses are again extensively developed, there are many opposing dips, which Mr. Murray thought were accounted for by corresponding contortions of the strata, while on the Petewahweh "the rocks are so generally affected by dislocation and disturbance, especially below Cedar Lake, that the attitude displayed by the stratified portions is not to be much relied on, except for short distances." Now, this was precisely my experience upon both the Bonnechere and Madawaska Rivers, and

Limestones not interstratified in lower gneisses.

Other troughs of limestones in gneiss area.

Puzzling dips of strata.

Extract from Mr. Murray's report.

Garnetiferous gneiss in Muskoka.

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* Report of Progress, 1866-9, map.

for a long time I endeavoured to ascribe to the strata a general southerly and south-easterly dip. This, however, resulted most unsatisfactorily, and it was always evident that a clue was yet wanting to the general geological structure. But these rivers now having been proved to run in synclinals of the strata, the many opposing dips of the rocks are readily explained, while the idea of similar troughs of rocks along the other rivers named is suggested. This suggestion has now increased almost to a conviction, and this mainly from a further perusal of Mr. Murray's reports, under the light of a more extended knowledge of our Laurentian rocks. To render intelligible the general conditions of these troughs of rock, and to show clearly their relations to the great gneiss system upon which they rest, and to the gneiss and limestone series with which they connect and form part of, I would next briefly direct your attention to the general geological structure of that portion of Ontario lying between the Ottawa and St. Lawrence Rivers, on the one hand, and between Lake Nipissing and its out-flowing rivers and the Rideau Canal, from Kingston to Ottawa, on the other. In this great area, a part of which only is shown on my map, two distinct formations have long been recognized—the Silurian and the Laurentian. The last of these occupies by far the largest portion of the country, and forms the great central nucleons around which the Silurian was subsequently deposited. This latter formation, as you are aware, clearly begins with the Potsdam and ends—in so far as this particular area is concerned—with the Trenton. In it the strata are horizontally arranged, and not being in the slightest degree metamorphosed, are at once easily distinguished from the inferior crystalline strata of the Laurentian. The bulk of the Silurian occurs to the front or on the St. Lawrence side and along the Rideau to the neighbourhood of Ottawa; but a further comparatively narrow and disconnected strip runs up the valley of the Ottawa, and forms isolated areas as far to the north-westward as the Alumette Island, opposite Pembroke, and, indeed, as I have recently discovered, still further, and some miles beyond the Deux Rivieres portage. In this last position grindstones of an excellent quality have recently been manufactured from an escarpment of thin-bedded sandstone which there borders the Ottawa. The next deposits of Silurian age in this direction are those on Lake Nipissing, as noted by Mr. Murray,* which are outliers probably from the Georgian Bay area. It is, however, my impression that at one time there existed a continuous strip of Silurian

Troughs of rock along river valleys.

General geological structure of Eastern Ontario.

Silurian, Potsdam to Trenton.

Silurian up the Ottawa valley.

Grindstones near Pembroke.

Silurian on Lake Nipissing.

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* Report of Progress, 1856-59.

rocks all along the Ottawa valley, from Ottawa to the mouth of the Mattawa, and thence by the valley of this last river to Lake Nipissing and Georgian Bay, thus entirely surrounding the gneiss nucleus of Eastern Ontario. And further, there is abundant evidence to prove that arms of this Silurian sea, at several points, stretched inland along depressions in the central gneiss system, which are now marked out by some of the more important of the river courses. Thus, as we have already shown, detached Silurian areas are met with along the westward course of the Madawaska valley, as far inland as Calabogie Lake, in Blythfield, and probably also still further, along the depression which has been traced through into Hastings County. Again, similar outliers are met with on the westward course of the Bonnechere River Valley, far inland from the Ottawa, and well in towards the centre of the great Laurentian area, where there are further evidences that at one time the Silurian was widely extended. It is just possible that the whole of the area under discussion was at one time covered by the Lower Silurian rocks, and that the detached islands of these that we now see are portions which have been protected from the surrounding and wide-spread forces of denudation, which have swept all else away. But I am more inclined to the view first given or implied—namely, that much of this Laurentian area was dry land during the Lower Silurian period, and that deep arms of the then encircling sea, stretched inland at several points, and possibly connected with an inner basin of some extent. It is a further curious and interesting fact, that in the greater number of instances these Silurian outliers represent, not the two lowest divisions of this formation —the Potsdam and Calciferous—but the two next in succession, namely, the Chazy, and Birds-eye and Black River, while in a few instances the Trenton is even included. But this point has already been brought forward in the Geology of Canada, and need not here be enlarged upon.

Gneiss nucleus in Ontario.

Outliers of Silurian.

Denudation.

Turning now to the underlying Laurentian system, we come upon a great series of crystalline rocks, which are not only highly metamorphosed, but most intricately contorted. This, in the section of country we are now referring to, has been described in general terms as consisting of great volumes of granitic and hornblendic gneiss and schist, with important bands of crystalline limestone, quartzite, hornblende-slate, and some diorites, while allusion has further been made to great areas of flesh-coloured and brick-red syenites, which have been considered as eruptive. To these rocks, at an early date during my own investigations, were added the peculiar strata of the *Hastings series*, which

Laurentian.

Brick-red syenites.

have up to the present time been regarded as a very recent portion of the Lower Laurentian system, if not, indeed, something much more recent, and unconformable. In these rocks, however, *Eozoon* was found, and consequently they have remained provisionally classed with the Lower Laurentian. Hitherto no attempt has been made to set forth clearly the order and superposition of the different members of this great crystalline series, as a whole, in Eastern Ontario, excepting in an incomplete manner, as given from time to time as the investigations progressed, in the reports of the Survey. Now, however, having traversed the whole of this great area, and being about to cross the Ottawa and commence our investigations on the Quebec side, I feel that it is proper that an attempt should be made to reduce to some order and sequence the rocks that have for so long a time been under investigation, and an endeavour made to present them in a more intelligible form, but this must be done very briefly.

Hastings Rocks.

Limited area of gneiss and limestone series.

In the area, then—the boundaries of which have been given—gneiss and syenite are by far the most abundant rocks, while gneisses, with interstratified crystalline limestones, occupy but a comparatively limited area, and this only toward the margins of the former. Indeed, I may go further, and state respecting the relative volumes of these two distinct sets of rocks, that the gneisses with crystalline limestones, bear about the same relation to the volume of gneiss and syenite, that the comparatively narrow belt of the Silurian does—in this section of country—to both of these together. But this point will become clearer as I proceed. We thus have at the outset two divisions presenting themselves in these old crystalline rocks, namely, a great uncalcareous division and a smaller and calcareous one. The first of these may be further subdivided into a stratified and unstratified portion, of which the latter is, undoubtedly, the lowest and oldest; but the line of demarkation between these two is not always clear. Both of these rocks are included in the red colour on the accompanying map, and from this a clear idea can be formed of their great extent. The gneisses and limestones of the second or calcareous division, occur altogether towards the south-eastern corner of this area, where they occupy that comparatively limited region or belt of country between the final outcrop or limit of the Silurian rocks, and the margin of the gneiss and syenite. They, doubtless, also form a continuous belt all along the southern part of the area under consideration, bordering upon the St. Lawrence; but in this direction they are entirely concealed by the Silurian. As may be seen from the map, and as has already been described in the reports of the Survey, north-

Two divisions of rocks.

Position of gneiss and limestones.

ward or north-westward of the line denoting the base of this gneiss and limestone series, there occur numerous and repeated troughs of the lower members of this division, which are spread out over the great fundamental gneiss system in a most irregular manner, and it is these that have given rise to the supposition that the older gneiss and syenite was interstratified with crystalline limestones. These troughs of the limestones continue, as we have shown in this report, up the Ottawa Valley, in which direction they again encroach upon the older gneiss; while the main body of gneisses and limestones, as a belt, crosses the Ottawa in the vicinity of Fitzroy, and enters Pontiac and Ottawa counties. In Hastings County, to the north of Lake Ontario, this regular sequence of gneiss and limestones is entirely concealed by the flat Silurian rocks; consequently, the troughs of the former were first observed, and were provisionally described as the Hastings series. The Hastings troughs of these rocks extend a very long way to the northward, the last one in this direction being, probably, that mapped in Dungannon Township; as Mr. Murray, in his traverse from the Bonnechere River did not meet with any limestone until he reached this trough. Westward from Hastings County, similar troughs were also noted through Peterborough County, but in this direction the Silurian rapidly encroaches upon the gneiss and syenite area and conceals them. The last, and most westerly indication of these troughs, is that met with by Mr. Murray at Balsam Lake, in proximity to Lake Simcoe, where, however, the geological structure has not yet been sufficiently investigated. Continuing on the course thus given to us between Hastings County and Balsam Lake, we shortly come to the bight of Georgian Bay and to the mouth of the Muskoka River. I have already, on page 269 of this report, alluded to Mr. Murray's traverse up the valley of this river to the Petewahweh, and merely refer to it again as bearing upon what I have been stating concerning these troughs of rocks. It is extremely probable that the garnetiferous gneiss, and the white and yellowish quartzites observed by him on the first of these rivers, occur in a synclinal or trough-form, and represent a condition similar to that of the rocks in the Madawaska and Bonnechere Valleys. In the Muskoka, as we have elsewhere stated, crystalline limestone does not occur or was not met with, but Mr. Murray's description of the gneisses and quartzites agrees precisely with what I should expect to find in a trough where the very lowest portion only of the gneiss and limestone series was represented. The same remarks will apply also to the exposures met with by Mr. Murray, also alluded to on page 271 of this report, in the valley

Troughs.

Hastings series first met with.

Most northerly trough.

Most westerly troughs.

Mr. A. Murray's explorations.

Absence of limestones in Muskoka Valley.

Meganatawan Valley.

of the Meganatawan, which I am convinced are likewise arranged in a trough-like form. Most unfortunately, in this direction the gneisses and crystalline limestones, as a belt, are entirely lost sight of beneath the waters of the Georgian Bay and Lake Huron, else we might here, in all probability, note the connection of these troughs with the parent body, as we have already clearly done in the case of the Madawaska and Bonnechere troughs on the Ottawa River. Now, if for a moment we set aside these trough-like forms which we have been describing throughout the whole of this area, we have only left to represent the gneisses with interstratified crystalline limestones (the calcareous division of the Laurentian) a comparatively narrow belt in its extreme south-eastern corner, namely, that occupying portions of Addington, Frontenac, Leeds and Lanark Counties. In other words, were we to draw a line on the map from Stocco Lake, in Hungerford—about eighteen miles from the St. Lawrence—north-eastward to Fitzroy Harbour, on the Ottawa, we should have separated the gneisses with limestones, from the gneisses and syenites, or non-calcareous division ; the former occurring on the south-eastern side and outwards to the St. Lawrence, and the latter to the north-westward, and extending across the whole county between this line and Pembroke, on the Ottawa. And I may here take the opportunity of stating that the further limit or boundary of the gneisses and crystalline limestones would be represented by an extension of this same line from Fitzroy Harbour up the valley of the Ottawa to Portage du Fort, in Litchfield, and thence north-eastward to the mouth of the Desert River, ninety miles up the Gatineau River. In this direction, this line would form the western boundary or limit of all crystalline limestone yet discovered, excepting in one trough occurring on the Grand Calumet Island, and extending into the townships of Litchfield and Huddersfield, which will be described in Part II. of this report.

Gneisses and limestones lost sight of.

Boundaries of gneiss and limestone sequence.

Limit of crystalline limestones.

In conclusion, I would direct especial attention to a fact which has not before been mentioned in my reports, but which was referred to in a paper some time ago, read before the Montreal Natural History Society ; namely, that this second division, or the gneiss and crystalline limestone series, is everywhere extensively traversed and dislocated by east and west faults, which likewise affect and dislocate the overlying Lower Silurian rocks, but do not extend downwards into the more ancient gneiss and syenite of the first or non-calcareous division. From this it would appear that the gneisses with crystalline limestones are more nearly related to the Silurian than to the underlying gneiss and

Faults.

syenite series.* So far, then, my investigations in Eastern Ontario show but three great divisions or groups of rocks, namely:—

Three divisions of rocks.

1. A great gneissic and syenitic series, without limestones.
2. A thinner gneissic series with labradorites and limestones.
3. Lower Silurian (Potsdam to Trenton).

II.

INVESTIGATIONS IN THE COUNTIES OF PONTIAC AND OTTAWA.

Investigations during 1876.

These investigations were commenced early in the season of 1876, when I was assisted by Mr. Lewis R. Ord. Before entering Pontiac County, we examined the valley of the Ottawa from Portage du Fort to Pembroke, and both shores of the Allumette Lakes. Hearing at Pembroke that lime was being burnt further up the river beyond the Deux Rivieres Landing, and thinking that this kiln was, in all probability, in proximity to a band of crystalline limestone, we ascended the Ottawa to Deux Rivieres, (a telegraph station and post office, about eighty miles from Pembroke) by steamboat, and from thence made a canoe journey in the direction of the mouth of the Mattawa River. On this journey no trace of crystalline limestone was met with, but red gneiss abounds. This gneiss is clearly bedded, and nearly everywhere dips at a low angle. In several places it is nearly horizontal. From the neighbourhood of the mouth of the Coulonge River, in Mansfield, it forms a mountainous range along the northern shore of the Ottawa as far up as our examination extended. The southern shore, for the first half of this distance, is low and comparatively level, and is extensively covered by deep drifts of yellow sand, while a large portion of Westmeath Township and the whole of the Allumette Island are occupied by Lower Silurian limestones—Chazy, Birdseye and Black River. At and around the mouth of the Petewahweh River, beyond Pembroke, a brick-red syenite is very extensively developed, and the same rock forms a number of islands in Allumette Lake. This red syenite was met with by Mr. Alexander Murray for a long distance up the Petewahweh. It does not, as a general rule, form hilly country, but rather extensive sandy plains, in which often no rock is seen over considerable areas. It is, undoubtedly, the foundation or base upon which all the succeeding rocks in Eastern Ontario have been

Deux Rivieres telegraph station.

Red gneiss.

Mountain range.

Silurian in Westmeath and Allumette Isle.

Sandy plains.

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* This fact, even if proved, does not, in my opinion, bear the interpretation given it by Mr. Vennor. The similarity in the general physical condition of the two series of gneissic rocks, as described by Mr. Vennor, is a consideration of much greater importance, and separates them both, widely and distinctly, from any known palæozoic formations.—A. R. C. S.

deposited; and I may add that there is as little doubt that it represents an older and distinct series. It continues to be displayed along the south shore of the Ottawa for some distance beyond the Upper Allumette Lake, still forming a low-lying and flat country, while immediately along the northern shore come in the mountainous ranges of gneiss, clearly resting upon the syenite, and dipping inwards, or to the northward at low angles. The course of the gneiss rocks, taken as a whole, is with the Ottawa Valley, or to the north-westward, but they are clearly seen to describe a number of undulations, and the local strikes obtained were almost as often to the north-eastward as to the north-westward. Some of these undulations carry the gneiss across to the south side of the Ottawa; and, indeed, above the Des Joachims, this rock occupies both sides of the river up to and beyond Deux Rivieres. There the rocks are almost horizontal, the incline, however, being distinctly to the eastward. They consist of greyish fine-grained and thin-bedded gneisses. The stratification is beautifully displayed in the weathering of the rock, the softer layers or beds wearing away and the harder standing out in relief. This thin-bedded gneiss continues for a long distance down the Ottawa towards the Roche Capitaine, and no doubt forms the greater part of the rocky rapids between these places. Along the Deux Riviere portage to the Mattawa boat landing, there is an immense accumulation of gneiss boulders, and many of these have worn holes or kettles for themselves in the underlying thin-bedded gneiss in which they remain imprisoned. These *pot-holes* are numerous and are very similar to those seen along the shores and islands of Lake Huron, in the Lower Silurian limestones. Inland, or southward from Deux Rivieres, the superposition of the gneiss upon the red syenite is again clearly seen, and in places the former was observed lying horizontally upon the latter without the slightest appearance of disturbance. From this position, a few miles to the southward of the Ottawa, and immediately opposite the Deux Rivieres—through to the mouth of the Petewahweh, the red syenites are frequently met with, and everywhere form the boundary or limit of the clearly stratified gneisses. A straight line drawn from Deux Rivieres in a westerly direction for about twenty-four miles would strike the mouth of the Mattawa River, and if this were extended it would reach and pass through Lake Nipissing. Now, in this last position there are both gneisses and crystalline limestone with iron ores, and it is not unnatural to suppose that they are a continuation or westward extension of the rocks we have so far been describing. It is true that up to the Deux Rivieres no crystalline limestone was observed,

Very old series.

Des Joachims and Deux Rivieres.

Clear stratification.

Gneiss boulders.

Pot-holes.

Superposition of gneiss upon syenite.

Gneisses and limestones of Nipissing.

nor was it to be expected in this very low portion of the series; but there is no reason why it should not immediately reappear wherever the conditions of the underlying gneisses are such as to have permitted of the deposition of some of the succeeding members of the formation. In a number of the troughs which have elsewhere been investigated this *pinching-out* of the crystalline limestone was clearly observed, and I believe the same is the case in the Ottawa Valley.

Absence of cyrstalline limestones explained.

I have already alluded to the small outlier of Lower Silurian limestones beyond Deux Rivieres. This is clearly an extension of the Chazy limestones of Allumette Island, opposite Pembroke, and I was informed that other small and detached masses of the same had been found all the way to the mouth of the Mattawa. On the outlier near Deux Rivieres there is a limekiln and grindstone quarry.

Remote outlier of Silurian in Ottawa Valley.

Having failed to discover any further traces of crystalline limestones on this traverse up the Ottawa Valley, we returned to Portage du Fort, in Litchfield, and set about a detailed investigation of the rocks in this neighbourhood. These explorations embraced the townships of Clarendon, Litchfield and Mansfield, the Grand Calumet Island, and the two channels of the Ottawa, known as the *Calumet* and *Roche Fondu.* The Coulonge River was also examined for some distance into Pontefract, and traverses were made to two important lakes, known by the names of "Big Squaw Lake" and "Moose Lake," in the township of Huddersfield. From the first-named lake, a further exploration line was carried down the south-west side of the Pickanock, and through portions of Huddersfield and Clapham Townships, to the south-western extremity of Otter Lake, in Leslie, and to a small tract of land generally known as the "Otter Lake Farm," the property of Gilmour & Co.

Return to Portage du Fort.

Further investigations.

In the area thus examined the rocks were found to be of precisely the same general characters as those which had been investigated in Horton and Ross Townships, on the opposite side of the Ottawa, and no difficulty was experienced in distinguishing in them the five groups or divisions which had already been established in Ross Township. These divisions we may, for convenience sake, again enumerate, to illustrate this section of the report. They are as follows:—

Rocks similar upon both shores of Ottawa.

1. The lower gneisses. (Without crystalline limestones.)
2. The first or lowest calcareous belt.
3. The second volume of gneiss.
4. The second, and great volume of crystalline limestone, with its associated labradorites, diorites and hornblende-slates.

General division of rocks.

5. The black and rusty-weathering hornblendic gneiss. (The first member of a great succeeding sequence of gneisses and *interstratified* crystalline limestones.)

(See also page 267 of this report.

Trough forms again.

These rocks, in the area the outline of which has just been given, are again arranged in a trough-like form, which may correctly be said to be the northward extension of the Horton, Ross and Bonnechere River trough; and I may here premise that this is the last position in which these lower rocks *per se* are thus arranged; for in subsequent explorations through Pontiac and Ottawa Counties, a regular and steadily-ascending sequence of rocks was met with, which embraced not only the five divisions just described, but also all the remaining members of the gneiss and limestone series, up to the apatite and plumbago bearing rocks, which I have always considered as properly belonging to the very highest portion of the series.

Apatite and Plumbago series.

A detailed description of the distribution of each band of rock in this trough is unnecessary; but some mention may be made of points of interest connected with these in a few localities.

The Lower Gneisses.

Gneisses of Pontiac County.

(1.) These in Pontiac, so far as examined, are all clearly stratified, and conform to the windings of the limestones which come in above them. The obscurely stratified red gneiss and syenites (the fundamental rocks) were observed in a few places at some distance outwards from the margins of these, but it was found impossible to draw a line—unless a provisional one—which would truly represent the junction of these two, apparently, distinct formations. This difficulty is largely due, however, to the nature of the country occupied by these older rocks. This is of the most rugged description, and barely traversable, except by means of some of the larger streams, which again are beset with difficult portages. Hence, anything like detailed geological work is out of the question. I have, however, invariably observed in our ascent of the main streams—such as the Coulonge, Black River and Pickanock—that a point on each was always reached, beyond which the rocks partook of a syenitic character, and all trace of stratification was lost. In approaching these syenitic rocks, the clearly stratified gneisses assume a very slight incline, and are often nearly horizontal; but, as might be expected, there are occasional exceptions to this rule, and areas were met with through which the dip of the strata was very nearly or altogether vertical. At some of the furthest inland points reached, enquiries were made of *squatters*, and men

Rugged country.

Unstratified rocks

left in charge of the lumber depots, concerning crystalline limestone, but without success. A few of these persons had been employed for very many years as "timber limit locators," and had in this vocation traversed many hundreds of square miles in the direction of the head-waters of the streams we have already mentioned. These men were necessarily intelligent, and close observers, and I met with but few who knew so little about the rocks of the country as not to be able to tell us whether or not they had met with crystalline limestone in the portions of country they had been over, while in one or two instances we had fairly described to us the different characters displayed by the gneiss in the section enquired about. I bring forward these facts here in support of what has already been several times stated in this report, respecting the entire absence of interstratified limestones in this very old and lowest syenite and gneiss formation.

Great areas of gneiss without crystalline limestones.

The Crystalline Limestones.

(2 and 3.) These I shall at present refer to together, and, therefore, necessarily must include the second volume of gneiss (3). It will be remembered that these rocks where last described in Ross township, where, after sweeping in a U-shaped curve by Foresters' Falls, they finally reached the Ottawa River in proximity to the town line of Westmeath, and crossed the Roche Fondu channel—on some maps called a lake—to the Grand Calumet Island. Their further run, however, on this island is such as to cause the following arrangement of the respective divisions. The upper mass of limestone (4) first nearly traversing the island on a north-east course, suddenly curves to the north-westward, and in this direction runs out to its extremity, and into the river; the underlying volume of gneiss (3) following the same course, is only represented by the comparatively small area in the extreme north-western portion of the island, or that which is cut off from the main body, by a narrow arm of water, while the lowest limestone belt (2) not being seen at all, must occupy a position in the valley of the Roche Fondu channel. From such an arrangement of these rocks it is evident that they do not immediately cross to the opposite side of the Ottawa, but on the contrary, appear to be turning again up the valley of this River, which position, I may say, they continuously keep, (excepting the trough digressions) all the way up from Fitzroy Harbour and Arnprior. It was owing to this apparent north-westward strike on the Grand Calumet Island that the traverse—already described—was made in the direction of Pembroke and Deux Rivieres, but with what success has already

Distribution of crystalline limestones.

been stated. It must, however, be borne in mind, that in this direction outliers of the Lower Silurian rocks occur through much of Westmeath, and over all of the Allumette Island, and, consequently, it is not certain but that the crystalline limestones may be distributed in this direction, though concealed. From the arrangement and attitude of the lower gneisses, where exposed along the southern side of the Ottawa up to Pembroke, and also along the northern shore to a position opposite this last place, I should be inclined to infer a synclinal form, the axis of which would be the Ottawa Valley; and further, consider it extremely probable that, if the truth were known, the crystalline limestones would be found to occupy the position of this synclinal, at any rate as far up as the head of the Upper Allumette Lake, beyond which the convergence of the opposite gneiss margins would, as might reasonably be expected, entirely pinch them out. Thus, then, it is possible that between the Horton, Ross and Bonnechere synclinal or trough, and that at present being described in Pontiac County, there exists a third and intermediate one up the Ottawa Valley, which might be called the Allumette Lake trough; these three, as looked at on a map, presenting a tri-lobed appearance, and standing out in relief from the great red gneiss area which bounds them to the northward and north-westward.

Concealment of crystalline limestones by Silurian rocks.

Synclinal of limestones in Ottawa Valley.

Three troughs.

The next point at which crystalline limestone was observed was on the line between the townships of Litchfield and Mansfield, and about four miles north of the Calumet channel. Up to this point the whole country, both to the east and west, is covered by a heavy drift of sand, and the rocks are completely concealed. From the place where the limestones were first met with on this line, they continue to be fairly exposed, and were followed in a direction a little west of north, through Mansfield, to a position on the Coulonge River, between ranges A and B, of Pontefract, where they strike in a decided north-west direction, with a dip at an angle of 45° to the north-east. A section made here in a south-westward direction from the Coulonge, and through Mansfield, proved that these limestones correspond to sub-division (4,) being clearly underlain in succession by the volume of gneiss (3), the lowest calcareous belt (2), and the lower gneisses (1.) Throughout the whole of this section the dip is steady to the north-east, and this lessens perceptibly as we descend, until in the lower gneisses (1) the incline is seldom more than 10° or 15°. Now, it will be observed that this strike of the rocks in Mansfield, if continued in a south-east direction, would carry them through the southwest corner of Litchfield, and thence

Drift of sand.

Limestones on Coulonge River.

on to the Grand Calumet Island, where they would connect with the limestones which have been already referred to as traversing this island, and thus it might be inferred that these limestones did not participate in the Allumette Lake and Ottawa Valley synclinal. But we have already clearly seen that the rocks on the Grand Calumet Island do turn in the direction of the upward course of the Ottawa Valley, namely, to the north-westward; therefore, it is plain that they cannot connect directly with those through Litchfield and Mansfield. As previously stated, a deep sand drift covers a large portion of the fronts of both of these townships, and the rocks for a long distance along the river are completely hidden. Now, these sand drifts, as I have frequently observed, are distributed along valleys and over flats, which are underlain by crystalline limestone, and in the present instance the contour of this sand area towards the lower part and mouth of the Coulonge decidedly points to a turn of the limestones in this direction, which would carry them along the front of Mansfield, in which case they would represent the opposite margin of the Calumet channel trough. The sudden rounding off of the hills, representing the lower gneisses in Mansfield as they approach the Ottawa Valley, is also a strong proof that this view is a correct one. The fact, nevertheless, remains, that apart from the two positions alluded to, namely: on the Grand Calumet Island, and on the upper portion of the Coulonge, in Mansfield, in which the limestones were well displayed, no further exposures were met with either between these places or on the upward course of the Ottawa.

Grand Calumet Island.

Sand drift.

Limestones disappear.

Before leaving Mansfield, I may state that the lowest calcareous division (2) is beautifully represented to the west of the Coulonge River, where the strike of the strata is first to the northward and then to the north-westward. On this last strike they run through into range B, of Pontefract, and continue along the south-west side of the Coulonge River, which here coinciding with the general strike of the rocks, runs also in a north-westerly direction. This calcareous division is similar in every respect to that in Ross township, on the opposite side of the Ottawa, of which it is undoubtedly an extension. It cannot be called a band of limestone, for this rock barely composes one-half of its volume; but since it is in this portion of the series that crystalline limestones first make their appearance, I think it well to bring this fact prominently forward by continuing to allude to it as *the lowest calcareous division*. In Mansfield and Pontefract, much of this limestone is very coarsely crystalline, and large portions of it are of a salmon or flesh-red colour, and here again as before, when referring to it in Ross—we are led to compare

Lowest limestones.

Salmon-coloured limestones.

Similar coloured limestones elsewhere.

it with some very much higher and more recent crystalline limestones which also exhibit this colour on the Gatineau River, in Hull, and in North Burgess, on the Rideau, in Ontario. This resemblance is further strengthened by the occurrence in the Mansfield limestones of grains of phosphate of lime and green-coloured crystals of pyroxene. Thus, either phosphate of lime occurs both in the very lowest and highest limestones yet discovered in this great crystalline series, or else the apparent geological structure is somewhere, and most unaccountably, at fault. Other marked characters in these lowest limestones, are the frequent occurrence of a conglomerate, or breccia—for it partakes of both characters; the abundance of silver-white and very black mica in small scales; the interstratification of numerous rust-coloured quartzites and bands of greenish and white pyroxene; and lastly, the frequent dissemination of claret-coloured and brownish garnets in the quartzose subdivisions. Of these, the conglomerates present the most noteworthy feature. They consist of a multitude of rounded and angular gneiss fragments, cemented in a calcareous matrix—this matrix not differing from the adjacent bands of limestone, and containing the same minerals. It is from this evident that the immediately underlying gneiss (1) had suffered much from erosion and other destroying agencies before the first member of the calcareous division had been deposited upon it.

Phosphate of lime.

Conglomerate or breccia.

Garnets.

Erosion.

Magnesian limestones with serpentine.

Besides these coarsely crystalline limestones, there are others more finely crystalline, indeed, often almost compact, and these are invariably more or less magnesian or dolomitic. In these last there is always a great deal of quartsose matter in grains and layers, or as veinlets cutting the mass, and serpentine of a greenish-yellow colour is not unfrequently met with. Thus quartz, in various forms, largely characterises this lowest limestone division; and I may add, the same is the case also in the apatite-bearing rocks at the summit of this series, in which, it will be remembered, great beds of cellular quartzites occur, interstratified in the garnetiferous gneisses. The gneisses which occur in this division (2) are peculiar, and are not what might be called typical. They are for the most part thin-bedded, and are of a whitish colour. The rock, consists of a fine-grained mixture of quartz, feldspar, mica and pyroxene; the latter mineral occurring in layers, lumps and grains. Red gneiss, of very obscure stratification, also forms a part of this division. Such rocks occupy the whole south-western side of the Coulonge River, in range B, of Pontefract, as far as lots forty-four and forty-five.

Extensive developments of gneiss on Coulonge River.

Beyond this position on the Coulonge, the detailed run of the rocks representing sub-divisions 2, 3 and 4 could not be satisfactorily ascertained on acount of the very rugged and wooded condition of the township of Pontefract. One road alone ran northward, and this did not extend much further than the ninth range; while the Coulonge itself, owing to rapids, is not navigable for canoes. The general geological structure, however, is clear; consequently the non-determination of a few of the minor undulations or zig-zags of the strata is unimportant. Merely stating, then, that the strata immediately to the north of the Coulonge are affected by a series of transverse undulations which cause the respective outcrops to assume a serrated form, I pass on to remark that the rocks representing divisions 1, 2 and 3 continue on a general northerly course through the eastern part of Pontefract up to the north-western extremity of Big Squaw Lake, in proximity to which they appear to turn sharply to the eastward, and then return in a south-easterly direction along the valley of the Pickanock stream—chiefly to the westward of this—through portions of Huddersfield and Clapham. We thus have a great U-shaped synclinal, the axis of which would run through the centre of Huddersfield.

Rough township.

Plication of rocks.

In Pontefract, the lower gneisses (1), which I must here, again, briefly allude to, extend in a westward direction to the valley of the Coulonge, presenting everywhere a steady incline to the north-eastward; but this incline in a westward or south-westward direction becomes slighter, until finally, in the vicinity of the Black River, large areas are occupied by nearly horizontal gneiss. Similar gneiss (1) occupies an immense area in the unsurveyed region to the northward of Big Squaw Lake, and I was informed by intelligent lumbermen that one might travel for days in that direction and meet with no other rock than red gneiss, but on this point I have already dwelt. Following the turn of the crystalline limestones (2), the gneiss sweeps round to the Pickanock stream in the north-eastern corner of Huddersfield, and continues to form a mountainous range along the entire north-eastern side of this river, through Clapham and a portion of Leslie Townships, where it terminates in two or three lofty hills, in proximity to "Otter Lake Farm." I say terminates, in reference to its surface distribution, for in Leslie it forms an anticlinal spur, round which the opposite outcrops of the lowest calcareous division (2) meet, as represented on the map of Pontiac County. The opposite margin of the gneiss (1), however, returns along the north-western side of the Pickanock, on its further north-eastward course, and extends in this direction for a great number of miles, passing through Dorion and into Eagan township, where its south-eastern boundary is only a short distance to the westward of the mouth of the Desert River, on the Gatineau. Thus, in Clapham Township, and

Lower gneisses.

Great areas of red gneiss.

Anticlinal spur of gneiss.

Desert River.

within the V-shaped bend of the Pickanock stream, we have a great anticlinal of the lower gneiss (1), the axis of which might be represented by a line drawn due north from the "Otter Lake Farm," in Leslie. The lowest division of the crystalline limestones (2) is well represented along the entire south-western side of the Pickanock in its course through Huddersfield and Clapham, it being here only separated from the lower gneisses by the river valley. In several places exposures of a very beautiful salmon-coloured limestone were met with, in which spangles of a silvery-white mica were thickly disseminated.

Anticlinal of gneiss.

Salmon-coloured limestones.

At the outlet of Big Squaw Lake into the Pickanock, the rocks largely consist of the peculiar yellowish quartz and orthoclase rock, which has been already once or twice referred to. This rock is generally garnetiferous, and much of it is stained with various tints of rust colour, sometimes assuming a brilliant hematite-red, and again a claret-colour. Similar strata, with an occasional band of limestone, were followed from Big Squaw Lake outlet all the way to "Otter Lake Farm," in Leslie, and on a perfectly straight south-easterly course. Immediately above these, and further westward, in Huddersfield, was also seen the volume of gneiss, (3) which separates the limestones (2) and (4.) This also runs on a general south-easterly course through Huddersfield from a position immediately to the southward of Big Squaw Lake to the south-eastern corner of the Township. The limestones (4), however, were not met with in Huddersfield; but their position is indicated by some flat and low lying country in which several small lakes occur. To the west of "Otter Lake Farm," in Leslie, it is evident that the strata are all affected by a series of transverse undulations, which are, undoubtedly, an extension of those which have already been described as occurring in proximity to the Coulonge River, in Pontefract, on the opposite side of this trough. By these undulations, the various outcrops of rocks are deeply serrated and carried in a south-westward direction through Litchfield to the shores of the Ottawa.

Garnetiferous quartzite and feldspar rock.

Plication of rocks in Litchfield.

On lots eight, nine and ten, in the tenth range of Litchfield, and in proximity to the creek which there runs parallel with the range line, the crystalline limestones (4), are again well displayed, and strike in a west-northwest direction, with incline to the north-eastward. To the eastward they are lost sight of in low land which surrounds the lower portion of the long U-shaped lake, in the tenth and eleventh Ranges; but I am convinced that the very singular shape of this body of water indicates the further course of the limestones in this direction, and that they form a junction with the Huddersfield limestones in the vicinity of Bear Lake, on the town-line of Litchfield. From lots eight, nine and ten, in the tenth range, the creek just alluded to runs round a spur or mountain of the gneiss of sub-division 3, and thence in a south-westerly direction to the Ottawa. In this direction the limestones (4) are entirely lost sight of beneath the great accumulation of sand which here follows the course of this creek. It may be mentioned that this body of sand occupies a position in a synclinal form of the crystalline limestones (4), being clearly limited on both sides by outcrops of these rocks showing opposite dips. The western margin of this synclinal is represented by that exposure of limestone already noted as occurring on the town-line of Mansfield, and thence traceable to the bend of the Coulonge River, in Pontefract. Now, it will be remembered that in this last position the drift of sand curved round, and swept past the mouth of this river, occupying the whole front of Mansfield, and it was thought probable that the limestones also ran in this direction. This conjecture is now made the more probable from our determination of the course of the limestones on the opposite or eastern margin of this trough through Litchfield. Here the sand drift likewise turns, but in exactly the opposite direction to that in Mansfield, and runs along the shore of the Calumet channel in a general south-easterly direction. This course the Litchfield limestones undoubtedly follow, for on a portion of the shore in the fourth range of this township, they are again well exposed, and are seen to overlie the gneiss (3), striking to the north-westward, and dipping at an angle of forty-five degrees to the south-westward. In this position they are directly opposed to the limestones of the Grand Calumet Island, which, as already stated, strike to the northward and north-westward, with eastward and north-eastward dips. Consequently, we have here another synclinal or trough-form, the centre of which is occupied by the black hornblendic gneiss of sub-division (5,) the distribution of which has yet to be described. It may be well to state here that this black hornblendic gneiss does not appear to be present in the synclinal through Litchfield and Huddersfield, and there is every indication of its being suddenly pinched out just at the point where it should cross from the Calumet Island to Litchfield; but this feature will be again referred to. From the shore of the Ottawa, in the fourth Range of Litchfield, the limestones (4) were traced on a nearly straight south-eastward course into the twenty-third and twenty-fourth lots, of the ninth range of Clarendon, where, however, their position is only indicated by a long low-lying strip of meadowland, the centre of which is traversed by

Sand drift.

Sand drifts conceal limestones.

Black hornblende gneiss.

Limestones in Clarendon.

a creek which runs north-westward into the Ottawa. Along the whole of this run, the limestones (4) are clearly seen to be bounded to the north-eastward by a mountain range of the gneiss (3), the thickness of which corresponds closely with that given to it in Ross township—namely, 3,500 feet. Beneath this again, and a little further to the north-eastward, the lowest limestones (2) were also identified, but these, shortly after entering Clarendon, pass under a heavy drift of sand, which spreads over a large part of this township, and were not again seen. In the vicinity of Collfield post office, in Litchfield, and close to the town-line of Clarendon, the limestones (4) were found about three miles in a straight line to the north of Bryson or Havelock village, to which position (see page 259) the opposite outcrop of the same band, namely, the Horton, Ross and Portage du Fort limestones, had previously been traced. At Collfield post office the dip is clearly to the south-westward, while at Bryson village this is as decidedly to the eastward and north-eastward. In the trough thus formed, and between the two outcrops of limestone, the heavy black hornblendic gneisses (5) come in, in a mountainous mass, and again form the highest member of the rock series.

Mountain range of gneiss bounding limestones.

Black hornblende gneisses.

Beyond the meadow just alluded to in the ninth range of Clarendon, the limestones (4) are entirely lost sight of, and the gneiss hills (3) suddenly flatten down, and the country becomes covered by the sand-drift. In fact, of the whole five divisions of rocks, the highest alone (5) continues to be exposed in a southward direction through Clarendon; but the boundary or outline of this may fairly be assumed to indicate the further course of the inferior divisions, and may be simply described by stating that the road from Bryson to Portage du Fort, in Litchfield, follows it closely to the westward, while in Clarendon, a line drawn between the twenty-second and twenty-third lots, and from the ninth to the first ranges, would very nearly coincide with its eastern outline. The average breadth thus given to this mass of rock is close upon three miles; but this, it must be remembered, is across a synclinal trough. Towards the Ottawa, and in proximity to Portage du Fort, this width rapidly diminishes, until at the shore of this river, and in the extreme front of Clarendon, the whole body of rock is confined between the mouth of a small stream in the twenty-fourth lot and the town-line of Litchfield. Directly across the Ottawa from this last position, and in Horton township, are seen the hills of black and rust-coloured rock, which there represent this division (5), and hence there is left no possible doubt as to the identity of the Horton and Ross and the Clarendon

Flat country.

Trough form of rocks.

Hills of black hornblende rocks.

and Litchfield synclinals. It may be further stated, respecting the limestones along the eastern border of this mass of rock in Clarendon, that no exposures were met with between the ninth, and third ranges, but that in this last range, and in proximity to the small stream just alluded to, running through the twenty-first, twenty-second and twenty-third lots, these again come in, in considerable body, striking westward towards the Ottawa River, and dipping clearly to the northward. The volume of gneiss (3) underlying these limestones, is likewise, again met with in the third range of Clarendon, on lots eleven to fifteen, where it strikes directly for the Ottawa or to the south-westward with vertical dip. The rocks here being well exposed, careful search was made for the lowest division of limestones, (2) but without success. Towards lots ten and eleven, in this same range, however, the limestones of (4) were suddenly encountered, and from this position were traced to the town-line of Bristol, striking in a general north and south direction, and dipping to the eastward. Thus, undoubtedly, these limestones are directly opposed to those just noted as running through the twenty-first, twenty-second, and twenty-third lots of this range, and the intervening gneiss must represent an anticlinal form of (3,) through which the lowest limestones (2) do not break. Now, as it was an exceedingly interesting point to determine the further course of this anticlinal of gneiss across the Ottawa, and to note the manner in which it connected with the Horton synclinal of limestones, some careful investigation was made in this direction, the general result of which I shall now briefly give.

Run of limestones concealed.

Volume of gneiss. (3)

Limestones. (4)

Anticlinal of gneiss.

On examining the second and first ranges of Clarendon to the shore of the river, this gneiss (3) was found to occupy a prominent position between the fifteenth and eleventh lots. It here runs into the Ottawa on a south-westerly strike, and lengthways with these lots; the dip continuing to be vertical. The width of the river at this part is close upon one mile and a-half, and its course is directly across the strike of the rocks. Standing on the shore of Clarendon, say on the twelfth or thirteenth lot, and looking directly across towards Horton, two points are visible, namely, Castleford post office, and Bonnechere Point, at the mouth of the Bonnechere River, both of which have already been referred to on page 257 of this report, and special attention directed to the reappearance there of red gneiss hills. These, undoubtedly, represent the extension of the Clarendon anticlinal across the Ottawa River; and this is a very important fact, for it clearly explains the non-appearance of the lowest limestone division (2) on the south side of the Horton and

Gneiss.

Red gneiss hills.

Ross trough. The distribution of this gneiss (3) to the westward of Castleford post office has already been described, and it has been stated that after passing to the southward of Renfrew village it expands in volume and occupies an immense area between the Bonnechere and Madawaska Rivers. Thus, a line which might be said to represent the axis of this anticlinal would pass straight through the centre of Clapham Township, and midway between the V-like bend of the Pickanock stream to "Otter Lake Farm," in Leslie; thence in a south-westerly direction through Thorne, and the centre of Clarendon Townships, to a point about midway between the mouth of the Bonnechere River and Castleford post office, in Horton; and lastly, from this point in a west-south-west direction, directly through Renfrew County. The sub-divisions of rocks which form the crown of this anticlinal along particular sections of this line, are as follows:—In Clapham township the lower division of gneiss (1) is the only rock brought up; at "Otter Lake Farm," and through the remaining portion of Leslie and Thorne the lowest limestone division (2) in their turn form the crown of the anticlinal, and continue to do so for some distance into Clarendon. These, then, taper out, and give place in the front portion of this township to the gneiss (3) which, as we have seen, continues to form the crown of this anticlinal into and through Renfrew County. In the great expanse, however, of this anticlinal to the westward, and between the Bonnechere and Madawaska Rivers, the ground has not yet been sufficiently investigated, and it is only natural to suppose that in this direction we shall yet find that the lower divisions of rocks (2 and 1) in their turn again re-appear, diverge, and give place to the still older syenitic series.

Immense area of gneiss.

Axis of Anticlinal.

Rocks forming crown of anticlinal.

More investigation required.

During these later and second investigations in connection with this anticlinal form in Renfrew County, an important fact was discovered which before had escaped observation. This was the existence of a third and intermediate trough of crystalline limestones, which runs into the southern portion of Horton Township from the Ottawa River, between the Bonnechere River and Sand Point. This consists simply of the limestones and hornblende-slates of (4), which lie in a synclinal depression of the gneiss of (3). The outline of this trough has yet to be made out. I may, however, state that there are indications through the township of Bagot which would make it probable that it runs through in the direction of Calabogie Lake, and possibly connects with the trough of similar rocks seen along the valley of the Madawaska.

Intermediate trough of limestones.

Pontiac County.

But to return to Pontiac County, which we left in tracing the anticlinal of gneiss (3) across from Clarendon to Horton. The limestones of (4,) on the eastern side of this anticlinal, occupy the whole front of Clarendon from the tenth to the first lots, and town-line of Bristol, then strike in a north-north-east and north direction, and dip at a steep angle to the eastward. This strike continues across the Ottawa, and in a south-south-west direction would clearly bring these limestones into junction with those just referred to in the southern portion of Horton Township, and there is no doubt but that these last represent a portion of the Clarendon band. On passing from lot ten to lot one, in Horton, this great volume of limestone is traversed from its base to its summit, and its identity with (4) is shown by the medial subdivision of black hornblende-slate which is well represented. At the line of Bristol Township this limestone is succeeded, first, by the black hornblendic gneiss (5), and next by the red granitic gneiss and crystalline limestone of still higher horizon, and thus, for the first time since leaving Lanark County, we again commence to ascend somewhat in the series. For the present, however, I wish still to confine my remarks to the great underlying band of limestone (4), and to explain as clearly as possible the distribution of this in the Ottawa Valley, and then northward as far as it was followed. From the position occupied then by this body of limestone in the first ten lots of Clarendon, its lower portion, as we have seen, crosses the Ottawa, and extends westward through Eastern Ontario in a number of ramifying synclinals; these we have already described. Its upper portion, however, keeps to the valley of the river, and skirts the whole front of Bristol Township, to its extreme south-eastern corner. We have already, on page 246 of this report, recorded the position of the front portion of this band, at the steamboat wharf at the terminus of the Pontiac Horse Railroad, and have shown that from this point it curves round and courses south-eastward, and then southward through Fitzroy township, and finally in this direction reaches and connects with the great Ramsay, Lanark and Dalhousie band of limestone.* Thus we find that were we to ignore the existence of the minor troughs or ramifications of the lower portion of this band of limestone, its direct course from Ramsay would carry it to the positions just given to it along the front of Bristol and south-eastern portion of Clarendon Townships, beyond which, as we have yet to show, it runs inland or northward for upwards of one hundred miles, and after describing a number of zig-zags, which, occasionally again cause it to approach the Ottawa River, it finally joins the Petite Nation and Grenville series.†

Limestones in Clarendon.

Connection with Horton limestones.

Higher portion of series.

Ramifying synclinals.

Connection of limestones with Grenville series.

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* Group IV., Report of Progress, 1874-75.

† See Report 1863-66, page 19, *et seq.*

Distribution of limestone in Ottawa and Pontiac Counties.

But it is desirable to give some details respecting the distribution of this band of limestone northward and north-eastward, through Pontiac and Ottawa Counties. In Clarendon, almost immediately upon leaving the river, another and extensive drift of yellow sand commences, and spreading over the greater portion of this township, conceals for some distance the outcrops of rock. The limestone, however, is again met with on the town line between Clarendon and Bristol, in the eighth concession, and at another point about three miles to the northward of this, in the eighth and ninth lots of the ninth and tenth concessions of the same township. In both these positions the strike is to the north-eastward and the dip to the south-eastward, and as the distance between these points closely corresponds to that across the whole outcrop in the first ten lots at the river shore, it is probable that these more inland exposures likewise show both the base and summit of this band of limestone. Beyond these positions in Clarendon, all trace of limestone is again lost in the flat, sandy country which immediately succeeds to the northward; but in Bristol Township, to the eastward of Clarendon, exposures of the limestone were observed for some distance in the seventh and eighth concessions, and these all indicated an easterly strike and southerly dip. To the northward of these, again, and in the twelfth concession of the same township, a marble quarry has been opened upon a very extensive body of beautifully banded limestone, which strikes in a north-westerly direction, with low north-eastward dip. Now, this strike and dip being directly opposed to that exhibited by the limestones in the seventh and eighth concessions, it is clear that between these two positions there must exist an anticlinal, of which the general course of the Quio stream would represent the axis. Of this anticlinal, however, there is not the slightest surface evidence, but rather, on the contrary, the conditions of the intervening country would lead one to conjecture a synclinal form. Depressions on the crowns of anticlinal forms are, however, by no means an uncommon feature in the structure of the Laurentian system. Another opening in an outcrop of limestone near the town-line of Onslow, but in the tenth concession of Bristol, further defined the eastward run of this band, and here are found indications of its folding over the axis of an anticlinal.

Limestones lost sight of.

Marble quarry.

Anticlinal.

We, therefore, may safely state, that from the eighth and ninth concessions of Clarendon this great band of limestone, representing (4) is suddenly thrown almost entirely across the township of Bristol in a deep and V-shaped anticlinal, which ultimately carries its outcrop

V-shaped anticlinal in Bristol.

through the twelfth concession of this township, and into the first five or six lots in the thirteenth concession of that first named. Upon mapping this V-shaped portion of these limestones in Bristol, I was not surprised to observe that it exactly corresponded with the anticlinal form of the same division of rocks in Litchfield Township, and that the line representing the axis of the one, when extended, met that which might be said to represent the axis of the other. This line measures close upon twenty-two miles, and runs in a direct north-west and south-east direction. In the thirteenth concession of Clarendon, and through the first five lots, this band of limestone is again well exposed, and here it is clearly seen to overlie the volume of gneiss (3), which forms a mountain range to the southward of it, and along the northern side of the Quio stream, through the twelfth concession of the same township. The strike of both divisions of rock (3 and 4) is here clearly to the north-westward, with rather flat-lying dip to the north-eastward. From this position, these rocks continue to be well exposed up through the centre of the first half of the townships of Thorne, in ranges A and B, and through the eastern portion of the northern half of the same township, whence they enter the south-eastern corner of Leslie. In this direction the country is mountainous, but both gneiss and limestone (3 and 4) lie at a very low angle, the dip seldom exceeding 25°, and being often very much less. The lowest division of limestones (2) are first again clearly recognized towards the eastern extremity of "Farm Lake," between the second and third concessions of Leslie, where they are arranged in a very nearly horizontal attitude, and occupy a considerable area from this position westward to "Otter Lake Farm." In this area, there undoubtedly exists an anticlinal of this division (2) of rocks, resulting from the junction of the opposite outcrops, where these fold over the Clapham anticlinal of the lower gneisses (1). At the eastern end of Robinson's Lake, in the seventh concession of Thorne, the limestones of (4) contain a large amount of serpentine and pyrallolite, which weathers out into a variety of shapes on the surfaces of the beds. Close search was made here for traces of Eozoon, but without success. From Leslie, and north-eastward, much difficulty was experienced in satisfactorily identifying the respective subdivisions of rocks; a difficulty mainly attributable to their nearly horizontal attitude, and to the extensive drifts of sand which here everywhere cover them. But the outline of the lower gneisses (1) being clearly defined, the positions of the succeeding divisions could generally be sufficiently closely ascertained.

Bristol anticlinal of limestones.

Axis of anticlinal.

Slight dip.

Serpentine and pyrallolite.

I may then briefly state, that from Clapham, the eastern margin of the red gneisses (1) continues in a general north-easterly direction—with a few slight deviations—to Lac Mer Bleue above Dorion Township; whence following the general course of Eagle Creek, it occupies a position in the western portions of Maniwaki and Eagan Townships, and finally reaches the "Forks" of the Gatineau some eighty miles north of the Desert Settlement. Westward of this line, go where you will, no other rocks than gneiss and syenite are to be met with, and the whole country in this direction is of the most rugged and barren description. In Eagan Township, and between the Desert River, on its north and south course, and the Gatineau River, the yellowish quartz and orthoclase rocks, and mica-spangled limestones of (2), are widely expanded, and lie in a very nearly horizontal attitude, while on the Gatineau, and winding along the course of this river to the northward, we have abundant indications of the limestones and black hornblende-rocks of (4). At the Desert settlement, the limestone again abounds in serpentine, and presents singular forms on its weathered surface.

Barren gneiss area.

Serpentine limestone.

The further course of these rocks, from the mouth of the Desert, has yet to be made out in detail, but I have already gathered sufficient evidence to allow me to state, that the limestones continue as far northward as the "Forks" of the Gatineau, where, or in proximity to which, they turn and traverse the country to the east of the Gatineau in a general south-easterly direction towards the Riviere aux Lievres. Thus, in the country between the upper portions of these two rivers—the Gatineau and the Lievres—there must exist a great synclinal of rocks, comprising not only the divisions from (1) to (5), which I have so far been describing, but also several other and higher divisions of rocks to which I have yet to refer.

Turn of the limestones on the Gatineau River.

Having thus given the run of the limestones of (4) from the front of Clarendon to the Desert River, a distance of about sixty-two miles, in a direct line, I may next proceed, briefly, to describe the divisions of rocks which succeed and overlie these eastward, through the western portion of Ottawa County, and towards the Gatineau River. Work, however, in this direction is still in progress, and what is now stated must be in the form of a simple *resume* of the explorations as completed in 1876. The area, then, which I would now particularly refer to is that triangular one which would be enclosed by a line drawn from the south-eastern corner of Clarendon Township to the mouth of the Desert River, on the Gatineau, and the valley of this last named river, from the Desert to the Ottawa, in Hull Township.

Rocks overlying (4) limestones.

1876 field-work.

In this section of country, the rocks present a steadily ascending sequence in passing from west to east, and their strike conforms to that of the divisions of rock just traced through to the Desert settlement. The deep V-shaped anticlinal form in Bristol Township, affects the strata all the way to the mouth of the Gatineau, but with this exception the rocks strike, on the whole, steadily to the north-eastward, with, almost invariably, slight dip to the south-eastward.

Limestones in Bristol.

The rocks met with consist of alternations of gneiss, crystalline limestone and pyroxenic strata, in which are interstratified a number of zones of rust-coloured rock or *fahlbands*, and three or more horizons of magnetic iron ore. These rocks, undoubtedly, correspond to those included in Groups V. and VI. of my last report,* of which a detailed section, in ascending order, was given. (See pages 151, 152.) In Lanark County, it will be remembered, these rocks disappear under the Lower Silurian formation in the south-eastern portion of Ramsay Township, but continue occasionally to protrude through this formation in the form of isolated knols and ridges in the direction of Fitzroy Harbour on the Ottawa. Thence, they clearly pass directly across this river into Bristol Township, and occupy the whole of the triangular area just referred to west of the Gatineau. We have already seen that these rocks, with the exception of their very lowest division (5), do not participate in the synclinal forms described by the lower limestones up the Ottawa Valley, but this suggests no want of conformity between these higher and lower subdivisions of rock, as the front or upper outline of the limestone (4) conforms perfectly to the outline of the base of the succeeding series everywhere through Lanark, Pontiac and Ottawa counties. In passing, then, say from "Otter Lake Farm," in Leslie, south-eastward to the Gatineau, we find just the same sequence of rocks as we had heretofore studied in Frontenac and Lanark Counties, and more particularly in the townships of Olden, Oso, South Sherbrooke, Bathurst, North Crosby and North Burgess. A general section of these rocks is given on page 152 of my last report,† and as this still holds good for the region of country at present under consideration, I need only here again direct your attention to it. As in Lanark County, so in the county of Ottawa, this gneiss and limestone series terminates in apatite-bearing rocks. These occur between the lower portions of the Gatineau and Aux Lievres Rivers, and in the townships of Hull, Templeton, Buckingham and Portland. Here the rocks are again

Rust-colored zones and magnetic iron.

General section of rocks.

Apatite-bearing rocks.

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* Report of Progress, 1874-75.

† See same Report.

arranged in synclinals, but these do not appear to be of so superficial a character as those in North Burgess.

Iron Ore Horizons.

Iron ores.

The iron ore horizons, marked by the Forsythe, Balwin and Haycock mines, in Hull and Templeton, are in precisely the same relative stratigraphical position as are the magnetic iron ore horizons of South Sherbrooke and North Crosby, as illustrated by the Silver Lake, Meyer's or Christie's Lake, Fournier's and Allan's mines. These iron horizons are clearly beneath the true apatite-bearing rocks, although a few deposits of this last mineral have been found occasionally associated with and beneath them. One feature in connection with the iron ore deposits in the Ottawa section should be mentioned. This is the intermixture and interstratification of hematite with the magnetite. In no one instance does this condition occur in the corresponding iron horizons in South Sherbrooke, or North Crosby, where the ore is invariably a crystalline magnetite, varying, of course, in purity, but without a trace of hematite. Hematite frequently occurs, however, in Lanark County, both below and above the magnetic ore horizons, but always by itself, or in association with apatite and pyrites. In North Burgess, and in some of the openings made for apatite, I have frequently observed a large admixture of a finely-crystalline hematite, which coloured the apatite a deep red. Again, in Bathurst, and in the Foley mine, apatite occurs with coarsely crystalline magnetite, but here there is not a trace of hematite. The Haycock mine, in Hull and Templeton, is on a deposit consisting of magnetite and hematite intimately associated, which belongs to an horizon corresponding to that in North Burgess, in which hematite, pyrites and apatite are intermingled. This appearance and disappearance of hematite in the same horizon is an interesting point, and one which I think is not yet quite understood. The Hull iron mines were not being worked during my investigations in 1876, nor were the Haycock iron ore deposits, and I, therefore, have nothing to add to what has been already published concerning these, except to state that the horizons in which these ores occur were connectedly traced for upwards of sixty miles in a northward direction. On this course, however, only a few further indications of the ore were met with, and none of these of importance. The country, however, is not favourable to close exploration, and there is little doubt but that in this direction other large deposits of magnetite and hematite will yet be discovered. It is much to be regretted that work has not been continued at the Forsythe and

Hematite and magnetite.

Foley mine.

Haycock mine.

Hull mines not worked.

Further discoveries probable.

Baldwin Mines, as upon the success of these depends the future prospects of all iron ore mining in the Ottawa section.

Forsythe and Baldwin mines

The distance between the South Sherbrooke and Hull deposits of iron ore is, in a direct line, close upon fifty-six miles; and although no other deposits of ore of any importance occur between these positions, this is mainly owing to the fact that most of the intermediate country is occupied by the flat-lying rocks of the Lower Silurian formation, which, of course, entirely conceal the lower crystalline rocks. The very fact, however, that iron ore occurs in workable quantity in Hull Township, and immediately where the crystalline limestones and gneisses first again become well exposed, appears to me to give considerable encouragement to those interested in this ore, respecting its permanency in certain horizons of rock; but until some one or more of the deposits have been thoroughly and systematically mined for some time, we cannot say what the prospects are of the continuance of the ore in depth. It must be borne in mind that iron ore, though often in all appearance a clearly interstratified mass, is not a continuous deposit. It may occur at intervals for many miles in a section of country, and yet between the exposures of ore there may not be the slightest indication of its existence. Most of the large deposits of iron ore in Eastern Ontario and in Ottawa County are exceptional occurrences, and their unusual extent is due to the recurrence of the outcrops of ore on anticlinal and on synclinal folds of the strata. For example, the "Big Ore Bed" in Belmont, exhibits an anticlinal and synclinal fold; the "Seymour Ore Bed" in Madoc is a decided synclinal, in which two outcrops of iron ore, each fifteen feet in thickness, are sharply folded, the one upon the other; while the great "Hull Iron Ore Bed" consists of an anticlinal of magnetic ore, through which breaks an inferior band of crystalline limestone. So often, indeed, is the importance of an iron ore deposit due to one or other of these forms, that I have for some time been in the habit of directing prospectors to such points as those in which the strata folded over or under the axis of an anticlinal or synclinal, and so far many of the trials made at these points have been successful. Dislocations of the strata, or faults with their accompanying dykes and lodes, have also much to do with some of the larger deposits of iron ore, but on this point we cannot at present enlarge. The iron mines in Bristol township belong to a very much lower horizon than that on which the "Hull Iron Mines" are situated. They have not been worked for some years, and the openings were all full of water and *debris* at the date of my visit to them in 1876. The deposits of ore here are quite superficial, and con-

Iron ore not a continuous deposit.

"Big Ore Bed" Belmont.

Bristol iron mines.

sequently are not of great promise. They appear to be kept at the surface by undulations of the strata, and a considerable quantity of ore has been obtained without any deep mining. The horizon in which these mines occur appears to correspond with that on which the "Foley Mine," in Bathurst, is situated, but in Bristol, as yet, apatite has not been found associated with the iron ore.

Iron ore at Post Creek, Gatineau.

The most northerly position in which iron ore was met with by us in 1876 was on, or in proximity to, Post Creek, in Cameron township, and between the Gatineau and 31-mile (Big) Lake. This point is about fifty-four miles in a direct north line from the Ottawa River. The ore occurs in straggling and irregular deposits at the junction of crystalline limestone and gneiss, and was traced by frequent exposures southward to the mouth of the Kazabazua, between the townships of Aylwin and Hincks. The horizon in which the ore occurs here is, undoubtedly, the northward extension of that on which the "Hull mines" are situated.

Horizon of ore.

Further Distribution of Crystalline Limestones.

As I have already stated, investigations are still in progress throughout the whole of this district of country, and it will require another season's field-work before details respecting the general geological structure of the region can be given. I may, however, mention that on a south-east section, made from Post Creek, on the Gatineau, through Cameron, Blake and Hincks Townships to White Fish Lake, four important belts of crystalline limestone were met with, namely:—one on the general course of the valley of the Gatineau, which I may for convenience here call the Gatineau band; a second midway between the Gatineau and 31-Mile (Big) Lake; a third through this last-named lake, and a fourth along the north-western shore of White Fish Lake.* These bands of limestone are separated by important volumes of gneiss, which, however, all partake of the same, or nearly the same, lithological characters; and I must also add that the limestones do not present any special characters by which one band could be distinguished from the other. The fourth and highest band, namely—that through White Fish Lake—is, perhaps, more highly charged with serpentine than any of the others, and with this mineral chrysotile is frequently largely associated. Beneath the whole of these four bands of limestone, and to the westward of the line of section just given, occur the limestones of my first described subdivisions

Investigations still in progress.

Four belts of limestone.

Serpentine in limestone.

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* This White Fish Lake band has since been found to be a repetition of that through 31-Mile (Big) Lake on the opposite side of a great synclinal form. (See map.)—H. G. V.

Six belts of limestone.

(2) and (4,) thus, making in all six stratigraphically distinct belts of crystalline limestone. Now, it will at once be observed that this number exceeds by two that given by Sir W. E. Logan in the Geology of Canada, as the probable number of the limestone bands in the area examined by him in the counties of Argenteuil and Grenville. A fifth band was, indeed, met with in this eastern section of country; but this, the "Proctor's Lake" band, when referred to by Sir William, was mentioned as "too small for separate consideration." This, possibly, may be included among my six bands of limestone in the Ottawa County section, but if so, I can only state that it must have considerably increased in volume between the position in which Sir William observed it, and where I met with it, as all of the six bands referred to by me in Ottawa County are distinct and important strata. I have, however, reasons for concluding that Sir W. E. Logan did not meet with my lowest calcareous division (2), and that this is not included in his four great bands of limestone; or, on the other hand, there is just a possibility that where this may have been come upon, it has been considered as a low portion of his first and lowest limestone. Certainly, this first limestone band—the Trembling Lake band—as described by Sir William, bears a striking resemblance to my second (division 4) belt of limestone, and I do not think I am far astray in considering them to be identical. Thus, by adding my limestones (2) to Sir William's section, and by giving greater prominence to his "Proctor's Lake" band, both sections are made to agree in showing six bands of limestone, and five separating volumes of gneiss. If a line were drawn from Mer Bleue Lake—immediately above Dorion Township, in Pontiac County—south-eastward' through Ottawa County to the centre of Bigelow Township, it would traverse this whole series of rocks from the lowest gneisses (1) to the very uppermost limestone, which in Bigelow Township lies in a synclinal and marks the summit of the system. Such a line would measure nearly thirty miles, throughout the whole of which distance the rocks present a steadily ascending sequence; but the angle of dip is almost invariably slight. Were this otherwise, or were the dip, as a general rule, vertical or steep, a line of ten or twelve miles would be sufficient to embrace every outcrop of rock from the base to the summit of the series. Perhaps it is proceeding a step too far to attempt at present to estimate, even in a general way, the total thickness presented by this great series of crystalline rocks; but as such an estimate will serve as a basis upon which to compare future calculations, I may state, that from careful comparisons of estimates

Limestones compared with those in Argenteuil and Grenville.

Agreement of sequence in both places.

Estimate of total thickness of series 50,000 to 60,000 feet.

made in some four or five widely separated positions, it would appear that the whole volume is not less than between 50,000 and 60,000 feet; and this estimate does not include the great fundamental gneiss and syenite series, but commences only with the first strata of clearly stratified gneiss. The thickness of the great underlying gneiss and syenite series—which, for the sake of convenience in future descriptions, may be represented by the letter A, it is at present impossible to estimate.

Rocks between Whitefish Lake and Lievres River.

I should, perhaps, have stated more clearly that my reasons for considering the Whitefish Lake band of limestone the highest in the series are, that to the eastward of this position, in Bigelow Township, the axis of a great trough or synclinal was observed, and the Whitefish Lake rocks are all repeated at the surface to the eastward of the Aux Lievres River. Thus in journeying from Bigelow Township in an easterly direction, we again descended in the series, and encountered, one after another, the opposite outcrops of the same bands of limestone which had been previously traced out to the west of Whitefish Lake. It is clear that another great anticlinal of the lower gneisses (1) occurs to the eastward of the Aux Lievres River, and through the townships—recently laid out—of Kingsland, Killally and Bidwell, and over which the succeeding series of gneiss and limestones would fold somewhere in proximity to the township of Lathbury, to the rear of Lochaber, and thence join in with the rocks of the Petite Nation Seigniory synclinal, as traced out and mapped by Sir W. E. Logan. Thus, in Ottawa County we have one great central anticlinal and two adjacent synclinal forms, the axes of all of which run in a general north and south direction. The western or Gatineau and Aux Lievres synclinal is much the more extensive of these two, both as regards its northward extent and its east and west breadth. It reaches the "Forks" of the Gatineau River at a distance of between 160 and 200 miles from the Ottawa, and may even extend further. The second, or Petite Nation Seigniory synclinal, is not one-half the length of the first, and does not extend much further north than Lake Nomining, situated about thirty-six miles north of the northern boundary of this Seigniory and about fifty-four miles from the Ottawa. Much work has yet to be done before this beautiful piece of geological structure can be properly delineated upon the map, and the connection of all the outcrops of rock shown throughout the counties of Pontiac, Ottawa and Argenteuil; but sufficient has already been accomplished to prove that the whole of the rocks in these counties are simply the eastward extension of those which are so

Anticlinal of lower gneisses.

Gatineau and Lievres synclinal.

Petite Nation synclinal.

More work required.

largely developed in Eastern Ontario, and on which my reports have treated now for a number of years. The chief point of interest now left to determine is the stratigraphical position of the labradorite rocks which have been found to the eastward of Argenteuil County, and to note whether or not these constitute a distinct and unconformable system to those we have been describing in the present report. If so, then these last constitute a middle series between the Lower and Upper Laurentian; but if not, that is, should these labradorites prove to be but a portion of this gneiss and limestone series, then we shall simply have a Lower and an Upper Laurentian system.

Position of the Labradorite rocks.

Lower and Upper Laurentian

III.

THE APATITE AND PLUMBAGO DEPOSITS OF BUCKINGHAM, PORTLAND, TEMPLETON AND HULL TOWNSHIPS, OTTAWA COUNTY.

In the immediately preceding section of this report, the iron ores of Ottawa County have been referred to, and I shall now proceed to consider the economic deposits next in importance, namely—those of apatite or phosphate of lime, and plumbago or graphite. Much information respecting the latter has already been given in previous reports of the Geological Survey, more particularly in the Geology of Canada (1863), and Report of Progress for the years 1863-66. The latter contains Sir W. E. Logan's notices of the plumbago deposits of Buckingham Township, which include several that were afterwards somewhat extensively worked. When the reports referred to were written, however, very little was known respecting the relative stratigraphical position of the apatite and plumbago deposits, nor had the geological structure of the immediately surrounding section of country been worked out. I shall now review all the more important of these deposits, showing the mining that has been done on them up to the present time, (close of 1876,) and point out their true stratigraphical position.

Previous reports on apatite.

Apatite or Phosphate of Lime.

The mining for this mineral in the Ottawa section of country, is of comparatively recent date, and except in one or two of my late reports, it has been but little noticed. The rocks in which it occurs occupy a distinct position, geologically and geographically, from those in which the plumbago deposits are found, and recently they have been proved to belong to a higher portion of the series. In Buckingham and Templeton Townships, the apatite is confined to a belt of rocks averaging about one

Position of apatite-bearing rocks.

and three-quarters of a mile in width, which runs in a general north-easterly direction from Perkin's Mills, on the Blanche River, near the centre of Templeton, through the extreme north-western corner of Buckingham, and thence across the Aux Lievres River, through the south-eastern corner of Portland, into about the central portion of Derry Township. This belt is very productive, and yields a finer quality of apatite than I have yet met with in any other section of country. On it are situated all the apatite mines of any importance which have so far been opened, and it will be in the repetition of it, on the opposite sides of anticlinal and synclinal folds of the strata, that other similar deposits will probably yet be discovered. I shall now enumerate the properties upon which apatite has been found and worked in Buckingham, Portland and Templeton.*

Portland Township.

Portland, Range I., Lot 7.—This lot is the property of the Buckingham Mining Company, and was being worked for this company under the superintendence of Peter Powers, formerly of North Burgess. Here there are twenty-four or more openings, some of which are exceedingly promising. They are all towards the rear portion of this lot, and on the north-east side of the Aux Lievres River. The largest and, so far, the most important opening, is situated close to the line between the first and second ranges. It is a pit of irregular width, and about ten or twelve feet deep, on a very beautiful deposit of a clear bluish-green crystalline apatite, which, in places, measures from twenty to twenty-four feet across what is supposed to be its strike; but like all apatite deposits it is very irregular, and cannot be depended upon one yard beyond where it is actually seen. Strings or layers of apatite, two, three or six inches in thickness are observed in the distance of a few yards to expand into masses measuring several feet in thickness, which on further stripping as suddenly disappear. From the opening just referred to, a trench has been carried for about fifty yards in an east and west direction, throughout which distance a fair amount of apatite has been uncovered. In the main or central opening there is a great deal of a very black mica, in large sized crystals, and this rather adds to the cost of mining, owing to its being scattered thickly through some of the best portions of the deposit. Calcite, however, which is often present in large quantity in some of these deposits, appears to be almost entirely absent in that now referred to, and very

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* It must be borne in mind that the above remarks were made at the close of 1876, when the phosphate enterprise had but just been started. A forthcoming report will show the very extensive area now worked over for this mineral. The map, however, which accompanies the present report, contains much of this additional information.

large masses of apatite have been extracted from it without any visible impurity. The mica is of no economic value, it being almost black, and the faces of the crystals much warped, and cut by jointings or faults. The enclosing and adjacent rock, is a light brownish-weathering mixture of pyroxene, feldspar and quartz. This deposit was only discovered in July, 1876, and upwards of one hundred tons of No. 1 apatite have since been taken from it. Of this amount sixty-eight tons were shipped to England by the Buckingham Mining Company. Towards the Aux Lievres River, and on the same lot, a number of other openings have been made, in all of which apatite was found, but occurring in a most irregular manner, through a rock largely composed of greenish-grey, granular pyroxene or *coccolite*, associated with a great deal of white or translucent quartz and coarsely crystalline, red orthoclase rock. The same kind of rock, with traces of apatite, runs through to the shore of the river at the " Little Rapids" on Lot 8, Range II., of Portland, where mining was also at one time attempted, but soon abandoned*

Portland Township.

Portland, Lot 6, Range II.—On this lot apatite is being mined by Mr. Watt, formerly of North Burgess. It occurs in a number of places, and under similar conditions to that just referred to. The deposits here are clearly an extension of those on Lot 7, Range I. Apatite also occurs upon Lot 7, Range II., but here very little exploration has yet been made.

Buckingham Township.

Buckingham, Lot 27, Range XII.—This lot is also owned by the Buckingham Mining Company, and is of considerable promise. So far little more than prospecting has been done on it; but this has brought to light very many promising surface deposits. The rocks on this lot are the direct south-westward extension of those on Lot 7, Range I. of Portland, and there is every reason for supposing that the apatite also extends from one lot to the other.

Buckingham, Lot 28, Range XII.—On this lot there are also several fair surface *shows* of apatite, but beyond uncovering them very little has been done on any of these. They are an extension of those on lot twenty-seven of the same range.

Miller's openings.

From this position, this particular zone of apatite-bearing rock runs directly through towards the centre of Templeton township, but in this direction there are no further openings until we reach Perkins' Mill, on the Blanche, where apatite has again been discovered, and is being mined by Mr. Miller on lot fifteen in the eighth range. †

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* See Report of Progress, 1873-74, page 144, *et seq.*

† There are now upwards of 150 openings on phosphate of lime deposits in Templeton.—H. G. V.

The properties so far enumerated occur along the most northerly of two productive zones in the apatite-bearing belt. The other is situated about one mile and three-quarters to the southward, and is well defined by some very important mining locations. These are as follows:—

Buckingham Township.

Buckingham, Lots 17, 18 and 19, *Range XII.*—These lots, with the exception of the south half of lot eighteen—which is the property of Dr. J. A. Grant, of Ottawa—belong, again to the Buckingham Mining Company. This location I have once before alluded to in the Report of Progress for the years 1873-74, page 145, but much work has since then been done, and several new deposits of apatite discovered. Indeed, at the date of the report just cited, apatite was only known to occur in some two or three places in the whole township. On these lots the best *shows* of the mineral occur on the first part of lot nineteen, and central portion of eighteen. Here, a large part of it is in the form of crystals, of every size, but there are also large bed-like deposits. The apatite is here very much discoloured by iron rust, probably due to the decomposition of pyrites; and this feature, and the occurrence of aggregations of crystals, especially characterise this horizon throughout. Crystals of apatite were not observed to any extent in the first or last described horizon, where the mineral appears to have been deposited under somewhat different conditions.

Rust-coloured apatite.

On first examining the rust-coloured apatite deposits, on lots eighteen and nineteen of the Buckingham Mining Company's property, I was not favourably impressed with their appearance, as it seemed probable that so large an admixture of iron would lessen their market value. This, however, does not appear to be the case, as Mr. Stephenson, the General Manager of the company, subsequently informed me that specimens of the most unpromising appearance, analysed by Prof. Chapman, returned an exceedingly high per centage; still, I am not altogether satisfied that this laboratory test completely proves that the value of the deposit, as a whole, is not more or less injured by this foreign admixture. A shipment of some fifty or sixty tons, however, has been made to England, and the result will soon be known. Calcite is almost invariably present in these ferruginous deposits, and often forms the matrix in which the crystals of apatite are embedded. Through the fronts or southern parts of lots eighteen and nineteen there are a few small bands of crystalline apatite, with further indications of rust-coloured strata, and as past experience in the North Burgess field has clearly shown that when these come in the apatite "gives out," I should judge that on the lots just enumerated we are upon the southern limit of the apatite-bearing belt. Towards the front of lot nineteen a large opening has been made, and a quantity of apatite removed from what appears to be a very extensive bed. Close by, a second opening reveals a deposit measuring from ten to twelve feet across, and another of seven feet; this last is not ferruginous, but is of a clear bluish-green colour. On the same lot there is quite a mountain of rock, and throughout the whole of this, apatite occurs in more or less abundance. The fact is, however, still evident that none of the deposits are regular or well defined, and are only discovered by haphazard workings, and when thus found there is no certainty of their extending beyond where they are actually seen. Dr. Grant's property—the south half of lot eighteen—contains some fair *shows* of the mineral, but very little work has been done on it since I last examined it. This lot is particularly favourably located as regards shipment by the Aux Lievres River to Buckingham. On the north half of the same lot but little work has been done as yet, but the apatite shows in many places. Towards the centre of the lot, crystals are abundant, some of which are of an extraordinary size, and a pink or flesh-coloured carbonate of lime occurs in considerable quantity. One of the large crystals obtained here was forwarded to Philadelphia, and weighed upwards of sixty-five pounds. I observed fragments of other crystals on the ground, which when complete, could not have been much less than four or five hundred pounds in weight. This apatite crystal-bearing horizon is a most interesting one, but does not differ in any marked manner from one or two which were met with on the Rideau, in North Burgess, Ontario.*

Buckingham.

Buckingham, Lot 17, the last of the Buckingham Mining Company's, was being prospected at the time of my visit. A number of strippings had been made upon layers and masses of apatite, some of which were of great promise. Nearly all of it is of a deep rust-colour, and a large proportion is in the form of crystals. Pyrites was also visibly present in much of the rock thrown out of the openings, and the general conditions of the deposits is similar to that of those exhibited on lots eighteen and nineteen. A very beautiful greenish-black pyroxene, in large crystals, resembling a black form of apatite, also occurs in some abundance on lot seventeen. Specimens of this were collected and submitted to Dr. Harrington for examination. A large amount of mica, of a much lighter colour than any I have yet met with in Buckingham, also occurs on this lot. The openings on lots seventeen, eighteen and nineteen, in the

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* This mining location of the Buckingham Mining Company at present appears to surpass anything that has yet been discovered.

twelfth range of Buckingham—just described—are situated about two miles and a-half to the south-eastward of those previously referred to in Portland, and the two positions may be considered to represent, in this particular section, the width of the apatite-bearing belt of rocks. The rock through the intermediate portion of country appears to be barren of all mineral, or, at least, it has not been found so far. We thus have clearly two distinct horizons on which to search for further deposits, either of which having been discovered, the other may be closely calculated upon.

Buckingham.

Buckingham, Lots 18, 19, 20 and 22, *Range IX.*—Mr. Gerald C. Brown, formerly of Perth, to whom the Geological Survey has been much indebted for information relative to mining matters in Burgess and Dalhousie, has been actively engaged in apatite mining in the eleventh range of Buckingham. He first worked the northern parts of lots eighteen and nineteen, on the northeast side of the Aux Lievres River, and immediately abutting the same numbered lots in the twelfth range. On these lots a great deal of apatite was mined from deposits in every respect similar in character to those already described. Openings were also made on promising deposits in the northern parts of lots twenty-one and twenty-two, more especially the former, and these also resembled, in general conditions, those on lots eighteen and nineteen, in the twelfth range. Here, again, much of the apatite is strongly rust-coloured, and a zone of rock thus coloured can be traced directly through into the Buckingham Mining Company's location, in the twelfth range, the strike being in a general north-east and south-west direction.

Buckingham.

Buckingham, Lot 25, *Range X.*—The apatite on this lot was also discovered and opened up by Mr. Brown. It is on the south-westward extension of the rust-coloured belt which crosses the northern parts of lots twenty and twenty-one, in the eleventh range. On this lot there is a mountain known by the name of the "Burnt Mountain," of rotten rust-coloured pyroxenic gneiss; and in this apatite occurs in a similar manner to that already described. At the date of my visit to Buckingham, Mr. Brown was prospecting in this direction, and had suspended his operations on lots eighteen and nineteen, in the eleventh range. The distance between the two productive horizons of apatite, up to the twenty-fifth lot, in the tenth range, remains about the same as has been already given, namely—about two miles and a-half, and so far no deposits of any importance have been discovered in the intermediate strip of country.

South of the tenth range of Buckingham, apatite has not been found

Extension of the apatite belt.

in workable deposits, but in some places apatite crystals are embedded in the calcareous *gangue* of the plumbago veins. From the twenty-fifth lot, in the tenth range, apatite continues to show in scattered surface exposures to the first, second and third lots, in the twelfth range of Templeton, whence the belt passes into the eleventh range, and runs on a more southerly course through the eastern side of this township. Unfortunately, in this southward course of the rocks toward the Ottawa, the country falls away and becomes much covered by soil, and, consequently, any deposits of apatite which may occur in this direction will probably never be brought to light. On the north-eastward extension of the apatite-bearing belt from Buckingham, however, or through the south-western portion of Derry, the country is high and mountainous, and the rocks are favourably disposed for prospecting. I expect much from future discoveries in this direction, but to be successful, prospecting must be conducted systematically, and with some knowledge of the stratigraphical position of the two productive belts of apatite-bearing rock. Prospectors will also do well to bear in mind that the apatite-bearing rocks do not extend for an interminable distance north-eastward, but on the contrary, very early on their course through Derry, turn first to the northward and then to the north-westward, and finally return to the Aux Lievres River, and crosses to the opposite shore, some distance below the "High Falls," situated immediately to the north of the township of Portland, and about twenty-five miles from the village of Buckingham.

Cost of Mining and Transport of Apatite from Buckingham to Montreal and Portland.

Cost of mining and carriage.

The Buckingham Mining Company have made some shipments of apatite to England, and Mr. W. H. Stephenson informs me the total cost was as follows:—

Mining	$4.00 to	$5.00	per ton
Drawing to barge	—	50	"
Freight to Buckingham	—	50	"
Drawing to wharf, Ottawa River	—	50	"
Freight to Montreal	1.00 to	1.25	"
Handling, &c., Montreal	—	50	"
Freight to England	—	4.00	"
Further handling, &c.	—	75	"
		$13.00	

In winter, when the mineral is drawn directly from the mines to the Ottawa, the cost is about the same.*

Apatite in Hull and Wakefield.

Additional localities of apatite.

On the repetition of this same belt of apatite-bearing rock, on the opposite side of a trough or synclinal form, in the townships of Hull and Wakefield, the mineral has recently been discovered in some two or three localities, but there are, as yet, no openings worthy of the name of mines. On the south half of lot three, in the thirteenth range of Hull, Mr. Haycock, of Ottawa, has uncovered some very irregular deposits of apatite. From what I saw on this lot, I should judge that neither of the productive belts of rock had been reached, but the occurrence of the apatite here is, however, encouraging. Some small openings have also been made on the northern parts of lots four and five, in the eleventh range, which, I believe, also afforded indications of the mineral. In Wakefield, and not far from the town-line of Hull, on lots fourteen and fifteen of the first range, some slight work has recently been engaged in by Mr. G. Clark, of Ottawa. The apatite here appears to be of excellent quality, but as yet there has not been enough done to justify any conclusions as to the extent of the deposits. At present there are no locations in either Hull or Wakefield at all comparable to the majority of those in Buckingham and Portland Townships; but as the horizon of rock is the same in all of these places, there are no reasons why apatite should not yet be discovered in workable deposits, not only in Hull and Wakefield, but northward for some distance along the course of the Gatineau.†

Plumbago or Graphite.

Character of plumbago-bearing rocks.

The true plumbago-bearing rocks, in Buckingham, occur to the south-eastward of the apatite-bearing belt, and occupy a very large area in this and Lochaber Townships. They consist of rust-coloured plumbaginous schists, hornblende slates, strata almost entirely composed of quartz and feldspar, pyroxenic gneisses, and brown-weathering, crystalline limestones, with pyroxene, mica, pyrites and graphite. All these rocks are deeply rust-coloured, a feature which appears to be due to the decomposition of pyrites. The limestones are peculiar and unlike the generality of those elsewhere met with in this series. They weather to

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* This was merely an experimental shipment. Transport of ore now effected by the Ottawa & O. R.R. at the rate of $1 a ton to Montreal.—Feby., 1878.—H.G.V.

† Both Hull and Wakefield now yield largely, and the openings are almost innumerable. See map.

a yellowish-brown colour, and are filled with fragments of a dark-greenish pyroxene rock. In Buckingham these rocks appear to be on the summit of an anticlinal form, and hence their very great development. The manner in which the plumbago occurs is already well known. The beds in which the mineral is thickly disseminated, are the most important next the true or fissure veins, and lastly the irregular deposits embedded in the crystalline limestones, or at the junction of these with other rocks. As in the apatite-bearing belt, so in this, there are two horizons which are especially productive of mineral, but as there are indications of an anticlinal fold, it is extremely probable that the one horizon is simply a repetition of the other. Very little was being done either in the mining or preparing of plumbago during the year 1876; in fact, excepting the work on the Dominion Mining Company's location, some stripping and prospecting done by the Buckingham Mining Company, and some mining conducted on one lot by Mr. Miller, all other locations stood idle and unworked, not only in Buckingham, but also in Lochaber. The mill of the old Canada Plumbago Company, now the Montreal Plumbago Mining Company, had been destroyed by fire, and this location, with its extensive openings yet rich in plumbago, had been abandoned.

Distribution of plumbago.

Localities examined and worked.

Messrs. Pew & Weart's location, which adjoins that of the Montreal Company, and from which some 200 barrels of pure lump plumbago had at one time been taken, lies in the same state of desertion, and all the openings are filled with *debris* and water. The openings also made some years ago by Mr. Labouglie, and known as the St. Louis and St. Mary Mines, were also long since abandoned; and lastly, the numerous plumbago locations, at one time so extensively worked in Lochaber by the Lochaber Plumbago Mining Company, and with which had been connected a mill for the preparation of the crude ore, had for years been idle, and at the date of my visit presented a most dreary and ruinous appearance. I shall not here attempt to enter into the reasons for this suspension of work and abandonment of these mining locations in Buckingham and Lochaber, nor am I sufficiently acquainted with their past mining history to justify me in doing so, but would at once pass on to enumerate the lots visited by myself during the year 1876, which embrace a number of the more important of the old mining sites as well as several others which have been more recently discovered. In this enumeration I shall commence with the more northerly in Buckingham, and proceed thence in order to those situate to the southward. With the exception of some two or three lots, all of the mines and locations of any importance occur in the west half of Buckingham Township, namely—from lots fourteen to twenty-eight, and between ranges ten to four inclusive.

Plumbago in Buckingham.

Buckingham, Range X., Lots 13 and 17.—These lots were the only ones to which my attention was directed in the tenth range. The strata here are upon the immediate south-eastern border of the apatite-bearing belt, and constitute what may be described as the north-western margin or limit of the plumbago-bearing series. On lot thirteen (east half) some important openings have been made by Mr. Miller on a bed of disseminated plumbago. The enclosing rocks are rust-coloured hornblende-slates, and strata largely composed of quartz and feldspar, which are similarly coloured. The strike appears to be to the north-eastward, with steep incline to the north-westward. From this bed Mr. Miller has extracted upwards of 300 tons of crude ore, or more correctly speaking, graphite rock, which may contain between sixteen and eighteen per cent. of graphite. This still remained on the ground awaiting shipment.

Graphite schists.

The seventeenth lot, in the same range, has only been recently uncovered. It is the property, I believe, of Mr. Lynch, of Buckingham village. The uncovering has been made on a zone of graphite-schist, about twelve feet in width, which runs about midway through the lot. The strike of this bed is to the north-eastward, with steep but decided incline to the north-westward. There is, evidently, a considerable quantity of disseminated plumbago here, but there is also much barren rock intermingled. On this location the plumbago is distributed thickly along the planes of bedding, and occurs precisely in the same manner as mica does in the soft mica-schists of another portion of the rock series. Certainly, if such deposits may be worked with profit, then there are few lots in Buckingham which may not yet be thus turned to advantage; but I have but little faith in this particular form of deposit as a useful source for the mining of plumbago. On lots three and four, in the tenth range, on property owned by the Buckingham Mining Company, (400 acres) nothing has been done since I last referred to these lots in the Report of Progress, 1873-74, page 143; and the same remark applies to lots four and five, in the eleventh range, also belonging to the Buckingham Mining Company. These, and the last mentioned lots in the tenth range, undoubtedly lie on the run of the plumbago-bearing belts from Lochaber Township, from which they are only a few miles distant. There must be a great deal of plumbago in the western portion of the ninth range, but here, as yet, there appears to be no openings of importance.

Buckingham, Range VIII., Lots 20 *and* 21.—The southern halves of

Buckingham.

these lots belong to the Dominion Plumbago Mining Company, who have erected a plumbago mill, connected by a tramway with the mines, on the western portion of lot nineteen. This location was the only one being actively worked during my visit in the fall of 1876. At this time the mill was being supplied from an opening made in the face of an abrupt escarpment of rock on the southern portion of lot twenty. On this lot the rocks slope at a slight angle to the south-westward, and present a series of abrupt outcrops facing the north-eastward. Among these outcrops are several in which plumbago is thickly disseminated, and these succeed one another, with but slight intervals, from the base to the summit of the escarpment referred to. The strata towards the upper portion of this face of rock are deeply rust-coloured, and contain a great deal of plumbago in a disseminated condition; but lower down, and at the base of the hill, an outcrop, measuring from three to four and a-half or five feet, consists almost entirely of soft, black plumbago, with but little admixture of rock. This outcrop was being mined when I visited the property, the crude ore thrown out being carried by rail to the mill erected on lot nineteen. The mill-house, containing a battery of twenty stamps, is a fine commodious building. The stamps are driven by a seventy-five horse-power engine, to which has been allotted a separate and appropriate building.

Plumbago in veins.

On lot twenty-one there has also been a considerable amount of plumbago mined by the same company. Here, and in the north half of the same numbered lot, in the seventh range, the mineral, for the most part, occurs in the vein form, and much of it is exceedingly pure. The rock thrown out of most of the openings is a very coarsely crystalline mixture of quartz and feldspar, which I consider to be the vein-rock, as portions of this were observed, to which were attached fragments of different characters of rock. For example, a highly crystalline limestone was abundantly met with in the pile of refuse thrown out at one particular point on the run of a vein; while a few feet beyond, and on the continuation of the same pile, most of the fragments consisted of rust-coloured hornblendic or pyroxenic slate; with both of these, however, the coarse quartz and feldspar rock is intimately associated. There are a great number of these veins cutting the strata on lots twenty-one, in both the seventh and eighth ranges, the general bearing of which varies from east and west to some ten or fifteen degrees north of west and south of east. The strike of the strata is very variable, but on the average appears to be to the northward, while the dip is as often to the eastward as westward. In one vein I observed a great deal of apatite and calcite, the former occurring in crystals coated with graphite. One shaft is upon a vein of plumbago averaging about one foot and a-half. This was exposed for a distance of about fifteen feet in a nearly east and west direction, beyond which, in each direction, it rapidly diminished to two or three inches, and bifurcated. The examination of this property conveyed the impression that the plumbago in veins had proved too irregular to be worked with profit. Mining in this hard quartz and feldspar rock is costly, and a great deal of this has to be removed in the extraction of the pure plumbago, which, as a general rule, occurs only in layers of from two to five inches. Occasionally a pure mass of plumbago is accidentally hit upon, and is removed with but trifling cost; but this, at the most, only extends for a few feet before it branches and thins out. Under these circumstances, the Dominion Mining Company have probably acted wisely in directing their energies to the development of the beds of disseminated mineral, as these may be expected to prove more persistent, not only in their superficial extent, but also in depth.

Veins not constant.

Buckingham.

Buckingham, Range VII., Lots 21 *to* 28.—The whole western portion of the seventh range, from the twenty-first to the twenty-eighth lots, is taken up by different mining companies. The locations are divided somewhat as follows:—

Lot 21,	North half	Dominion Mining Company.
Do.	South half	Buckingham " "
Lot 22		" " "
Lots 23 and 24		Dominion " "
Lots 25 and 26,	South halves	Pew & Weart.
Lot 27,	do.	Buckingham Mining Company.
Lot 28		Pew & Weart.

These mining locations embrace an area of about 1,300 acres, over the greater part of which plumbago occurs in greater or less abundance. Perhaps the most important is that of the Buckingham Mining Company, on the south half of lots twenty-one and the whole of twenty-two, which, taken in connection with the adjoining property of the Dominion Mining Company, constitutes one of the most promising blocks of plumbago-mining ground in the whole township. Having already referred to the north half of lot twenty-one, in the seventh range, in connection with lot twenty, in the eighth range, I need merely add that the conditions in which the mineral occurs on the south half of twenty-one and twenty-two, in the seventh range, are precisely the same, and that the veins on these last are the south-westward extension of those observed on the first. A great deal of work has been done on both of these lots by the Buckingham Mining Company, and the Dominion Company have by mistake extended some of their cuttings into this property. As a source of pure lump plumbago, perhaps there are few others that can equal this location; but as before mentioned, and as has already been stated by Sir Wm. E. Logan, these vein-forms of deposit are not likely to prove the most profitable, as they are too irregular and uncertain in their distribution to be depended upon. Beds of the disseminated mineral, however, also underlie the whole of this property, and these will probably yet be developed. The twenty-third and twenty-fourth lots, the property of the Dominion Mining Company, have not yet been opened to any extent, and judging from what I saw of this property, I do not think it embraces any deposits of importance.

Pure plumbago in veins.

Messrs. Pew and Weart's location, the south halves of lots twenty-five and twenty-six, in the seventh range, was not examined, as my attention was not directed to any openings in this direction, and as I was aware that the energies of this company had been mainly centred in the development of their property in the sixth range, to which we have yet to refer.

Other localities in this range.

The south half of lot twenty-seven, in the seventh range, the property of the Buckingham Mining Company, remains as it was when last reported on.* This is a valuable property, and I am surprised that no work has been done on it. This, however, may be to some extent accounted for by the fact that until recently this company have been chiefly engaged in opening up their phosphate of lime property in Buckingham and Portland, and carried on but little work on any of their plumbago locations. The rocks on this lot are the northern extension of those—so rich in plumbago—which occur on the once famous "Castle" property, (lot twenty-eight, in the sixth range,) now owned by the Plumbago Mining Company. One large bed of disseminated graphite has been traced directly into the property now under consideration, and there are other good indications of the mineral in several places.

The last lot, in the seventh range (lot twenty-eight) is owned by Messrs. Pew and Weart, but little work has been done on it. Judging from its position relatively to the Montreal and Buckingham Mining Company's properties, it ought to be a promising location. Both Messrs. Pew and Weart, however, have been absent for a number of years, and their mining operations have been long since suspended on all of their locations.

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* Report of Progress, 1873-74, p. 142.

Mr. Weart visited Buckingham during the summer of 1878, and had the property cleared up, and further deposits uncovered. He is at present offering the whole property for sale.

Buckingham, Range VI., Lots 15 to 28.—In this range plumbago occurs more or less abundantly from the fifteenth to the twenty-eighth lots, but all of the most important locations occur between this last and the twenty-second lots, inclusive. The north halves of lots fifteen and sixteen, the whole of twenty-two, and the south half of twenty-three, belong to the Buckingham Mining Company; the twenty-fifth, twenty-sixth and twenty-seventh lots are the property of Messrs. Pew and Weart; and lastly, lot twenty-eight is at present held by the Montreal Plumbago Mining Company, formerly the Canada Plumbago Mining Company.

The fifteenth and sixteenth lots (Crosby Newton's) have previously been alluded to in the Report of Progress for 1873-74 (p. 141) since which no further openings have been made.

Beds of disseminated plumbago.

Lots twenty-two and twenty-three have also been referred to in the same report, but here the Buckingham Mining Company have made further developments. Indeed these lots now have a most promising appearance, and certainly contain a number of rich deposits of disseminated plumbago. On the south part of the twenty-third lot there are a number of uncoverings or strippings on beds of what might correctly be termed graphitic schist. These are enclosed in schistoze and deeply rust-colored strata, and are thrown into every conceivable shape through synclinal and anticlinal folds. In places the bedding is almost horizontal; while again, within a few yards it is almost vertical. Towards the summit of a hill on this half lot, there is a ridge of the white and coarsely crystalline quartz and orthoclase rock, through which graphite in a very pure form occurs in frequent layers and patches, on a transverse measurement of upwards of twenty feet. Whether this belongs to a vein or bedded deposit is not yet satisfactorily ascertained. Specimens of the plumbago from this lot were brought to Montreal for further examination.* On the twenty-second lot, also owned by the Buckingham Mining Company, there are a number of beds of disseminated plumbago, which twist and wind with the strata in all directions. But all of these beds at the surface look alike, and a description of them at one place applies to them everywhere. What is now required is to determine, by deep mining, whether the beds are persistent, and to adopt some more

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* See Mr. Hoffmann's Notes in Report of last year.

thorough process of treating the ore than has yet been attempted, so as to ascertain the lowest percentage at which a bed may be profitably worked. During my visits to several of the mines in Buckingham, I was frequently informed that such and such a layer or bed of plumbago "would go" 16 p.c., 18 p.c. or 20 p.c., as the case might be, but on what grounds such assertions were based I cannot possibly conceive. Where, however, a particular bed of plumbago has been steadily mined and milled for a fair period of time, some estimate may be formed of its average percentage. Towards the fronts of lots twenty-three and twenty-two, crystalline limestone comes in, interstratified with the plumbaginous schists, and these occasionally hold plumbago, but almost invariably in a very irregular form.

Percentage of plumbago.

The twenty-fourth lot in this range is the property of Robert Donaldson, at whose house Sir W. E. Logan remained while making the investigations recorded in the Report of Progress, published in the year 1866. On this lot there are a few deposits of plumbago, but these do not appear to be of importance. In fact, the rocks on this and the two adjoining lots to the westward are somewhat different in character from those constituting the true or profitable plumbago-bearing strata. On these lots there is a great deal of crystalline limestone and red orthoclase rock, in which the plumbago occurs for the most part in veins of very limited extent. These two lots, twenty-five and twenty-six, to the westward of Donaldson's, are, as we have already stated, the property of Messrs. Pew and Weart.

Large vein of plumbago.

The twenty-seventh lot belongs to the same company, and is the lot already mentioned as the one on which Messrs. Pew and Weart had centred their exertions when mining in this section of country. It at present, however, forms one on the long list of abandoned mining locations, and the main openings are filled with water and *debris*. As nearly as I could ascertain, mining operations were commenced on this lot in 1872, and were continued only through this one year. The chief opening was made towards the centre of the lot, on a splendid vein of plumbago, which runs in a nearly east and west direction, with vertical dip. This vein has been opened for a distance of from seventy to eighty feet, and has been shafted in one place to a depth of thirty-five feet. From these openings a very large quantity of exceptionally pure plumbago was extracted, barrelled and shipped to Jersey City; the purest only being taken for shipment. A great deal, of second quality, still remains on the ground for future treatment. The width of the plumbago in this vein was, where first opened, and for some distance beyond, about four feet; but at the bottom of the thirty-five feet shaft it had diminished to twenty inches. The shaft, however, being full of water, I was unable to examine the vein at this depth. The rock thrown out from these openings consists of a hard and highly crystalline limestone, and a coarse mixture of quartz and feldspar, in which pyroxene was also observed, This latter rock is of the same character as much of that thrown out of the openings of the Dominion Company on the north half of lot twenty-one, in the seventh range, and is the same as that which accompanies the veins of plumbago wherever these are met with in the township of Buckingham. In some of the fragments of this *gangue*-rock which lie on the ground around the old shaft, I observed a number of smaller veins of plumbago of the beautiful lamellar variety. These had formerly been connected with the main vein, and had formed what might appropriately have been called *leaders* to it. They ran at right angles to the main deposit, and seldom penetrated beyond the *gangue*-rock. The thickness of these transverse veins varied from one to three or four inches, but they invariably diminished to mere threads of plumbago on approaching the wall rocks of the lode. Specimens of this form of the mineral have been examined by Mr. Hoffman, and the results are given in the Report of Progress for 1874-75, page 428. As nearly as I could ascertain, upwards of 200 barrels of lump plumbago had been shipped from this location by Messrs. Pew & Weart to Jersey City, and a number of barrels-full still remain in the *cobbing*-shed at the mine. There was no mill or other machinery employed at this location; the ore being entirely *cobbed* and sorted by men and boys. The only reason given, as far as I could gather, for the abandonment of this promising plumbago location, was, that a sale which had been on the point of being affected had fallen through.

Character of the vein.

Product of the vein.

We now come to lot twenty-eight in the sixth range, on which plumbago mining was at one time so extensively carried on by the Canada—now the Montreal—Plumbago Mining Company. This is the lot referred to by Sir W. E. Logan,* as bordering upon Twin Lakes, but at the time of his visit work had only been commenced. On this lot the plumbago occurs both in the form of fissure veins, cutting the strata, and as disseminated beds. Of the first there are three, which are about equidistant from one another, and the strike or bearing of which is in an east and west direction, with underlie to the north. Of the last there are several, but the most important is a bed, averaging seven or eight feet, which runs

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* Report of Progress, 1866, p. 25.

in a general northerly direction through this lot and into the southern portion of lot twenty-seven, in the seventh range. Of the three veins, one is undoubtedly the westward continuation of that so extensively mined by Messrs. Pew & Weart, while indications of the remaining two were also found to extend eastward across the same property. The large bed of disseminated plumbago was worked in an open cutting for about 300 or 400 feet, and to the depth of about twenty-five feet before the shafts were sunk. Two of these were put down to the depth of thirty feet, at a distance apart of 200 feet. Thus the total depth reached from the surface of the ground was about fifty-five feet. A third shaft was also sunk upon one of the main east and west veins to a depth of seventy feet. All of these openings were commenced upon the summit of a hill, which rises abruptly to the height of about 350 feet above the waters of Twin Lake, and the crude ore was carried from the openings to scows on the lake by means of a long inclined trough which rested on trestles up the face of the hill. Scows carried the ore to the company's Plumbago Mill, containing sixteen head of stamps, which had been erected during the year 1867, in proximity to a creek in the northern part of lot twenty-eight in the fifth range. A great deal of plumbago was extracted, both from the great bed of disseminated plumbago and from the shaft sunk on the vein; and I was informed that in the bed, at one point, the mineral had a breadth of close upon twenty-six feet. During the year 1875 this mill was, unfortunately, burnt by the bush fires, after which all work was suspended by the company. After the year 1872, however, mining had not been very actively engaged in, and during the two years previous to the burning of the mill, the only work in progress had been the manufacture of stove-polish from the material which had been previously mined and brought to the mill.

Explorations on bedded deposits.

On lot twenty-eight there is a great deal of very dark rust-coloured quartz and feldspar rock, as well as hornblende-slate. The strata are, evidently, much plicated, and there can be no doubt but that the same beds of plumbago are several times repeated at the surface. There is yet a great deal of plumbago visible in the open cutting and shafts on the main bed, but these are fast becoming filled up with *debris*. Besides this lot, the Montreal Plumbago Mining Company hold the north half of lot twenty-three, in the fifth range of Buckingham, and the first, second, and south half of the third lots in the tenth range of Templeton. About forty men were employed at this location during the time it was actively worked, namely—between the years 1867 and 1872.

Buckingham, Range V.—This range is the last in Buckingham in

Buckingham.

which plumbago is met with in deposits of any importance. It embraces some of the earliest worked mines, namely—those at one time opened by Mr. Labouglie, and known as the St. Louis and St. Mary's mines. No work, however, has been in progress in any of the locations for a number of years, and, consequently, I have little to add to what has already been written concerning these. The plumbago in this range occurs precisely in the same manner as described in the sixth range, and all of the most important locations occur between the twenty-second and twenty-eighth lots, or in its western portion.

The mining locations are divided as follows:—

Lot 19, south half	Labouglie's, or the St. Mary's mine.
Lot 23, north half	Montreal Plumbago Mining Company.
Lot 24, Do. Lot 27,	Buckingham Mining Company.
Lot 26, north half	Messrs. Pew and Weart.

Crystalline limestone and plumbago.

Labouglie's mine, on lot nineteen, is of but little importance; the plumbago occurs in it under like conditions to those of the deposits on Crosby Newton's, lots fifteen and sixteen, in the sixth range. In both positions crystalline limestone occurs in considerable volume, and wherever this is the case the plumbago becomes much scattered, and occurs more in the form of accidental masses than well-defined deposits. In the other three locations named, plumbago occurs abundantly, but the deposits are simply the southward extension of those in the same numbered lots in the sixth range, which we have already described at some length. Mention has also been made of these by Sir W. E. Logan in the Report of Progress, published in 1866, and by myself in that for the years 1873-4, p. 139, *et seq.* Mr. W. H. Stephenson, of the Buckingham Mining Company, informs me that this company intend, in connection with their new mill, to work both the twenty-fourth and twenty-seventh lots in the fifth range, the twenty-fourth lot in the fourth range, twenty-two and twenty-three in the sixth, and the twenty-second lot in the seventh ranges.

Southward of the fourth range of Buckingham the country falls off rapidly towards the Ottawa River, and becomes covered by a heavy drift of sand, while in proximity to the river, the front of the township is occupied by the sandstones of the flat-lying Lower Silurian formation.

Lochaber Township.

Lochaber.—From Buckingham the plumbago-bearing rocks extend eastward into the adjoining township of Lochaber, where extensive deposits of the mineral again occur in a number of places. Some of these were worked some eleven or twelve years ago by a Boston company, under the name of the Lochaber Plumbago Mining Company. A plumbago mill was erected on a small stream called the Blanche, towards the front of the twenty-eighth lot, in the tenth range, and not far from the ninth range line. Work was done by this company on a number of widely-separated lots, of which the most important were the properties of J. Murphy, lot twenty-three, in the twelfth range, and J. McKoy, the twenty-third lot, in the eighth range. Plumbago also occurs on lots twenty-four and twenty-five, in the eighth range; lot twenty-two, in the tenth, and lot twenty-six, in the eleventh ranges. The Lochaber Plumbago Company worked for about four years, off and on, previous to 1868, since which time work has been suspended. From information gathered from several of the old settlers in this township, I learned that the mining operations had been conducted here in a most unsystematic manner, and this fact was borne out by the shape and position of many of the openings which had been made. Mr. Pearce, who acted as general mining captain for this company, spent much of his time in devising plans for the mechanical separation of the plumbago from foreign matter, but with the exception of making some amusing mechanical toys, and adding greatly to the working expenses of the company, accomplished but little. While Mr. Pearce thus experimented, each miner was his own mining captain, and as might have been expected, the greatest confusion prevailed until the company suspended work. I mention these facts here to explain the true cause of the total failure of this mining enterprise in Lochaber; for the suspension of work at one after another of the plumbago mines in both Buckingham and Lochaber has greatly discouraged those who are interested in their development. In conclusion, I would remark that plumbago yet abounds in both Buckingham and Lochaber, and all that is requisite for its successful mining, is a cheap and effectual method of separating it from the impurities which are mechanically mingled with it. I have been informed that in the plumbago so treated at some of the mills there yet remains a considerable percentage of lime, sufficient, in fact, according to Messrs. Morgan Brothers, to render it worthless. This, however, only goes to prove that the method of treatment in the mill process is yet defective, and, consequently, it is to this point that especial attention should at once be directed.

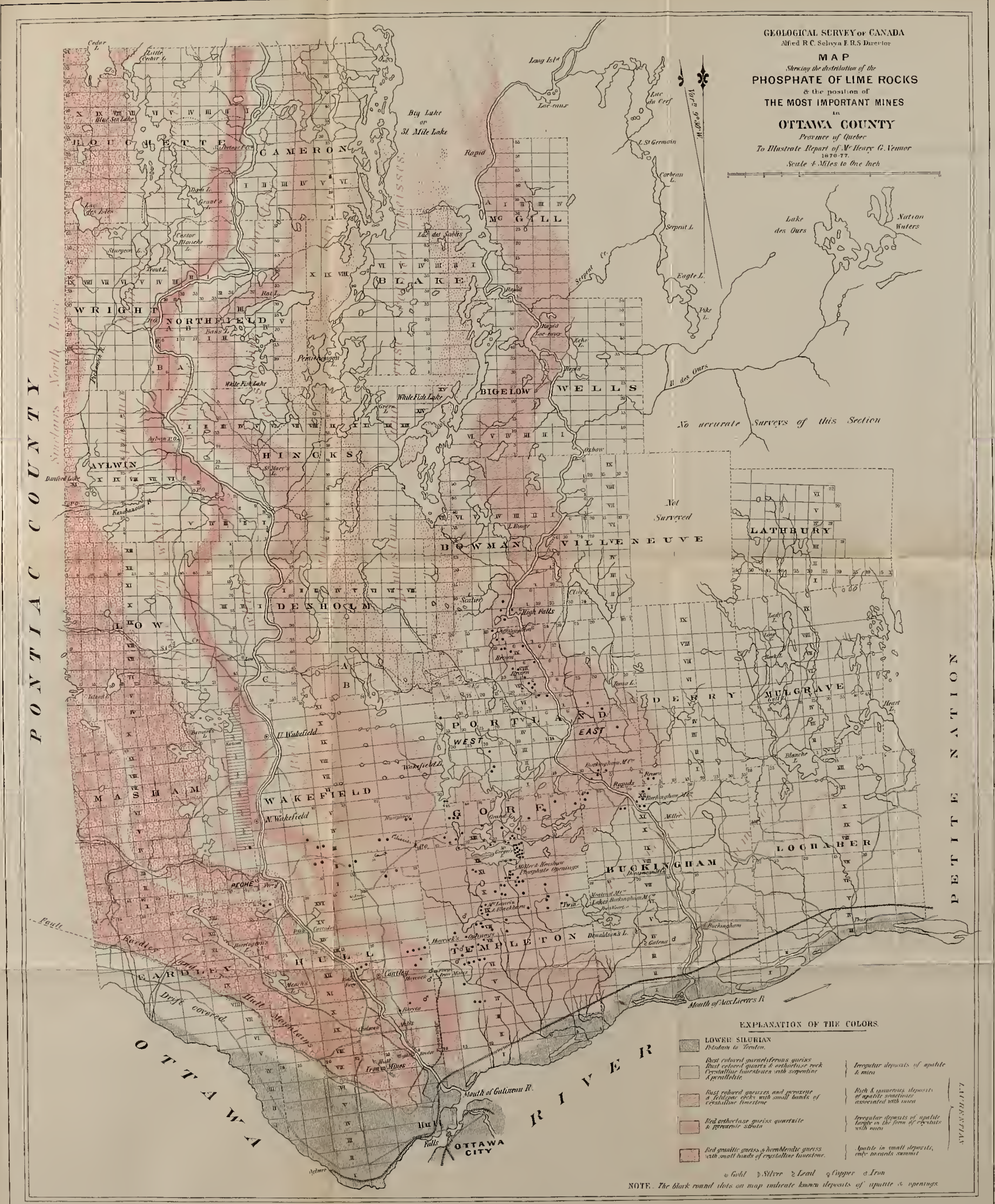
Cause of abandonment of works.

Improvements desirable in treatment of plumbago.

The bearings given in this report are magnetic, the variation being about 9° 30′ west.

Bearings magnetic.

NOTE.—The map of Ottawa County is the only one at present published, as the measurements effected in this section of country have been more extensive, and have, consequently, afforded us some means of checking the inaccuracies of the early surveys. Pontiac and Renfrew Counties clash seriously with one another, and the Ottawa River, which separates them, would appear to have been surveyed and mapped quite independently of either of them. Consequently, the geological structure cannot be laid down at present with any degree of precision. A map, however, is at present being put together by Mr. Robert Barlow, of the Geological Survey, which will shortly enable me to show correctly, and in a connected form, the entire geological structure of the country between Hastings County and the Ottawa apatite mining region. To this map, then, when published, I would refer those interested for the clear elucidation of my three reports.



Computed and drawn by L. H. Ord

The Burland-Desbarats Litho Compy Montreal.

REPORT

ON THE

SLATE FORMATIONS OF THE NORTHERN PART OF CHARLOTTE COUNTY, NEW BRUNSWICK,

WITH A SUMMARY OF GEOLOGICAL OBSERVATIONS IN THE

SOUTH-EASTERN PART OF THE SAME COUNTY,

BY

G. F. MATTHEW, Esq.,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq., F.R.S, F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Saint John, N. B., 1st March, 1877.

Sir,—I have the honour to submit herewith my report on an examination of the slate region in the northern part of Charlotte County, partly made in company with Professor L. W. Bailey in the year 1872, but chiefly by myself in 1875. Also a summary of observations made in the south-eastern part of Charlotte County during the past summer.

I have the honour to be,

Sir,

Your obedient servant,

G. F. MATTHEW

I.

On the Geology of the North-Western Part of Charlotte County.

The general features of the geology of Charlotte County are described in the Report of Progress 1870-71. In the Report on the Geology of Southern New Brunswick there given, several groups of strata of undetermined age were described, of which, one—the Mascareen series—has since been found to be Upper Silurian, and was so described in the Report of Progress 1874–75, pp. 84 to 89.

Hills of pre-Silurian rock.

Another tract of rocks, chiefly "argillites," of uncertain age, was described at pp. 190 to 200 of the former report. In the summer of 1872, by your direction, I re-examined this area of "argillites," and found reasons for referring a part of them to the Devonian formation. Further observations given in this report lead to the conclusion that the remainder of these slaty rocks are Upper Silurian.

Before speaking of the Upper Silurian clay-slates or argillites, a few paragraphs on the associated pre-Silurian rocks may not be out of place. These form a border of hills along the southern side of the clay-slate region, and consist of hard and compact strata, resembling the Laurentian and Huronian rocks of St. John County. They are cut through the centre by granite—a narrow band connecting the extensive granitic area of Washington County, Maine, and the Nerepis Range of granite hills. Hard schists and feldspathic rocks, with diorites, like those of the Huronian formation in St. John County, form the more northerly eminences and slopes of this connecting range, which rises several hundred feet above the general level of the inland part of Charlotte County.

These older rocks are first seen at Baring, Maine, whence they extend through Calais and into New Brunswick, at the mouth of Waweig Inlet, continuing along the eastern side of the Waweig River for some miles. Roix Station, on the New Brunswick and Canada Railway, is on their northern slope. From this station they trend away to the eastward in the direction of Falls Brook, on the Digdegguash, but a few miles beyond that river the range of hills composed of these rocks sinks down to the level of the low country on Clarence Brook and neighbouring streams tributary to the Magaguadavic River, and disappears. The rocks of these hills are chiefly fine-grained diorites of a dark-grey colour, and they are, usually, a little porphyritic, with imperfect crystals of feldspar. Some

Iron and copper.

of the diorites are earthy and slightly schistose; others are more distinctly crystalline, and without a trace of foliation. They are seldom without minute points of iron pyrites; a mineral often freely and even abundantly disseminated through the rock. Small quantities of copper pyrites are also contained in them.

Associated with the diorite is a fine-grained gneissic sandstone, which in appearance approaches fine-grained gneiss. The layers of this rock are thin and much crumpled, and on worn surfaces run in waving and zig-zag lines. On the road to Whitcher Ridge, on the northern slope of this range of hills, there are grey cryptocrystalline felsites, marked with fine, black, waving sedimentary lines.

The rocks of this belt are greatly disturbed, shattered, and injected with numerous veins and masses, of grey, fine and coarse-grained diorite and syenite, having disseminated grains of magnetic iron ore. These crystalline rocks have not been found to cut the overlying Upper Silurian sandstones and slates; but they are themselves traversed by veins of red granite, similar to that in the central granitic band and the red granite of Washington County, Maine, which come within a few miles of them, and which is known to intersect the Upper Silurian rocks at several points.

Fossiliferous Upper Silurian strata of Oak Bay.

As a preliminary to the examination into the age of the "dark argillites" of Charlotte County,* a visit was made to the fossiliferous strata of Oak Bay, for the purpose of ascertaining the succession in this known Upper Silurian tract.

Along the eastern shore of Oak Bay, in the central part of the tract, the slates† are well exposed. They are fine-grained, of a pure grey colour, and greatly resemble the beds around the base of Blue Mountain, in Queens County; they have near the middle a well marked band of highly feldspathic, compact slate, containing small fragments of grey felsite and black slate, weathering pale-grey. The argillites below this band are mostly of a pure grey colour, and those above it have a faint lilac tinge. The dip of the strata here is to the south-south-east at an angle of 45°, and the slates are cut off by a fault running south‡ along the shore of the estuary for several hundred yards. Near some old Indian shell-heaps or "Kitchen middens" the shore line recedes to the eastward of this fault, and the ledges are concealed by post-pliocene clay, sand and gravel, except at one point, 450 yards down the shore, where there are ledges of grey clay-slate, with dark-grey, fine-grained diorite. This

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* Report 1871.

† Report 1875.

‡ All bearings in the report are magnetic. Variation 20° W.

group of strata is again exposed in the middle of the peninsula between Oak Bay and Waweig Inlet, on each side of the road from St. Andrews to St. Stephen, the beds here dipping S. 30° .E., < 70°, and holding species of *Nuculitis*, *Orthis*, *Rhynchonella*, etc., and also on the road from St. George to St. Stephen, about a mile from the head of Oak Bay, with the same dip. There are two other outcrops of clay-slate, soft, and of a grey colour, to the north-east of these—one at a small mill on the Waweig (at a point where the stream is crossed by the "Board Road" to Dumbarton Ridge), the other, on the St. Andrews and Quebec Railway, one and a-half miles north-east of the last named locality. These several outcrops show the direction in which the band of Upper Silurian clay-slates, visible on the shores of Oak Bay, runs in its extension inland, and it will be observed that it is parallel to the range of hills of pre-Silurian rocks described on a preceding page.

Upper Silurian sandstones.

The next group of Upper Silurian strata is not visible at Oak Bay south of the slates, where, as already intimated, the rocks by which the latter are overlain are concealed by surface deposit. Around the shores of Waweig Inlet, however, and further east, there are ample exposures of the overlying group, which consists chiefly of sandstones. These were first observed on the line of the St. Andrews and Quebec Railway, between the fifteenth and sixteenth mile posts (from St. Andrews) where for a width of half-a-mile they are exposed in cuttings, with an average dip to the southward of 30°. Many of the beds in the cuttings at this place are covered with scales of grey mica, and all are feldspathic and characterised by a purplish tinge, like the beds of the same group in Queen's County, Ledges of this rock are visible near and at the mouth of Waweig River, on the west side of which they border a hill of syenite, lying to the north of a road which crosses Oak Bay Peninsula at this point. The sandstones on this road, which are very fine-grained, flinty, and dark coloured, were found to contain shells of the genera *Orthis* and *Rhynchonella*.

For nearly half-a-mile south-west of the mouth of Waweig River, clay beds conceal the Silurian measures. But from the point at which the latter emerge from beneath the clay, to the lower bridge over Waweig Inlet, there is a continuous, though not very clear section of the sandstones, of which the lowest beds dip south-west, the middle south, and the upper (southernmost) south-east; while the average inclination of the strata is 40°—thus giving a thickness of 1,500 feet to the sandstones and included diorites exposed along the shore.

Below the bridge a narrow cove, bordered by clay beds, interrupts the continuity of the exposures; but on its southern side, nearly on the line of strike of the highest ledges above named, sandstones reappear on the shore. They are lilac-grey in colour, hard, fine-grained and highly feldspathic, having ripple marks on some of the layers, and dipping south-east at an angle of 45°. Only about sixty feet in thickness of beds are exposed, and these are conformably overlain by a mass of grey petro-silicious rock, which, with the included diorite beds, is 600 feet thick, and extends along the shore for four hundred yards, with a southerly dip of 30°. This rock is of a grey colour, and is divided by numerous colour-bands of dark-grey, which exhibit the bedding. In one of these bands a layer of shells was observed, chiefly of a species of *Chonetes* resembling *C. Nova Scotica.*

Upper Silurian petro-silicious rocks.

These silicious beds terminate at the foot of a high hill of dark-grey, fine-grained diorite, which crosses the Oak Bay Peninsula from shore to shore. On the Oak Bay side of the peninsula, similar petro-silicious strata may be seen on the northern slope of the diorite hill; here they have a width of 600 feet, and pass out of view beneath gravel and clay beds on the shore of Oak Bay.

Great fault.

Passing to the northward, across these post-pliocene beds, one comes to the outcrops of the clay-slates referred to above as occurring on the eastern shore of Oak Bay. The fault, previously alluded to, which intersects the measures at this place, is one of great importance, or at least, is connected with one of the most important of the cross-fractures which affect the strata in the southern hills of New Brunswick, since it cuts directly through these old ridges of metamorphic and crystalline rock from the centre of the parish of St. David to Quoddy Head, in Maine, a distance of thirty miles. The direction of this great break is S. 5° E., and in its course lies that branching portion of the Saint Croix Inlet from which the river derives its name. It extends on the one hand through Oak Bay, and on the other, along the "Quoddy River,"—a name given to the deep salt-water channel, forming the passage between the West Isles in the Bay of Fundy and the United States coast.

The pressure on this line of fracture has been from the eastward, the down-throws being on the western side: thus, along the Quoddy River, the slates and felsites of Campobello and Deer Islands are ridged up in sharp folds against the Upper Silurian sandstones, etc., of Moose Island, (Eastport). Along the Saint Croix River the Upper Silurian sandstones and the Perry sandstones* of the St. Andrews peninsula are

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* Report of Progress 1870-71, p. 200.

opposed to a mass of granite, of post-Devonian age, on the opposite shore, and on Oak Bay a similar attitude may be observed in the different parts of the Upper Silurian series itself.

It was observed that at the southern end of this fault, on its eastern side, the strike of the slates, etc., in Deer Island and Campobello leads round to the southward in approaching it, and the measures are nearly vertical, but that the adjacent strata on the opposite side of the fault, in Moose Island, lie at low angles, and fossils occur. Similar conditions prevail at the northern end of the fault; but here they are reversed, the curving strikes which approach the fault being on the west side, and the disturbed fossiliferous measures showing along the eastern side in Oak Bay Peninsula.

Repetition of the lilac sandstones.

A careful examination of the shores of Oak Bay, at one point on the line of this fault—namely, to near the Kitchen Middens at Simpson's Beach, reveals the presence, below tide-mark, of the lilac sandstones; though the ledges at high-water mark are composed of clay-slates. These sandstones extend for nearly a mile northward along the shore, both above and below high-water mark, their continuity being broken only for a short distance by a point of conglomerate rock, which is unconformable to the sandstones. Along this shore, the lilac sandstones have an average dip of 50°; being 40° at the more southerly exposures, and from 60° to 65° at the conglomerate outlier. The trend of the coast in this part of Oak Bay is nearly at right angles to the dip, and a great width of sandstone beds is exposed here.

Beyond the conglomerate outlier, the sandstones, which are probably overturned, graduate into beds which, though still retaining the purple tint and other characteristics of this part of the Silurian series, are dark-coloured and rusty-weathering, without lustre, and marked by numerous little dark specks, like many of the coarse beds among the "argillites" north of Oak Bay.

Petro-silicious bed repeated.

These rusty-weathering beds, which apparently underlie the sandstones, are followed by flinty slates of the same kind as those seen on the shore of Waweig Inlet below the lower bridge. They are well exposed in a cliff extending nearly to the head of Oak Bay. The most southerly beds, which are supposed to be the lowest, dip S. E. $< 50°$. At a point 230 yards up the shore from where the first ledges appear, there is an anticlinal fold, and 180 yards further on, the corresponding synclinal, beyond which the dip rises gradually, until at the last exposures it is E. S. E., $< 60°$. Dark layers are more numerous here than in the petro-silicious beds exposed in Waweig Inlet. They are, usually, one or two inches thick and rarely exceed six inches, but are accompanied by beds of black clay-slate—some of which are as much as two or three feet thick—and by beds of grey felsite, from ten to twenty feet thick. The clay-slate bands become more numerous at the last exposure, where the rock is chiefly black clay-slates. No diorites were observed in this band of petro-silicious rocks. The foldings which they have undergone make the estimate of their thickness uncertain.

The structure of the Upper Silurian strata in this area seems to be anticlinal, the axis running through the slates which are brought up between Oak Bay and the Fredericton Road. On each side of the slates lies a belt of sandstones, and outside the sandstones petro-silicious strata, with low dips in the southern band, and several crowded folds in the northern.

Dark argillites examined.

I next examined the neighbouring, but much larger tract, occupied by slates and sandstones, which in the Report 1870-71 were called "dark argillites" (page 191). A visit was first made, in company with Professor L. W. Bailey, to the exposures along the shores of the Saint Croix River, between "The Ledge" and Saint Stephen. Here there is a succession of strata similar to that at Oak Bay, but showing evidence of greater metamorphism. The sandstones along this part of the river have the same lilac tint as at Oak Bay, but are more micaceous; and they are traversed by veins of quartz, etc. To the north of them, as on Oak Bay, there is a band of coarse, rusty-weathering rock, which becomes more schistose near St. Stephen, and resembles gneiss. The rust, due to the oxydation of pyrites, is so abundant as to give rise to deposits of bog-iron ore. The beds, which correspond in appearance to the lower part of the Upper Silurian succession, may be seen about the mouth of Dennis Stream, and are largely made up of black clay-slates, grey, flinty slates and carbonaceous slates.

Micaceous sandstones at Spragg's Falls.

At Saint Stephen, and for some distance above, pre-Silurian gneiss and calcareous and magnesian schists border the Saint Croix, but at Spragg's Falls, above the gneissic belt, and about five miles west from St. Stephen, another band of sandstones crosses the river. They resemble in appearance those which cross below Calais near "The Ledge," and are also quite micaceous, and they are underlain to the northward by similar black and dark-grey clay-slates. In the latter, and in slaty layers of the sandstone, there is an abundance of small imperfectly formed and earthy crystals of andalusite. Between the mouth of Waweig Inlet and the point on the St. Croix where the Devonian slates occupy the banks of the stream, there are three main bands of sandstones which cross the river;

all dipping southwardly, and accompanied by slates having a similar inclination. The prevalence of southerly dips in similar rocks is equally marked in the vicinity of Moore's Lake, on Dennis Stream, about six miles north of St. Stephen and ten miles north-west of the falls above named. On both sides of the lake are found at short intervals repetitions of the sandstone beds, and the associated rusty, gneissic layers, all dipping at high angles to the southward, and cut through by dykes and masses of feldspathic granite. Near here the metamorphism of the "dark argillites" is more strongly marked than elsewhere, and though the slates abound with crystals of mica and andalusite, the perfectly regular colour-bands enable one to recognise without difficulty in some places the fine-grained slates of Division 2 of the Upper Silurian series.

Metamorphism of the argillites.

The micaceous condition of these slates is most marked in the vicinity of red granite, to the intrusion of which the alteration of the slate seems due. These granites are highly feldspathic, have usually but little mica, and are in some places coarsely porphyritic, like those of the Nerepis Hills in the eastern part of Charlotte County. Around the projecting masses of granite great quantities of mica, and abundance of staurotide and andalusite crystals have been formed in the slates. This formation of crystalline minerals has taken place chiefly along a line of granitic domes and ridges, which protrude through the slates at various points between the sources of the Monnaes Stream, in the parish of St. Stephen, and the South Branch Oromocto Lake, in the parish of Clarendon. At the Moannes Stream, in the north part of St. Stephen, the granite breaks through syenitic gneiss, and it appears more conspicuously at Moore's Lake and Gallup Lake, in St. David; further east it comes into view on Sorrel Ridge and Clarence Ridge, in Dumbarton; then at Piskahegan Falls and Mount Pleasant, in St, George, and finally at Coal Brook, in Clarendon, on the South Branch Oromocto River.

At Moore's Lake, the crystalline minerals are abundant in the schists along the south side of a large granitic dyke on the west side of the lake, but in the narrow belt of slates intervening between this dyke and a ridge of dirorite, they are scarce. At Dumbarton Ridge, which is on the line of granitic outcrops described above, though no granite was found *in situ*, the slates are crystalline, and abound with mica, staurotide and andalusite, and at an intermediate point between this ridge and Moore's Lake, (near Gallup Lake), where the granite appears, small red garnets are added to the other minerals of the mica-slates. A still greater variety of minerals were observed in the "dark argillites" which appear in the hill south of Gaspereau Station, in the extreme north-east

Minerals at Gaspereaux Station.

corner of Charlotte County. The schistose rock in this hill is traversed in places by a network of granite veins, of which rock an extensive area lies to the south of the hill, and contains crystals of actinolite, garnet, chlorite, epidote, quartz, magnetic iron and various forms of pyrites. Mica is also present in drusy cavities, or veins, and molybdenite occurs in quartz veins in the granite near this station, and has been met with in loose pieces near Moore's Lake. Andalusite, in small imperfect crystals, is quite abundant in many beds of the slates in the space between Moore's Lake and the town of St. Stephen. These crystals are clear and unmistakable in the slates about the lake, but in those nearer the town are imperfectly developed, becoming in the more southerly outcrops of slate, mere bluish-black specks in the matrix. The largest crystals of this mineral observed were in the quartz veins in the slates east and north-east of Moore's Lake, where they are to be found several inches in length and half-an-inch in diameter.

Graphite at Dumbarton Station.

Associated with the hard sandstones of this series there are beds of graphitic slate. Such beds are common in the south part of St. Stephen, the north part of St. Patrick, and near Dumbarton station, on the St. Andrew's and Quebec Railway; but it is only at the latter locality that they appear sufficiently rich in graphite to give any promise of being valuable, economically. In the black slates which outcrop on the hill south of this station there are pockets of graphite sufficiently pure to be available for lubricating purposes, or for stove polish.

The steely lustre and dark lavender-grey colour, so prevalent in some clay slates and mica slates of the two parishes above-named, and those of St. David and Dumbarton, appears to be partly due to the presence of this mineral, with mica, and numerous small crystals of andalusite.

Pyritous ores in actinolite-schist.

In the diorite rock of the ridge north of Moore's Lake there are intersecting quartz veins abounding with magnetic and common pyrites, and containing also arsenical pyrites and small quantities of the sulphuret of copper and zinc. Captain Porter, of St. Stephen, has made several openings in these beds, and in the course of his operations has exposed masses of actinolite-schist lying in horizontal beds. This rock lies along the south-eastern base of the diorite hill north-west of Moore's mills, and is composed chiefly of calcspar and radiated actinolite, with a large admixture of iron pyrites. The actinolite beds appear again on the road from Moore's mills to Tower Hill, and other outcrops may be seen further east on Dumbarton Ridge near the road to Rolling Dam station, on the St. Andrew's and Quebec Railway. Besides the beds of this rock which have been opened up by Capt. Porter on the diorite hill, there are other similar beds close to Moore's Lake, which cross the road to Tower Hill. These may be seen to dip at a high angle beneath an abrupt hill of lilac quartzite. From its association here, and at other points with the lilac sandstones, it is evident that the actinolite-rock is closely connected with these beds, and is a part of the rusty-weathering band of schistose argillites, so frequently seen in the parishes of St. Stephen and St. David, which is the source of the bog-iron ores of this district. Owing to the abundance of pyrites in some portions of this rock, it may, at a future day, become available as a source of sulphur and sulpuric acid.

Conglomerates with pebbles of pre-Silurian rocks.

Over much of this district there is, in connection with the rusty-weathering beds and the lilac sandstones, a grey feldspathic conglomerate, holding fragments of grey felsite, white quartz, and black clay-slate, and a few of grey sandstone; the pebbles usually vary from the size of a pea downward, but a few are as large as a pigeon's egg. The felsite fragments are not distinguishable from that of the beds seen in the main band of pre-Silurian rocks in the parish of St. Patrick; it is in the beds of conglomerate nearest the hills of pre-Silurian rocks that the felsite fragments are largest and most numerous. This conglomerate was observed in the parishes of St. Patrick, Dumbarton and St. David.

Contacts of slate and granite on Piskahegan River.

For the purpose of examining other contacts of granite with the slates of this series I visited a district at the mouth of the Piskahegan River, a branch of the Magaguadavic.

In ascending the Piskahegan from its mouth to Treat's Falls, where the road to Piskahegan settlement crosses it, slates of this series were seen, portions of which appear to be repeated by faults and dislocations connected with intruded masses of red granite. Some of the slates in the gorge near the mouth of this stream are quite micaceous; the mica being present in the form of small silvery flakes irregularly set in the matrix—some parallel to the lines of bedding and others not so. The beds dip north-north-west < 50°. At the Lower Fall, there is on the right bank of the river a small outcrop of pale-red porphyritic granite. At its contact with the slates, this rock contains angular fragments of slate, which in the vicinity of the granite is highly micaceous, seamed with quartz veins, and sharply folded. At the second fall, the strata are dark-grey slaty sandstones, lilac-grey in the more silicious beds. Further up the stream, (within three-fourths of a mile of the bridge at Treat's Fall), coarse pale-red porphyritic granite appears. It forms much of the southern slope of a high hill on the west side of the stream, extending in that direction to the Magaguadavic River. The northern side of the hill is covered from base to summit with the sandstones which constitute the upper part of this series, and which, at the top of the hill near the granite, are very hard and fine-grained, passing into micaceous quartzite. Alternating with the quartzite are beds of a slaty gneiss, in which search has been made for gold, but so far as I could learn, without success.

Micaceous clay-slates on St. Croix River.

In order to complete our knowledge of the distribution of the clay-slates in the western part of Charlotte County, a traverse was made on the St. Croix River between the Eanous River, in St. James Parish, and Vanceborn, Maine, on the E. & N. A. Railway; and it was thus discovered that the dark-grey schistose strata which cross this river at and below Vanceborn, are folded, and sweep back again across the stream into New Brunswick at Little Falls. They cover a small area in Charlotte County on the Canadian side of the river, extending down as far as Rolf's Brook and the Little Simsquich. The first indications of this flexure were observed on the St. Criox River at Little Falls, where the stream breaks over grey, brown-weathering sandstones of the Devonian series. These beds are sparingly marked with carbonized fragments of plants. At "Pork Rips" (or Rapids), a few hundred yards below the falls, there is a marked band of grey feldspathic sandstone, having a high south-easterly dip. This rock cannot be distinguished from that which at many points further eastward may be observed at the summit of the Upper Silurian sandstones. Further down the river, at Cedar Island Rips, there are dark-grey chloritic argillites, also with a high south-westerly dip. From the mouth of the Big Simsquich as far south as Rocky Rips, beds resembling those of the main body of Upper Silurian slates are visible. At the latter point, where the beds consist of dark-grey, slaty mica-schists, crumpled and twisted, and having smooth shining surfaces, the dip, which a mile above Rocky Rips is N.N.W., < 70°, is much lower, and the folds of the strata have prevailing, though moderate, dips to the north. A mile below Rocky Rips, Devonian argillites again come upon the river, crossing it at Rolf's Brook, where the strata are vertical and the strike S. 75° W. The Upper Silurian rocks of this tract are more chloritic and micaceous than the generality of the slates of this age in the larger area to the eastward.

Structure of argillite series in the western parishes.

The high dip and repeated recurrence of the micaceous sandstones in the parishes of St. David, St. Patrick, St. Stephen and Dunbarton, show great disturbance in this series of rocks. Speaking in general terms, it may be asserted that an anticlinal fold passes through Cranberry Lake, in the south part of St. James, and extending thence through the low land on the north-west branch of the Digdeguash, crosses the Digdeguash

River at Jones Brook, in Dumbarton, and turns down along the valley of that river. Another tract, in which the soft slates in the lower part of the series appear conspicuously, extends upwards from the head of Oak Bay into the low lands drained by the branches of the Waweig River, thence it goes eastward, crossing the Digdeguash River below the Rolling Dam. Another anticlinal passes through the lowland south of Pleasant Ridge, drained by a number of small streams which flow to the Magaguadavic River, and crosses that river at the mouth of the Piskahegan.

Between these depressed tracts, in the country west of the Digdeguash River, there is a tract of ridgy land, covered with boulder clay, producing a fertile soil, on which are located some of the best settlements in this part of the country. Over a great part of this tract, the ledges which most frequently appear are micaceous sandstones and the rusty-weathering schistose beds which accompany them. In the more elevated part of it the strata do not lie in simple synclinal folds, but consist chiefly of a succession of monoclinal strata and irregular folds, with the layers dipping mostly southward at high angles. In the ridges on the eastern side of the Digdeguash River, the dips are reversed, the slope of the beds being northward, toward the belt of Devonian slates and sandstones along the southern magin of the central Carboniferous area of New Brunswick; and this arrangement of the monoclinal folds—except where the strata are overturned—prevails to and beyond the north-east corner of Charlotte County.

Conclusions.

By comparing the succession of members in the known Upper Silurian tracts with those of the "dark argillite" series, it will be seen that there is a great resemblance between them, thus:—

Div. 1 and 2 correspond respectively in both series.

Div. 3, *a* and *b*, of dark argillites, are equivalent to Div. 3 Upper Silurian.

Div. 3 *c*., of dark argillites, is equivalent to the petro-silicious bed of Oak Bay.

The metamorphism of these slates over considerable areas, and the absence of fossils, has been looked upon as an objection to regarding them as Upper Silurian; but in all cases where the slates have been examined the changed condition may have resulted from the proximity of granitic masses, similar to those which made their appearance further eastward at the close of the Devonian age.

As a result of the examination made in the western part of Charlotte County in the summer of 1872, and subsequently, I may state that I have been led to the conclusion that these slates are of Upper Silurian age.

Devonian Formation.— The visit made to the north-west part of Charlotte County, for the purpose of determining the age of the "dark argillites," enable me to add something to the information given in the report of 1871, relative to the "pale argillites," or Devonian slates of the same region.

Pale argillites.

In tracing this formation north-westward beyond the limits of Charlotte County, it was discovered that the band of these rocks which intervenes between the "dark argillites," or Upper Silurian slates, and the Lower Carboniferous formation, was part of a synclinal mass of sediment, of which the reversed, or southwardly dipping beds, are to be found beneath the central Carboniferous area of New Brunswick, and to the north of it. On the Piskahegan River, on the south side of the central Carboniferous areas, the beds of this series have lower dips than have been observed in it any where else. Half-a-mile above the Upper Silurian quartzites of the dark argillite band mentioned in the preceding part of this report as occurring at Treat's Falls, there are beds of greenish-grey clay-slate, alternating with thinner beds of a purplish-black colour ; the dip is northward and varies from 20° to 40°. At another rapid, about a mile above, there are apple-green, green-weathering slates, without mica films, and having dips to the northward, which vary from 30° to 45°. For eight miles above this point the Piskahegan runs through low swampy land, but from the exposures along the road through the Piskahegan settlement to Brown Ridge, it is evident that the depressed tract through which the river flows is underlain by the slates and sandstones of the Devonian formation.

Exposures on Piskahegan River.

Another tract of pale-grey sandstones of the same age, was observed on the north side of the band of Lower Carboniferous rocks which crosses York County from the escarpement west of Oromocto Lake, and passes to the northward of Toby Guzzle station on the St. Andrew's and Quebec Railway, to Trout Creek on the St. Croix. Only loose fragments of the Devonian slates are visible along the railway, but several miles eastward of it, they rise into a low rounded elevation, called Christy Ridge. This elevation is parallel to the ridge of intrusive granite on the south side of Magaguadavic Lake, and about two miles to the south of it. On the east side of the Magaguadavic River, in a line with the strike of these micaceous sandstones in Christy Ridge, the country is covered by the Lower Carboniferous rocks, which sweep around the western end of the central Carboniferous area, and the sandstones consequently are concealed.

Christy Ridge.

A narrow belt of rocks, unconformable to the Upper Silurian formation in St. David, extends in a curved line from the St. Croix River, between

Conglomerate.

the "Ledge" and the town of St. Stephen, across Oak Bay to its head, and onward into the flat wooded district east of the Tower Hill Road. It is the conglomerate alluded to in the Report of 1871, p. 164, and was probably formed before the close of the Devonian age, as it exhibits evidence of metamorphism similar to that of the Upper Silurian series. It has a grey calcareous sandy paste, and the pebbles consist almost entirely of fragments derived from the Upper Silurian and pre-Silurian hills near by. On the St. Croix River, where these hills are chiefly gneissic, the most numerous fragments are of fine-grained grey gneiss, pieces of a paler granitic gneiss being less numerous; the rock also contains many fragments of a grey felsite, abounding in glassy grains of quartz, a rock which, when weathered, would be easily mistaken for grey sandstone. Pieces of an epidotic rock, with clouded shades of green and purple also occur. In the knolls of this conglomerate, at the head of Oak Bay, boulders of dark-grey felsite, with glassy quartz grains, greatly predominate, though there are still many pieces of a grey granite with very little mica, and also fragments of grey sandstones and of quartz. Chips of hard black slate are frequent in the finer beds.

II.

THE GEOLOGY OF THE SOUTH-EAST PART OF CHARLOTTE COUNTY.

Coastal and Kingston series.

By your directions I occupied myself during a part of the past summer in examining the south-eastern part of Charlotte County, with the purpose of completing the survey of some tracts not fully examined in 1869; and of ascertaining the age of certain groups of strata in that quarter, which, on account of the prevalence of crystalline rocks among them, had been placed next the Coldbrook or Huronian formation in the report of 1870-71. These series of strata were described under the local names of "Coastal" and "Kingston."

Coastal rocks probably Laurentian.

Coastal Rocks.—Laurentian (?)—The first of these, namely, the "Coastal" group, is characterized by the prevalence of gneissic and schistose feldspathic strata in the lower part, and by quartzites, argillites, dolomites and limestones in the upper, and was found to be closely related to the Laurentian gneiss. The succession of strata in it is very like that of the "Upper Series" of the Laurentian area in St. John County, and in the map accompanying this report (compiled by Mr. R. W. Ells,) it has been coloured as part of the Laurentian system.

The parishes of Lepreau and Pennfield are traversed by a considerable belt of Laurentian rocks, which shows itself at the mouth of L'Estang (tidal) River, and along this river to within a mile of its head; thence it extends across Pennfield in a north-east direction, and crosses the Popologan and the post road to St. Andrew's, four miles back from the coast. It also crosses the New River, about two miles north of the St. Andrew's road, and is cut off by intrusive granite at the Lepreau River.

Belts of Coastal rocks.

Several smaller ridges of these ancient rocks crop out in this part of Charlotte County, of which the principal is that which forms the small islands called the "Wolves," about six miles south of Beaver Harbour, in the Bay of Fundy. In its eastward extension this belt strikes the coast of Charlotte County at or near Red and Barnaby's Head, and forms the south side of Lepreau Harbour, beyond which it passes into Saint John County. Of a third and more southerly belt, only the point of a ridge, less than a mile in length, and about two miles wide, lies in Charlotte County, and consists chiefly of rocks of the "Upper Series" of the Laurentian. It lies between Lepreau Basin and Dipper Harbour. Along the northern side the rock is gneissic, but on approaching the summit of the ridge, black and grey quartzites appear, and on the top there is an abundance of dark-grey and pale-grey limestones, such as are found in the Parish of Portland, in St. John County. Here there are excellent facilities for burning lime, as the ridge is covered with a heavy growth of wood, and there are two good harbours close at hand. The quantity of limestone is inexhaustible, and the quality apparently equal to that now so extensively burned at the "Narrows" of the St. John River.

Limestone.

Coastal rocks in Pennfield.

The band of "Coastal" rocks, in Pennfield is enclosed between the main belt of Laurentian gneiss, running from L'Etang River to Lepreau River, and a minor ridge of similar rock, which extends east from Deadman's Harbour to the head of Beaver Harbour; and the most continuous exposures of the intervening coastal measures appear along the L'Etang River. Eastward of this river, both the Laurentian gneiss and the coastal strata are concealed by an extensive sheet of surface deposits, gravel sand and clay, extending across Pennfield and Lapreau, the higher parts of which near the river are known as "Pennfield Ridge." These loose materials conceal the metamorphic rocks over extensive tracts, so that the arrangement of the measures can only be seen along the river side. The first mass on the south side of the Laurentian gneiss, on this river, is a grey (white-weathering) felsite, with limpid grains of quartz; to this succeeds a mass of grey, chloritic schist, and these are followed by quartzites, and grey slates supporting the limestones of L'Etang Peninsula. South of this promontory there is a reversion of the measures extending to Deadman's Harbour, (the schists occupy the neck of the peninsula between L'Etang and Black's Harbour,) and white-weathering felsites, with calcareous bands, come in view between Black's and Deadman's Harbour, while on the shores of the harbour last named protogene Laurentian gneiss appears.

Composition of Kingston and Upper Silurian alike.

Kingston series.—This is the more recent of the two groups of crystalline rocks of uncertain age in the south part of Charlotte County, and crosses that county in two belts, of which the more southern exhibits by far the heaviest masses of crystalline rocks. The investigation of the more northerly belt, led to the discovery on it of a succession of groups similar to that of the Upper Silurian series—Divisions 1 and 2 of the Kingston, being comparable to Divisions 1, 2 and 3 of the former series; and Divisions 3 and 4 of the Kingston, possessing lithological characters similar to those of the Upper Silurian Divisions 4 and 5. In this report the five divisions are used in describing both the Upper Silurian and the Kingston series.

Section on Magaguadavic River.

The parallelism between these two sets of strata is apparent in a section from McLeod's Mill, in the valley of the Magaguadavic River, through Bullock's Hill, to the La Tête Road, on the south side of that river. In the slates and felsites (described at page 127, Report 1870-71) as exposed for a width of a-quarter of a mile along the estuary of the Magaguadavic, near the mill named above, it is believed that Divisions 1, 2 and 3 are represented, as it has been found that the band of vesicular diorite and fissile black slate is the equivalent of the upper part of Division 3. The soft black slates, of which a narrow belt is exposed at the opposite (western) end of this section, are, perhaps, of an older series—the St. John group—fragments of which are found in the conglomerates of the Upper Silurian series (Divisions 2 and 3), at many points in Charlotte County. The Magaguadavic River interrupts the continuity of this section for a space of 1,000 feet, but beyond the river, and extending over Bullock's Hill, is the following succession of beds :—

	FEET.	FEET.
Dark-grey, compact and schistose diorite, with some beds of grey clay-slate..........	100	
Dark-grey clay-slate..........	100	
Dark-grey, chloritic schist and beds of diorite..........	50	
Measures concealed (east of this space, on the strike, are coarse hornblendic diorites)..........	350	
Measures concealed—in part a dark-grey, slaty, (reddish-weathering felsite)..........	200	
Dark-grey diorite..........	50	
These are beds of Division 4..........		850

	FEET.	FEET.
Dark-grey, feldspathic breccia, conglomerate, and dark-grey felsite. The conglomerate portion of this mass abounds with small angular fragments of flesh-red felsite, such as are found in a conglomerate at the base of the Upper Silurian Division 5, on the Mascareen shore, four miles to the south-west; there, however, the paste is of a bright-red colour	110	
Dark-grey, feldspathic, slate conglomerate, with grey slate pebbles and a more or less vesicular paste	220	
Schistose, grey, flesh-red-weathering felsite, and measures concealed	200	
Dark-grey, schistose diorite, and measures concealed	140	
Compact, but somewhat schistose, well laminated, reddish-grey, red-weathering felsite	220	
Dark-grey, slaty felsite	50	
Reddish-grey, flesh-red-weathering schistose felsite	140	
These are all beds of Division 5		1,080
Dark-grey, fine-grained diorite	200	
Coarse, hornblendic diorite	300	
		500

These are, probably, a repetition of a part of Division 4, and extend to the road to La Tête. South of the road, surface deposits conceal the measures. The strata in this section dip S. < 80°.

Divisions 4 and 5.

Along the La Tête shore, at the south-west end of the Mascareen peninsula, Division 4 becomes a very important portion of the series; for south of the felsites, in the ridge where Woodward's copper mine was opened, the diorites and chloritic schists have a surface breadth of 2,000 feet of nearly vertical measures; and on the south side of the ridge, where the Johnson mine is located, the width occupied by this group is 4,000 feet. It here consists of fine and coarse-grained, chloritic diorite; fine, dark-grey, compact diorite; coarse hornblende-rock; greenish-grey, micaceous slates, and dark-grey clay-slate. In this belt of Kingston rocks the beds of Division 5 have double the width that the corresponding beds at the Mascareen shore exhibit, and the apparent disparity in thickness between the strata of Division 4 in the two localities is even greater.

In the space between these and the belt of the typical Kingston rocks, come the Laurentian gneiss and "Costal" strata described on a previous page. The Upper Silurian sediments which rest upon these more ancient deposits, more nearly resemble those visible at the Mascareen shore than the intervening strata of La Tête, except that the groups are thicker. Of the Upper Silurian strata which overlie the Laurentian and Costal belts of rock, Divisions 1 and 2 are vertical, and have a breadth at Beaver Harbour, across the strike, estimated from the admiralty chart of Quoddy Head to Point Lepreau, of 2,000 feet. The quartzites of Division 3 show themselves on the south side of Deadman's Harbour, dipping N. < 30°, with an estimated thickness of 700 feet. There is then a space in Deadman's Harbour, and an exposure of Laurentian rocks of 1,300 feet, to which succeeds, on the peninsula between Deadman's and Black's Harbours, red conglomerate and sandstone, dipping N. < 30°; estimated thickness 1,000 feet. There is supposed to be a fault in Black's Harbour repeating these measures, which on its north side retains the same dip, and has an apparent thickness of 1,500 feet.

Divisions 1, 2 and 3.

Conditions of deposition.

These red rocks are regarded as shallow-water equivalents of the beds of Division 4. Division 3, also, in the scarcity of shales and the density and silicious composition of its measures, and in ripple-marked layers, gives evidence of littoral origin; and as low down as Division 2, there are plentiful, though badly preserved, remains of land plants. The conditions of origin of this belt of Upper Silurian rocks was, therefore, similar to those under which the strata at the Mascareen shore were deposited, and the different aspect of the measures in the intervening La Tête belt (supposing them to be Upper Silurian) is to be accounted for under the hypothesis of a sinking tract in which crystalline sediment accumulated, enclosed on either side by belts of comparatively stable Laurentian rock.

Exposures on Little New River.

An overlying set of red beds also exists on the north side of the main Laurentian belt. These overlying sediments are well exposed on Little New River, a stream which runs close to the St. Andrew's road, where it is crossed by the parish line of Lepreau and Pennfield. At this point the stream is bordered on the right bank by a band of protogene gneiss and coarse diorites of the Laurentian series, but on the left by prominent (white-weathering) ridges and knolls of dark-grey felsite, holding a few grains of quartz and crystals of feldspar. Similar white-weathering masses of rock, consisting of fine-grained feldspathic schist and gneiss, with very little mica, extend for half-a-mile north from this point, and similar ledges were also seen on approaching the dam at Little New River, one mile north-west of Donnelly's Inn. The rock here is a feldspathic schist, with pale-green chlorite, and numerous grains of quartz, and is exposed in high ledges on the south side of the pond below the dam.

Beds of dark-grey, white-speckled slates, to the south of the schist, dip S. 10° E. < 90°.

The rock at the dam itself, belongs to an overlying series, being a grey amygdaloidal (green-weathering) clay-slate, with beds of grey slate conglomerate; dip, N. < 90°. The conglomerate has beds of greenish and purplish grey clay-slates in it, and the fragments which it contains are usually elongated and angular, and are occasionally as much as a foot across. They have been derived from greenish-grey banded slates, grey chloritic quartziferous schists, and grey, white-speckled arenaceous schists, and are accompanied by a few quartz pebbles. All these are fragments of rocks found in older series south of the dam. At the distance of one-eighth of a mile north-west of the dam, there are a few ledges of purple and greenish coarsely-bedded clay-slates, exposed in the gravel flat which spreads north from the dam. They are seamed with calcspar and specular iron, dip N. 10° W. < 80°, and are, probably, a part of the set of beds exposed at the dam. The gravel flat is about a mile wide, and north-west of it rises a hill of hard, dark-grey clay-slates, with epidotic veins and cloudings; dip, N. 20° W. < 70° and 60°, belonging to the La Tête band of Kingston rocks. Not far to the north of these hard slates the sedimentary rocks are cut off by granite.

Micaceous slates.

Another belt of reddish-grey, silvery-weathering, micaceous slates, extends from the mouth of L'Etang River westward along the La Tête band of Kingston rocks. It apparently overlies the fossiliferous beds of Back Bay, and has conglomerates in connection with it at Frye's Island, and the small islands to the south-west of Frye's, containing fragments of "Coastal" and Laurentian rocks. It is, consequently, regarded as a part of Division 4, and equivalent to the micaceous, or nacreous slates at the base of this division in Grand Manan.

Rocks of Grand Manan.

Grand Manan.—The low eastern part of Grand Manan is underlain by a group of partially-altered rocks, which combine the character of the two belts of Kingston rocks, and those of the Upper Silurian strata resting upon the belt of Laurentian which divides them. This island was visited by Prof. L. W. Bailey, and the formations described in the report of 1870-71. The observations then made go to show that this group of rocks presents two anticlinal folds and one synclinal. The axis of both anticlinals are directed to the west of north, and run under the Mesozoic sandstones and trap, which form the higher part of the island.

Eastern anticlinal.

The axis of the eastern anticlinal passes through the chain of islets off the eastern shore of Grand Manan, and strikes that island in Flagg's Cove. Here the beds, which correspond in position to Division 1, are coarse, grey, sandy shales and slaty sandstones, with thin beds of conglomerate. They include some beds of hard, grey, white-weathering nacreous slates, and form the extreme point between Flagg's and Pette's (or Spragg's Coves.) Division 2 is represented by the overlying black, fine-grained slates, with narrow alternating colour bands (1 to 2 inches wide). Some conglomerate layers in this group contain numerous pebbles of pale-grey, flinty felsite. Division 3 begins with hard, grey, feldspathic grit and conglomerate—if, indeed, this is not a part of Division 2 (2 c.)*—but consists mainly of hard, fine-grained, feldspathic, slaty sandstone (3 b.) with thin beds of black slate, and fissile black shale interlaminated at intervals. The summit (3 c.) is marked by a band (20 feet) of dark-grey, and black, compact and fissile pyritous slate. The foregoing beds are exposed along the eastern shore of Flagg's Cove, but the higher members of the series are to be sought for in Pette's Cove. Division 4 begins here with pale-grey (white-weathering) nacreous slates. These pass into coarse, grey sandstones, having beds of grey nacreous and dark-grey slate interstratified, and having grey ochreous slate and slaty dolomite at the base. Overlying these beds there is a heavy mass of hard, grey, feldspathic and quartzose schistose rock, containing chlorite, and having beds of hard, grey slate, interlaminated at intervals. Division 5 is represented by gneissic strata in heavy beds on the eastern side of Pette's Cove near the lighthouse, and consists of grey feldspathic gneisses and dioritic schist, of the lower part of this group, and greenish-grey imperfectly syenitic gneisses, and grey clay-slates of the upper part.

Western anticlinal.

The axis of the western anticlinal runs between Red Head and Oxnard's Point, in the direction of Mark's Hill. Beds of Division 1 are brought up on the western side of the axis, along the shore north of Red Head, but are more chloritic and schistose than in the northern part of the island; and the banded slates of Division 2 appear along the same shore, with grey, and greenish coloured bands. Between Oxnard's Point and the head of Grand Harbour, the strata exposed along the shore are all like those which are found in Division 4, and the measures are probably repeated by fault. East and north-east of Grand Harbour the dip of the bed is low and irregular, and grey feldspathic rocks predominate. The structure of this tract is supposed to be irregularly synclinal, the course of the axis being indicated by the hard white-weathering feldspathic rocks, which extend from Woodward's Cove through Ross Island to the Gull Cap Island. This belt, may, however, consist in part of an

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* Mascareen section, Report of Progress 1870-71, p. 145.

older feldspathic series, from which the pebbles in the beds at Flagg's Cove have been derived.

Southern belt of Kingston series.

In the more southerly belt of Kingston rocks, which extends through to the peninsula of Kingston, there is an immense development of the crystalline schists. The best section of these rocks in Charlotte County, is that exposed on New River. For a mile and a-half back from the post road to St. Andrew's, where it crosses this stream, there are very few ledges exposed. These, beginning at the protogene gneiss of the Laurentian belt above the falls, are as follows :—

Greenish chloritic granitoid rock, with grey amygdaloidal clay-slate.
Dark porphyritic slaty felsite, with grains of quartz.
Grey clay-slate, and dark grey diorite (at the falls).

A short distance below the falls, about a mile north of the road are :—

Chloritic and feldspathic slate, and grit, with some slate conglomerate. Feldspathic grit, with fragments of red felsite. Dip N. 10° W., < 10° to 40°. Recomposed, chloritic slate, with grains of feldspar, and some fine-grained, sandy, micaceous slate. Dip S. 30° W., < 40°.

These measures are probably on an anticlinal fold, and are thought to be Upper Silurian. They are followed, after an interval of half-a-mile or more, in which the measures are concealed, by ledges of compact dark-grey diorite and flesh-red felsite. These are within a few hundred yards of the bridge at the post road, below which there is a continuous ascending series of ledges exposed along the road, to the mills at the mouth of the river. These have been measured by pacing on the road, and reduced to show the probable thickness of the several groups, which are as follows :—

	Apparent thickness.	
	FEET.	FEET.
Compact diorite, fine grained, and of a dark-grey colour, and flesh-red felsite, in frequently alternating beds of twenty to fifty feet in thickness. The diorites are seamed with epidote, and contain pockets of granular chlorite, having imbedded crystals of orthoclase feldspar, and masses of epidote, in large, radiating, bladed crystals ; the diorites also contain specks of copper and iron pyrites, and are imperfectly porphyritic, with crystals of grey feldspar. Dip, S. 20° E. < 70°.	950	
[The absence of exposures of the subjacent measures makes it doubtful whether these beds belong to Division 3 or Division 4.]		

	Apparent Thickness.	
	FEET.	FEET.
Hornblende-schist	395	
Schistose diorite, with some gneiss	395	
Hornblende-schist, and porphyritic, dark-grey diorite	420	
Porphyritic, schistose diorite, hornblende-rock and hornblende-schist	1,425	
Porphyritic, schistose diorite, and some felsite	765	
Hornblende-schist	500	
Hornblendic and feldspathic schist	450	
		4,550
The dip of the beds in this group is S. 15° E., < 70°. [These are typical rocks in the Kingston belt of Division 4: they differ from the corresponding measures of the La Tête, or northern belt, in the substitution of hornblendic for chloritic schists].		
Hornblendic mica-schist; porphyritic, feldspathic mica-schist, and slaty felsite. Dip, S. 15° E., < 70°	830	
Fine-grained, silicious mica-schist. Dip, S. < 60°	725	
Measures concealed	265	
Fine, slaty, hornblendic mica-schist. Dip, S. 20° E., < 30	200	
Hornblendic and common mica-schist. Dip, S. 15° E., < 70°	340	
		2,360
[At this horizon in the La Tête belt, there are micaceous slates, which appear to be connected with Division 4 rather than with the overlying felsites.]		
Silicious, feldspathic gneiss	330	
Grey, feldspathic gneiss. Dip, S. 15° E < 70°	260	
Measures concealed—to the west of the line of section this space is occupied by highly feldspathic, evenly bedded, (white-weathering) gneiss, with one thin band of sandy limestone	1,800	
		2,309
Chloritic, feldspathic gneiss, with some beds of chloritic hornblende gneiss, and of grey argillite. Dip, S. 15° E., < 45°.		800
		11,050

These gneissic rocks hold the position of Division 5, but it is probable that they do not include the uppermost measure; for a mile east of the mouth of New River, on the sea shore at Barnaby's Head, there are red schistose, granitoid rocks, grey, chloritic schist, and chloritic gneiss and grit, which extend to the extremity of the head in low undulations; these, if added to the series, would double the thickness of the chloritic gneisses.

St. John group.

The St. John group has been found to intervene between this belt of Kingston rocks and the enclosing Laurentian ridges in King's County, and fragments of black slates, like those so characteristic of the upper half of the St. John group, are common at a number of points in beds of Divisions 2 to 3 of the La Tête belt of Kingston rocks—showing that this band overlies the St. John group unconformably, and that it is not older than the Lower Silurian formation, (as distinguished from the "primordial.") Such fragments, however, have not yet been observed in the more southerly belt of Kingston strata. That the La Tête belt of Kingston rocks is Upper Silurian, is probable from the close parallelism between the successive groups of this formation and those of the La Tête belt, and also from the occurrence in the latter of the breccia-conglomerate at Bullocks Hill, mentioned above. No fossils of any value in determining the age of the Kingston group have been found.

Metals occurring in Kingston series.

Two important metalliferous zones exist in the Kingston series: viz., Division 4 and—in the southerly belt of these rocks—the upper part of Division 5. The metals occurring in this formation are copper, lead, zinc, bismuth and iron. Most of the localities where these metals exist are mentioned in the report of 1870-71. I add here an account of such as were visited in the course of the field-work of last summer.

Copper.

Johnston Mine.—The work at this mine has been suspended, but the large heaps of refuse vein-rock around the buildings show that extensive operations were carried on here. I was informed that the shaft had been sunk to a depth of 200 feet, and several levels driven on the course of the vein, which has an underlie of N 35° W., < 85°, but is said to be vertical at a depth of 80 feet. The ores mined here were copper pyrites, and variegated copper ore, but they were mingled with large quantities of magnetic pyrites, especially in the lower workings. The gangue consists of quartz and calcspar mixed, and there is a vein of schorl in one of the quartz veins parallel to the main lode. Native copper is said to occur in connection with hornblende rock at this mine.

Copper.

Oliver Lode.—This property is about a-quarter of a mile north of the Back Bay road, and to the north-east of the Johnston mine. It is on the system of veins seen at that mine. The lode is contained in schistose diorite, and chloritic schists, which, at the western pit, are full of open seams and cracks, so that there is little difficulty in draining the upper part of the vein. There were several tons of ore ready for removal, at the eastern pit sunk on this lode. This opening had been made where the main lode is crossed by one running east, with an underlie of 70° S. Feldspar and quartz form the gangue in this part of the vein, and there is much granular chlorite, in which native copper has been found. The miners were sinking a pit on another part of this lode which has an underlie of 70° to the north-west. The rock is divided by numerous irregular joints, and at the junction of these with the main vein the copper ore lies in pockets, while between these joints it is, in many cases, entirely pinched out. The ore at both of these openings is the yellow sulphuret.

Copper, bismuth and gold.

Cameron Lode.—About 150 yards north-east of the Oliver Lode, other metalliferous veins are exposed on the top of a low ride of chloritic diorite. The underlie of this vein is S. 35° E. < 65°. It carries sulphuret of copper (chalcopyrite) in a gangue of quartz, with some calcspar and foliated chlorite. It also contains native bismuth, native copper, (in the chlorite) carbonate of copper, and sulphuret of iron. Samples of this ore, analyzed under Dr. T. S. Hunt's directions, at the Geological Survey Office, in Montreal, yielded 10 p.c. of bismuth, and $5 to the ton of gold. The yield of copper, from samples analyzed by Prof. Nichol, of Halifax, was 29½ p.c.

In going northward from this point, the land for some distance is low, with occasional exposures of schistose diorite and clay slate, but about a mile from the Magaguadavic River, it rises into a ridge, showing the schistose grey felsite on its southern slope, and the associated grey slate conglomerate at the summit. On the north side of the ridge there are irregular beds of limestone, from two to three feet in thickness dip; S. 40° E. < 70°. In one of these is a vein carrying galena. Nearly half way from this ridge to the river the felsites are repeated, and as they appear again in Bullock's Hill, close by the river. There are, evidently, several folds or repetitions of the Kingston series in the triangular tract near the river.*

Relation of the lodes.

The copper-bearing veins at the Cameron, Oliver and Johnston mines, as well as those on Adam's and Simspon islands, to the westward, all belong to a set of lodes having a course of S. 55° W., and they are situated along a continuous line of veins, cutting the measures of Division 4 nearly parallel to the strike. In the southern belt of Kingston rocks, although there are numerous indications of copper at various points in the beds of this division, no lode of any importance has yet been found. The best indications of copper which the more southerly belt offers, are met with in the chloritic schists at the top of Division 5. The copper-bearing veins at this horizon occur along the sea shore, between Beaver Harbour and Popologan, but have not so far been found

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* In visiting these mines I was greatly assisted by Mr. Thaddeus Dick, of La Tête.

rich enough to encourage the expenditure of capital. They are marked on the accompanying map.

Devonian anthracite.

Devonian.—While in the vicinity of Lepreau Basin, completing the examination of the eastern border of Charlotte County, I visited the pit made by Mr. G. K. Hanson, Collector of Customs at that place, to test the beds of anthracite coal which he had found there. Mr Hanson had sunk a shaft ninety feet deep, on a seam of coal and shale, fifteen feet in width. His shaft is 8 × 4 feet, and timbered in two compartments. For some fifteen or twenty feet from the bottom of the shaft, an improved quality of coal had been met with, and several barrels were taken from outside the foot of the shaft; this led to the "blowing" of the bottom of the shaft, where a spring broke in, and put a stop to the work a week previous to my visit.

Character and position of the seam.

The mineral from this seam is a granular anthracite, which, with the accompanying shale, abounds in slickensided surfaces. Through the upper part of the working, the more slaty layers are irregularly distributed throughout the seam, but in sinking on the bed, the coal was found to improve in quality on the southern side of the shaft, so that at the bottom of the pit a thickness of four feet of the purer coal was penetrated, without reaching the foot wall of the seam. I found that the seams of coal and shale at this locality are on the horizon of the plant-beds in the Devonian formation at Saint John, being at the junction of the Dadoxylon sandstone, with the Cordaite slates. The main seam is separated from the coarser part of these slates by some beds of olive-grey, arenaceous shale; but the Cordaite beds themselves are red, and contain irregular bands of limestone, made up of the *debris* of the limestones in the "Upper Series" of the Laurentian area, which are found in the hills to the south of Lepreau Basin.

The Devonian beds in this basin have been subjected to severe pressure, which has ridged them up into folds of nearly vertical strata. An anticlinal of Dadoxylon sandstone runs along the north side of Lepreau Basin, and another through Belas Basin, an inner portion of the same harbour. Between the two sheets of water is a ridge of Cordaite slate, limestone and conglomerate. It is to the south of this ridge, on the Belas Basin side, that Mr. Hanson's pit is sunk.

Granite.

Granite Works.—While at St. George I made some enquiry into the condition of the factories established for shaping and polishing granite.

In the report of 1870-71 a description is given of the area of intrusive granite extending from St. George to Greenwich, in King's County, and different varieties of the rock described at pages 180 to 190. The value of some of these varieties for ornamental purposes, including those of St. George, is touched upon at pages 235 to 236. It is gratifying to know that at one point, at least, capital has been introduced to make a part of the inexhaustible quantities of handsome and durable stone in this county, available in the arts.

At Saint George, three companies have been formed for quarrying and working red granite, and the history of this industry, subsequent to our examination of the region in 1869, is given as follows:—

Discovery of red granite.

"In the summer of 1872, Mr. C. Ward, Canadian artist of the 'Illustrated London News,' at present secretary for the company– Bay of Fundy Red Granite Company—was desirous of fishing on Lake Utopia. Mr. Ward approached a fisherman to hire a boat which was anchored to the shore by a large red stone. In raising it, its rich colour attracted his attention, and upon looking at it closely he at once saw what it was, and it occurred to him it might be utilized for a better purpose than as a primitive anchor. Instead of going on his intended fishing excursion, he went hunting for red granite stone, and the result was the further discovery of immense ledges of beautiful dark-red granite—which led to the existence of the present quarries."

Bay of Fundy Red Granite Company.

The property of the Bay of Fundy Red Granite Company, includes 1,320 acres of land, situated about two and a-half miles from the town of St. George, and north of the "thoroughfare" or natural canal leading from the Magaguadavic River into Lake Utopia. This large tract of land is covered by rugged hills of granite, of various shades of red. "In the "eastern portion of the land, it is of a deep red colour, with some ledges "of pink and salmon colour." At the quarries the rock is red, of various degress of intensity, with occasional large patches, twenty to forty feet across and of indefinite length, of pale cream-colour, and grey. Several faces have been opened out along the hill side, and in these the rock is very conveniently jointed for quarrying. The vertical joints have a nearly east and west course, and there are two other prominent sets of joints—one with an underlie of 40° or 50° easterly, and the other of 10° to 20° westerly. Blocks of very large size, (twenty or thirty feet long), are taken out by blast in "Lewis" holes,* and these blocks can be readily split to any required dimensions. The rock at this quarry passes under the name of granite, but it is really a syenite, with very small quantities of mica and hornblende, or a binary granite, composed of orthoclase

Quarries.

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* These are made by drilling out two holes close together, and subsequently breaking out the core which divides them. When the charge is exploded, the rock breaks along a plane parallel to the longest diameter of the enlarged holes.

feldspar and quartz alone; hence the whole surface of the stone is capable of a very high polish.

At the time of my visit there were ten men at work in the quarries, a number which, I was informed, was considerably below the average. There is an easy descent from the hill-side where the quarries are situated, by a well graded road, to the Lake Utopia thoroughfare; and by it, and the Magaguadavic River, there is a good channel of communication by water with the village of St. George, two and a-half miles away.

Works.

The company have their works in this village, on the bank of the Magaguadavic just below the falls. The river here connects with tide-water in a narrow gorge, in which the water-power machinery is placed, by which the works are driven. The power is taken from a five feet Leffel wheel, (of 160 horse-power), with twenty-four feet of water, to a line of shafting passing into the buildings. The buildings of the company occupy three sides of an oblong space, about 300 feet long, and 175 wide, extending to the nearest street. In the enclosed yard is a travelling crane, for lifting and carrying the stone to all parts of the buildings; it has a hoist of twenty feet, and is capable of lifting eight tons. On the south side is the grinding and polishing shop, and on the west and north the cutting shed; the offices of the company are also on the north side, at the entrance to the yard. The buildings are so constructed that the work can be carried on without hindrance from storm and winter cold. The grinding and polishing shed is 300 feet long, and contains four large rotary carriage machines, or vertical rubbers, capable of polishing seventy or eighty superficial feet at once; also four hand rotary, vertical polishers, six pendulum machines, two of which are double, and thirteen lathes. This machinery is driven by a long line of four-inch shafting, connected with the water-wheel under the falls. There is an additional line of shafting at the west end of the polishing shop, for driving the lathes. These lathes are of various sizes, the largest being capable of turning columns twenty-eight feet long and three feet in diameter. The large carriage machines have carriage-beds four feet by ten feet, and the motion is taken to the vertical rotary polishers which work upon them, by cog-wheel movements; on the tables of these machines the stones are bedded to a uniform level with plaster of Paris. The four small rotary polishers are moved in a similar way, and have universal joints, to enable the workmen to move them at will to any part of his work.

Process of cutting and polishing.

The rough stone is first taken into the cutting shed, which is about 250 feet long, where it is dressed with chisels to the required form. It is next transferred to the grinding and polishing shop, where the rough grinding is done with sand and water. When the stone is sufficiently smooth the sand is cleaned off, and emery applied to the amount of one pound to two superficial feet of surface; this is kept upon the stone till it (the emery) is ground to an impalpable powder, or " sludge," free from grit. The emery is then thoroughly cleaned off, and moist putty powder (oxide of tin) applied, to polish the stone and give it a brilliant surface.

An ordinary spire six feet high, can be cut and shaped in four days by one workman, and when transferred to the polishing shop, about four days more are consumed in grinding and polishing the several sides of it. The expense connected with the preparation of this stone for market, is, therefore, considerable; but its colour and quality is such as to make it well worthy of the expenditure of time, labour and capital, and it is highly prized wherever it is known. At the time of my visit the works were being driven night and day, to fill an order for columns for the Roman Catholic Cathedral in Boston, Mass. Polished columns of this stone, have been erected at the Post Office in St. John, Parliament Buildings at Ottawa, and at several places in the United States. The works give employment to one hundred men and boys, at wages, ranging from fifty cents to two and a-half dollars per diem.

New Brunswick Granite Company.

New Brunswick Red Granite Company.—The quarries of this company are situated on the western side of the Magaguadavic River, opposite those of the Bay of Fundy Company. The situation of the quarries is good, being on a steep mountain face, where there would be no difficulty in getting rid the " grout" or rubbish stone, and being near to a navigable reach of the Magaguadavic River. The quantity of stone is unlimited, and the colour and quality similar to that on the east side of the river. The operations of this company have been attended by a strange fatality. Its extensive work-shops, erected at a cost of $30,000, were, unfortunately, burned soon after they were put in motion. These shops were on the bank of the Magaguadavic. After they were destroyed, the work of finishing the stone was transferred to St. John, but a short time ago the buildings there were also consumed, and much valuable plant lost.

Brothers Michael Quarry.

Quarry of the Brothers Michael.—This quarry is a short distance to the westward of those of the Bay of Fundy Company, on the east side of the Magaguadavic. It was opened at the beginning of the present season, and so far no attempt has been made to finish the stone, which is shipped away in the rough state. The colour and texture of the rock, is much the same as that at the quarries of the company last named, but the quarrymen here do not endeavour to get out such large blocks as are obtained from the ledges to the eastward of them.

Explanation of section.

General Section.—The accompanying section will show the general geological structure of the various bands of rock which traverse Charlotte County. It begins near the north-west corner of the county, and crosses the measures at right angles as far as Deadman's Head, on the Bay of Fundy, where it strikes the more southerly belt of Kingston rocks. The section recommences again about fifteen miles north-east of Deadman's Head, on the same belt of rocks, and extends from Little New River Bridge (on the post road between St. John and St. Andrew's) to the coast near Point Lepreau. This section intersects all the formations found in Charlotte County, except the Mesozoic trap and sandstone of Grand Manan Island, and a group of felsites, etc., of uncertain age, which cross the northern border of the county.The first portion, as far as the Waweig, intersects the clay-slates of Upper Silurian and Devonian age, which spread over a large area in the northern part of the county. Owing partly to the covering of forest in much of this slate region, to the scarcity of exposed ledges, and to the obscure lamination of the slates, the dip of the strata can be made out only at considerable intervals, and the details of the structure are obscured. Such dips as were observed along the line of section are marked upon it.

The second third, extends to Point Deadman, and exhibit the various attitudes of the Upper Silurian measures, where they rest upon Laurentian ridges. It includes the first belt of Kingston rocks, in which the beds are nearly vertical in position. But the other fossiliferous rocks are well exposed on this portion of the section, and the succession of the different groups is clear. The third portion of the section is intended to exhibit the structure of the main belt of Kingston strata, and of the Devonian and Lower Carboniferous measures which extend to the south-east corner of the county. In this part of the section, as in the tract of slate rocks crossed by the first third of the section, the pre-Carboniferous beds are tilted at high angles.

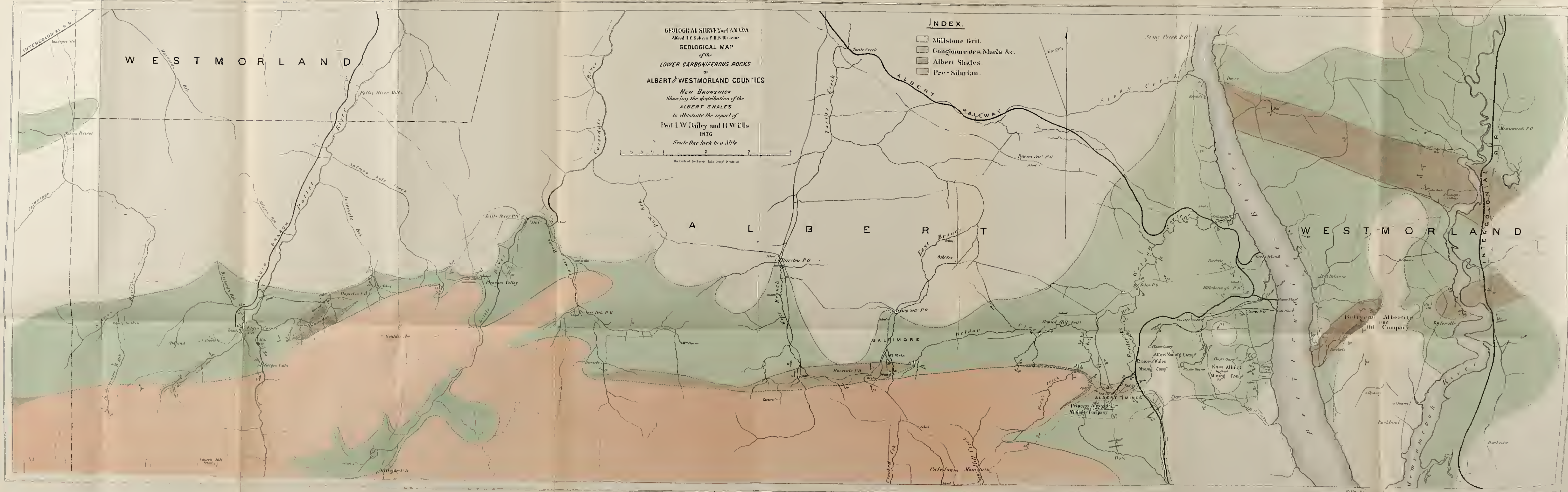
The fossils found in the Upper Silurian series of Charlotte County, do not show that any higher members than groups (Division) 1 and 2 are of Upper Silurian age. Those which occur at Back Bay, and at Pembroke, Maine, are not higher than the base of Division 3, and those of Frye's Island, also appear to be in Division 1 and 2. But as Division 3 is always intimately connected with Divisions 1 and 2, and contains several of the species of molluscs which are found in the underlying beds, it has been included with them as a lower section of the series, and is indicated on the section by a darker shade than the upper part. Between the three lower groups, and the two upper, there is often a difference in dip, due to disturbance of the lower beds before or during the deposition of the upper. Division 4 is very variable in thickness, and both it and Division 5, are, as regards the appearance and origin of the beds, in strong contrast to the lower divisions. There seems every reason for believing that the "Upper Silurian" series of Charlotte County, is the equivalent of the Gaspé series of the Province of Quebec, and as these upper series (4 and 5) may prove to be Devonian, they are distinguished on the map and section by a paler shade. This plan of indicating the lower group of beds by a darker shade, has been followed in mapping the "argillites" in the north part of the county, and the Kingston series in the south part. The Dadoxylon sandstone of the Devonian series in Saint John County—of which a small area is found in the south-east corner of the county—is, in like manner, distinguished from the Cordaite slates, etc.

High dips.

Throughout Charlotte County, very high dips prevail in these strata, except where the measures rest upon pre-Silurian gneiss and schist. Moderate dips, however, mark the strata around Passumaquoddy Bay, in the space between two granitic areas, one in Maine and the other in New Brunswick. In this tract the Upper Silurian measures are thinnest.

Publication of map and section deferred.

NOTE.—The publication of the map and section intended to accompany this report has been delayed, pending the more complete examination of the Kingston series.



GEOLOGICAL SURVEY OF CANADA
Alfred R.C. Selwyn F.R.S. Director

GEOLOGICAL MAP
of the
LOWER CARBONIFEROUS ROCKS
OF
ALBERT and WESTMORLAND COUNTIES
NEW BRUNSWICK
Showing the distribution of the
ALBERT SHALES
to illustrate the report of
Prof. L.W. Bailey and R.W. Ells
1876
Scale One Inch to a Mile

The Burland Desbarats Litho Comp^y Montreal

REPORT

ON THE

LOWER CARBONIFEROUS BELT OF ALBERT AND WESTMORLAND COUNTIES, N. B.,

INCLUDING TH^

"ALBERT SHALES,"

BY

PROFESSOR L. W. BAILEY, M. A., AND R. W. ELLS, M. A.,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq., F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Sir,—The following report embraces the results of geological observations made by us, in accordance with your instructions, in portions of Albert and Westmorland Counties, New Brunswick, during the past summer.

The particular purpose of the investigations in question, has been to afford a more accurate knowledge of the structure and relations of the belt of Lower Carboniferous rocks traversing these counties, and more especially of the belt of so-called "Albert shales," holding, near the town of Hillsboro, in Albert County, the famous deposit of *Albertite.*

Importance of Albertite deposit.

Since the first discovery, at the locality last named, of the remarkable mineral known as Albertite, much attention has been paid to the band of rocks in which it occurs, and large sums have been expended, with a view to the possible discovery of other similar deposits. Some of these attempts have been made under the direction of competent geologists, but in other instances mere guess-work would seem to have been the guiding principle upon which operations were conducted. Certainly, in no instance have they been based upon any complete or extended study of the entire series in which the mineral occurs, nothing being definitely known either of the succession or probable thickness of its members, or of the system of faults or dislocations by which it is broken. It has been to supply as far possible the knowledge thus wanting that our efforts during the past summer have been directed. This has been the more necessary, as, in addition to the observations made at different times, and by different observers, in the immediate vicinity of the Albert mines, at least two companies have been formed within the last year to search for albertite upon other portions of the band of Albert shales, to one of which has been entrusted the diamond drill formerly employed by the New Brunswick government in boring for coal at Grand Lake, and both of which have sought from the Geological Survey assistance in the prosecution of their researches.

Construction of geological map.

It having appeared to us, that an essential preliminary to a correct understanding of the district in question, would be the possession of a map showing with accuracy the distribution of the entire Lower Carboniferous series, with the position of its different members, and more particularly of the Albert shales, their course and dip at different points, together with all ascertainable faults and dislocations, our attention was first directed to the attainment of this object. A series of careful measurements, made partly by chain and partly by odometer, and embracing, as far as practicable, the whole region, was thus undertaken; the intermediate areas being, subsequently, examined by pacing, and the results embodied in a map, constructed on a scale of twenty chains to the inch, which is herewith submitted. From this larger map, a smaller one, constructed upon the scale of eighty chains to an inch, and embodying all the more important data, has been reduced, and accompanies the present report. In connection with the topographical work above referred to, the different members of the Lower Carboniferous series have received attentive study, as regards their structure, character and relations, as well as with a view to the determination of their approximate thickness. The results thus obtained are given below.

Acknowledgments of assistance.

In submitting our report, we would acknowledge our indebtedness to those by whom our labours have been facilitated, more particulary to the Managers of the Albert Manufacturing, and Albert Mining Companies, respectively, (the latter, among other favours, allowing us free access to the Albert mines, as well as the privilege of copying, for purpose of study, the underground plans and surveys of their works); the Directors of the Elgin Mining Company, James Blight, Esq.; and for the use of the odometer employed in topographical work—the Surveyor-General and other officials of the Crown Land Department at Fredericton.

The formations embraced in the area to which this report refers, are three in number, as follows:—

1. Metamorphic rocks of pre-Carboniferous age, with intrusive syenite.
2. Lower Carboniferous formation, including the Albert shales.
3. Millstone Grit formation, or lower member of the Carboniferous system.

I.—Pre-Carboniferous Rocks.

The Lower Carboniferous rocks, to which this report more particularly relates, lie along the northern flank, and at the eastern end of a chain of highlands, which, beginning near the city of St. John, extends eastwardly through the county of the same name, and finally terminates somewhat abruptly a little to the east of the centre of Albert County. The mean elevation of these heights, in the last named county, is not far from 800 feet, rising at its extreme eastern end, in Caledonia and Shepody Mountains, to as much as 1,200 or 1,400 feet, while that of the adjacent Lower Carboniferous areas would not average more than 150 to 300 feet. The rocks composing this elevated tract consist largely of slates, usually either chloritic or talcose in character, and of various colours; but with which are associated at some points, thick beds of grit and conglomerate, also chloritic or talcose, and, less commonly, beds of pink or flesh-red felsite or petrosilex. Their age has not yet been definitely determined, but from observations made upon the more westerly portions of the same belt in St. John and King's Counties, they would appear to belong to what, in previous reports, has been described as the Coastal Group, which is believed to be of pre-Silurian and possibly Huronian age.

Rocks of Caledonia Mountain.

Along the northern border of the metamorphic belt, and immediately adjacent to the Lower Carboniferous tract which traverses the centre of Albert County, the sedimentary rocks, which here consist mostly of chloritic slates, are associated with large quantities of reddish and grey syenite, which, in addition to occupying considerable areas, may be seen penetrating the slates in numerous veins and irregular masses of greater or less extent. They are well exposed on the Pollet and Coverdale rivers, and are the source from which the materials of the Lower Carboniferous conglomerates have been, to a great extent, derived.

Intrusive syenite.

Lower Carboniferous Formation.

The Lower Carboniferous rocks, referred to in the preceding section, as flanking the ridge of metamorphic rocks extending through the central portion of Albert County, form the eastward extension of a considerable area of such rocks which cover a large portion of King's County. Over much of this last named county no higher members of the Carboniferous system are met with, but in approaching its eastern boundary, the red sediments of which it is composed are at several points covered unconformably by isolated areas of grey rocks, having usually a much less inclination, and belonging to the millstone grit series, or the basal portion of the coal measures. In passing into Albert County, these overlying beds become more continuous, and stretching through its northern and central portions, reduce the Lower Carboniferous area to a narrow belt, following and immediately adjacent to the metamorphic ridge. Being unconformable alike to the older slates upon which they rest, and to the newer grey rocks which succeed them upon the north, these sediments present in their distribution great irregularity, filling on the one hand depressions and indentations in the underlying formation, while on the other, they are themselves often wholly or partially concealed by the deposits of the Millstone Grit. In the western part of the parish of Elgin, the breadth of the belt is about two and a-half miles, and a similar or greater breadth is again attained in the eastern portion of the same parish; but between the two, a spur of metamorphic rocks, extending north-easterly, serves to reduce this very greatly, and at one point, almost to bring these older beds into direct contact with the main area of Carboniferous rocks which lies to the northward. Further east, in the parish of Hillsboro, there is equal irregularity, but here it is from unequal denudation of the overlying millstone grit, the latter being often met with capping the summits of hills, of which the base, with the surrounding valleys, is occupied by Lower Carboniferous sediments. In the parish of Dorchester, also in the County of Westmorland, a like feature prevails, the older metamorphic rocks being wholly wanting, while the Lower Carboniferous sediments are, for the most part, confined to two great troughs, corresponding respectively to the valleys of the Petitcodiac and Memramcook Rivers.

Extent.

Westmorland County.

Disturbances.

Throughout the entire district to which the foregoing remarks apply, the rocks of the Lower Carboniferous formation show evidences of profound disturbance, being very generally tilted at considerable angles, while at many points they are nearly or quite vertical. These softer beds, in most instances, exhibit numerous and abrupt corrugations, while both they and the coarser sediments are broken by innumerable faults and dislocations. Under these circumstances, the determination of their true order of succession, as well as of their maximum thickness, is a work of great difficulty, and is to be inferred rather from an extended study and comparison of the different members throughout the entire area, than by actual measurements at any one point. From such comparisons, we are led to adopt the following, as, probably, representing the true succession; while the thicknesses given are in each case the least assignable to the different groups, allowance being made for their apparent increase by faulting. The order is an ascending one:—

Order of succession.

	FEET.
1. Basal conglomerate, sometimes wanting; when present usually of a dull greenish colour, less coarse than the conglomerates which succeed, and made up mostly of slaty fragments. Thickness unknown.	....
2. Calcareo-bituminous shales, from grey to dark-brown in colour, and including the so-called "Albert shales." At the base these beds are unconformably overlain by brownish-red, sandy shale. Thickness..	850
3. Grey, bituminous and micaceous, oil-bearing sandstones, and coarse conglomerates, in massive beds of very various composition, usually of a reddish tint; less rubbly and more calcareous than those of Division 1. Thickness..........................	700
4. Red and grey, calcareous, sandy and argillaceous beds, in frequent alternations, with thin beds of conglomerate, and towards the top heavy beds of fine, rubbly, brownish-red shales. Thickness....	450
5. Red and grey conglomerate, grey, flaggy limestone and gypsum. Thickness..	1,950

We now proceed to describe the distribution and characters of the above Lower Carboniferous rocks in somewhat greater detail.

Division I.—Basal Conglomerates.

Position.

Dr. Dawson, in his Acadian Geology, in describing the distribution and succession of the rocks of the Lower Carboniferous formation in the eastern part of Albert County, has referred to the so-called Albert shales, as being the lowest member of the formation there met with. These shales are, however, at several points, directly underlain by a series of conglomerates, probably of no great thickness, which form the true base of the formation in question. Where met with they are conformable to the shales, and like the latter are usually highly disturbed. They are, however, by no means constant in their distribution, and from faults or other causes, are not unfrequently wholly wanting. Though not always readily distinguishable by lithological characters from the more conspicuous conglomerates met with higher in the series, they usually differ in being more uniform in composition, being commonly made up to a great extent of slaty fragments, of grey and greenish-grey colours, imbedded in a paste of similar derivation. They are also often more rubbly, and less markedly calcareous than the higher beds, while their colour is a dull green instead of red; this being due, apparently, to the presence of disseminated chlorite in the materials from which they are derived. Their stratification is generally obscure, and as we have found them exposed only at a few points upon mountain brooks, we have been unable to make any exact estimates of their thickness, but think that this does not greatly exceed 200 feet. Their relations to the Albert shales will more clearly appear in some of the sections given below.

Character.

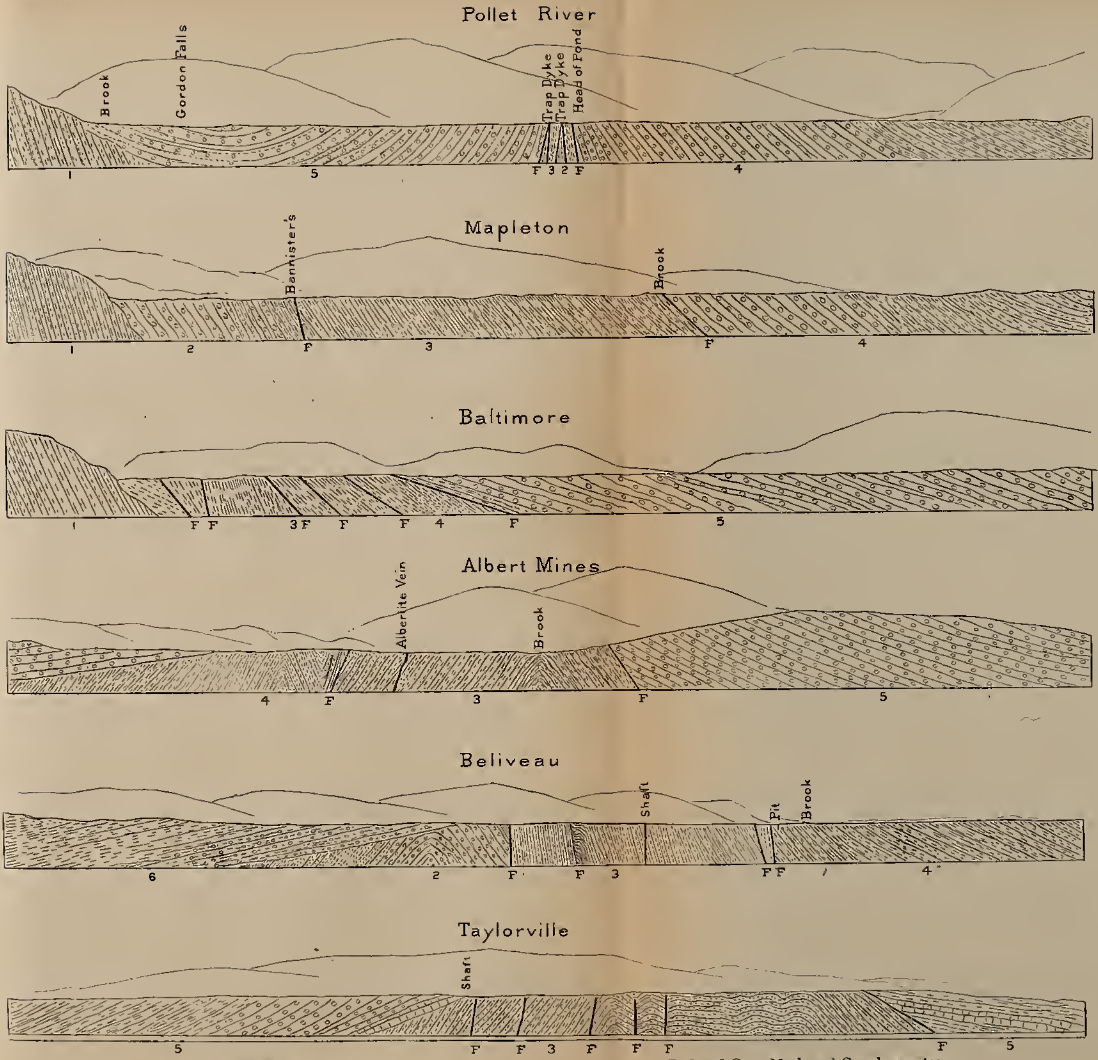
Thickness.

Division II.—*The Albert Shales.*

This interesting group of rocks, the most important from an economic point of view, of all the members of the Lower Carboniferous series, is also one of the most uniform and constant, being easily recognizable by its peculiar characters throughout almost the entire length of the extensive district in which it occurs.

As implied in the name, the bulk of the formation consists of shales, but while these are the prevailing rocks, there are also included, more particularly near the base and summit of the group, numerous beds of fine-grained sandstone, of greater or less thickness; and occasionally, but rarely, thin beds of conglomerate. The shales are, in general, thinly bedded, and often even papyraceous, splitting easily into thin and flexible sheets, but alternating with these are thicker and harder beds, destitute of any lamination, very tough, and breaking only with a chonchoidal fracture. Both the shales and sandstones, in common with the other Lower Carboniferous rocks of the district, are highly calcareous, so much so, indeed, as sometimes to approach a true limestone in character, while both calcareous and ferruginous bands and nodules are of frequent occurrence. The most peculiar feature, however, of the group, as well as the most persistent, is the extent to which they are everywhere impregnated with bituminous matter. This is not only evident in their colour, varying from a light-brown to a deep-brown or black, but also by their strongly bituminous odour, and the not infrequent

Character.



1. Pre-Silurian.
2. Basal Conglomerate.
3. Albert Shales.
4. Red and Grey Marl, and Conglomerates.
5. Red Conglomerates (upper series.)
6. Millstone Grit.

F. Fault.

Character

Thickness

Character

Petroleum in shales.

Fossils.

Horton Bluff.

occurrence, especially through the denser shales, of irregular streaks and layers of oily matter; while from the more sandy beds, fluid petroleum may be seen to flow at various points in quantities sufficient to admit of a limited collection. The source of these oily and bituminous substances is somewhat obscure; but, as will be shown in the sequel, is, in part at least, connected with the occurrence in certain bands of the shale of vast members of fossil fishes of the genus *Palæoniscus*, whose scales are also widely scattered through the formation, and serve as an important means of its identification. In contrast with this abundance of animal remains, the paucity of vegetable fossils is remarkable, the only plant remains met with, and these but rarely, being stems of species of *Lepidodendron* (*L. corrugatum* and *L. elegans.*) and of a Cyclopteris (*C. Acadica.*) These species, however, being typical Lower Carboniferous forms, are of much interest as serving to establish more definitely the geological age of the strata in which they occur. These latter are regarded by Dr. Dawson as the equivalents of the beds which in the Lower Carboniferous formation of Nova Scotia are exposed at Wolfville and Lower Horton. The beds of Horton Bluff resemble those of Albert County in their general lithological characters, as well as in their contained fossils, but the former are but slightly bituminous, and in addition to an abundance of fishes, contain also numerous vegetable remains.

Distribution.

The group of rocks to which the above remarks apply traverse the County of Albert in, at least, two distinct and well-defined bands. Of these the more northerly, running through the centre of the Parish of Elgin, is traceable for most of the distance, separating the waters of the Pollet and Coverdale Rivers, but to the eastward of the latter stream passes beneath, and is concealed by the overlying and unconformable millstone grit. The second is less continuous, being first met with, but only in an area of very limited extent, on Prosser Brook, a branch of the Coverdale, and nearly south of the eastern termination of the first-named belt; secondly on Turtle Creek, and in the settlement of Baltimore, where it occupies a considerable area; and thirdly, at the Albert mines—while between these two latter places it is mostly wanting, being, probably, covered over by the unconformable conglomerates of No. 3 and 5. For a like reason, it fails to come to the surface through the remainder of the Parish of Hillsboro, but on the east bank of the Petitcodiac River, in Westmorland County, and in the same general line with the localities above mentioned, it reappears, and is prominently displayed in the district of Beliveau, and again on the Memramcook River. At Dover, Beliveau.

in the same county, and four or five miles above Beliveau, a band of shales, which is probably continuous with the more northerly belt first described, emerging from beneath the millstone grit, crosses the Petitcodiac, and sweeping southward, also crosses to the Memramcook River, approaching that of Beliveau. The general relations of these rocks in Westmorland, are such as to suggest the existence here of a broad and open geosynclinal basin, having its eastern margin not far from the Memramcook River; but owing to the extremely broken and irregular character of the beds exposed, the establishment of such a relation is very difficult, while just east of the stream last named all the Lower Carboniferous rocks disappear from view, being concealed by the higher beds of the millstone grit, and so far as known, not being again disclosed in this direction.

Mapleton.

The best exposures of the rocks constituting the more northerly of the two belts above described, or that which traverses the parish of Elgin, are to be found a short distance to the eastward of the Pollet River, near Elgin Corner, and in the settlement of Mapleton. On the road leading southward from Elgin Corner, the shales are first met with on the farms of Alexander and John Stewart, and J. Bannister, being exposed in the beds of several small brooks flowing northward from the metamorphic hills. They are not, however, in immediate contact with the older rocks, of which the latter are composed, but as usual, separated therefrom by beds of rather coarse, greenish-grey conglomerate, of no great thickness, together with some beds of greenish sandstone, and limestone; the whole dipping north-westerly at high angles. The shales themselves present the usual varieties; some being massive, compact and hard, breaking into irregular blocks, while others are thinly bedded, or even papery, splitting readily upon exposure into thin sheets, which are both tough and elastic. Among the latter, both detached scales, and the complete forms of fossil fishes (genus *Palæoniscus*) are not uncommon. They are also, as usual, highly disturbed, exhibiting numerous small, but abrupt, corrugations, together with slickensided surfaces, indicative of faulting. The general dip of the series is nearly uniform, or about N. 20° to 25° W., $<$ 45°, though sometimes rising as high as 70° or 80°. On a course corresponding with this dip, the shales may be readily followed to the eastward to the settlement of Mapleton, where they are again well exposed just south of the main road traversing this place. Here, however, in the western part of the settlement the shales have a considerably greater breadth, and on the land of widow Stiles, include a considerable mass of conglomerate, the relations of which are somewhat obscure. This rock is greenish-grey in

Fossil fishes.

Included conglomerate.

colour, and rather coarse; (being made up of well rounded fragments of slate, felsite, quartz, etc., in a gravelly paste). It rises into a somewhat prominent hill, which, however, is flanked on either side by the shales, which thus become divided at this point into two slightly diverging belts. No conglomerates occupying such a portion have been met with in the eastern part of Albert County, and their occurrence here may, therefore, be only an effect of faulting; but as they are strictly conformable to the shales in dip, and very similar beds are again associated with the shales a few miles eastward, in what appears to be a continuation of the same belt, we feel compelled to regard them as actually forming a portion of the series at this point. Their relations will be better understood from the following section, measured from south to north across the strata. :—

Section in Mapleton.

	FEET.
Hard, green conglomerate, lying on the north slope of Goulden Mountain. Dip, N. 30° W., < 55°	...
Bituminous and marly shales—" Albert shales "	700
Ridge of greenish-grey conglomerate, somewhat resembling the underlying conglomerate. Dip, N. 30° W., < 60°	750
Bituminous and marly " Albert shale," to brook	450
Millstone grit	...

In the eastern part of the Mapleton Settlement may be seen another good exposure of the Albert shales, as well as of the beds which here immediately succeed them. They are to be found on a small stream crossing the high-road near the house of W. A. Colpitt, thence flowing northerly towards the Pollet River, and present the following ascending succession:—

Section in Colpitt's Brook.

		FEET.
DIVISION 1.	Conglomerates, greenish-grey, not very coarse, with pebbles of slate imbedded in a paste which is but slightly calcareous. These "basal conglomerates" form hills to the south of the Mapleton Road, and in immediate contact with the metamorphic ridges, but are not sufficiently well exposed to admit of measurement	....
" 2.	Brownish shaly beds, but slightly bituminous, and more or less rubbly, with layers containing concretionary nodules from half an inch to six inches in diameter. These beds extend nearly to the Mapleton Road, with a dip N. 30° W. < 35° to 40°, and represent an aggregate thickness of about	500
	Calcareous, bituminous shales, dark-brown, in alternating beds, of which some are soft and thinly laminated, and others hard, massive and compact, containing much iron, and weathering at the surface to a rusty-yellow. Dip, N. 25° W. < 25° to 40°. Thickness about	100

	FEET.
Massive, compact dark-brown shales, with interlaminated bands of fine-grained, somewhat micaceous sandstones, both bituminous. Dip, as before. Thickness........	270
Measures concealed....................................	250
Dark-grey, bituminous, and somewhat micaceous fine-grained sandstones and shales; in the upper beds very calcareous, and yellowish rusty-weathering. The dip rises from N. 25° W. < 55° to N. 25° W. < 70°........	140
Calcareo-bituminous, fine-grained sandstones, becoming coarser, and passing into a fine conglomerate. Dip, N. 10° W. < 80°.......................................	60
Grey beds, varying from fine sandstone to grit or fine conglomerate, in frequent alternations. Dip, as before...	500
Grey conglomerate, soft and rubbly, dipping N. 10° W., < 10°..	

[This latter conglomerate is unconformable to the preceding beds, and marks the southern limit, at this point, of the millstone grit formation.]

Pleasant Valley.

Between the settlement of Mapleton, and that of Pleasant Valley, to the eastward, the high-road runs for most of the way along a narrow valley, bordered on the south by high ridges of metamorphic rocks, and on the north by somewhat lower hills, of which the summits are covered by millstone grit. This valley is occupied chiefly by reddish and grey sandstones and shales, similar to those of Division 4; but in approaching the Coverdale River, a limited exposure of the Albert shales may again be seen near the intersection of the roads in Pleasant Valley, being bounded on the south by red conglomerates, and on the north by high ridges of millstone grit, overlying ledges of greyish conglomerate. Shales also appear on the flank of the hills bordering the southern side of the Coverdale River, nearly midway between Pleasant Valley and Parkin's mill, but at both these points the bulk of the formation, as compared with the beds at Mapleton, is greatly reduced, the surface breadth in neither case exceeding a few yards. This reduction is probably partly due to faulting, and partly to their being unconformably covered over by the conglomerates of No. 3; for, at the latter of the two localities just named, we find the shales, overlain by a greenish-grey conglomerate, dipping S. 25° E. < 60°, while at a point only fifty rods further north-east, similar conglomerates dip N. 15° W., < 85° to 90°. This is the most easterly point at which the shales have been observed in this northern belt, the area which they should occupy at and beyond Prosser Brook, being covered with the nearly horizontal grey beds of the millstone grit.

Elgin corner.

We now return to the vicinity of Elgin corner, with a view to trace the distribution of the same band of shales to the westward of that point.

Shales of Pollet River.

It has been stated that the shales are well exposed, and have considerable breadth, on the Stewart and Bannister farms, a mile or so eastward of the bridge over Pollet River. It might naturally be supposed, that with so great a body of these rocks as is here exposed, there would be no difficulty in following the latter on their line of strike, and that they would again be visible on the stream last named, with at least only a small diminution of their volume. One can, however, hardly pass the road traversing the farms in question, before finding that the shales have disappeared from view, their place being occupied by coarse and fine conglomerates, which apparently fill all, or nearly all, the space thence to the Pollet River. The shales do, indeed, appear upon this latter stream (at the head of the mill pond,) but in contrast with their breadth at Bannister's, have here a thickness of only fifty feet; being enclosed in a nearly vertical attitude between massive beds of coarse, grey conglomerate. It is very evident that the whole Lower Carboniferous series in this direction is extensively faulted; for while the conglomerates north-west of Stewart's exposure dip N. 55° W., $< 60°$, similar beds, only sixty rods further west, dip N. 20° W., $< 60°$; and again, on Pollet River, while the bulk of the conglomerates south of the shale exposure, and on the western bank, have a moderate dip (S. 20° E., $< 15°$), rising near the shale to S. 30° E., $< 60°$ to 75°, on the east bank, and to the north of the shale, the conglomerates dip N. 30° W., $< 60°$.

Fossil fishes.

Further evidences of disturbance at the same point are found in the occurrence with the true Albert shales, (which are thin bedded and grey, tough and leathery, and contain fossil fishes), of fine, grey and brownish-red shales, with thin beds of bright-green, coarse conglomerate, resembling those which at other points overlie the Albert shales, and which pertain to Division IV. of the Lower Carboniferous formation. One or more dykes of diorite, (which are of unusual occurrence in this region), pass through these beds, and may owe their origin to the same disturbances.

The following section at Pollet River, from the metamorphic rocks above the Gordon Falls to the bridge near Elgin Corner, will show more exactly the relations and probable thickness of the above named rocks:—

Section on Pollet River.

	FEET.
Red and grey conglomerates; holding pebbles of grey and purple slates and grits, chloritic gneiss, red jaspar, epidote, syenite, &c.; dipping at their contact with the metamorphic slates N. 30° E., < 20°; changing below the Gordon Falls to S. 20° E.; the angle and dip increasing from 10° to 90°, and forming a synclinal basin. Thickness about	1,200
Fine, grey and brownish-red, slates. Dip, S. 20° E. to 80° to 85°	60
Diorite dyke—passing into conglomerate	4
Bright-green, coarse conglomerate, with two red shale bands at end.	18
Trap dyke	1½
Hard, greenish-grey sandstone and conglomerate,—vertical	25
Albert shales,—vertical	50
Coarse conglomerate. Thickness unknown. Dip, N. 25° W., < 90°, decreasing to 40	.....

Robinson Brook.

Goshen.

The relations above described, as exhibited upon the Pollet River, appear to prevail also to the westward of the stream. At least, there is no considerable body of the true Albert shales visible in this direction, either in Albert County, or, as far as known, in King's County. The only shales seen west of Elgin Corner occur along the bed of a small stream (Robinson Brook) flowing through this settlement to Pollet River. They lie near the upper part of the stream at the foot of a high ridge of greenish-grey, rubbly, and rather fine conglomerate; weathering rusty and greyish-white, but of which the stratification is obscure, and with a north-westerly dip (N. 35° to 50° W., < 80°), are followed down the stream by beds of grey, calcareous grit and conglomerate, having the same dip. The shales are of the usual character, thinly bedded, calcareous and bituminous, with grey, calcareous bands and nodules, the latter containing fossil scales and fishes, while the overlying beds occasionally present imperfectly preserved stipes of ferns. To the westward of the above point, and through the settlement of Goshen, where the metamorphic rocks and the coal measures again approach each other, no trace of the shales was anywhere met with. It has been stated, that in the vicinity of Prosser Brook, one of the affluents of the Coverdale River, a spur of metamorphic rocks, extending to the north-east from the main body, serves to separate the more northerly or Elgin band of Albert shales, from that which extends through the parish of Hillsboro to the Albert Mines.

Prosser Brook.

The most westerly exposure in the second of these two belts, is to be found just south of the metamorphic spur in question, and almost at the source of one of the smaller branches of Prosser Brook. The shales here rest directly againt a high hill of petrosilicious or felsitic rock, and

Fossil plants and fishes.

present their usual characters, (yielding, in addition to numerous fishes, stems of *Lepidodendron*), but are of very limited extent, not more than a few rods of beds being visible, these overlain to the north at a distance of fifty yards by grey grits and sandstones. The dip of these Lower Carboniferous rocks at this point, (viz., N. 80° W., < 40° in the case of the sandtones, and N. 80° W., < 70° in that of the shales,) is peculiar, indicating a trend much more nearly north and south than is usually the case; but this appears to be quite local, as ridges of red conglomerate of the ordinary Lower Carboniferous type, which fill the valley a little to the north, again exhibit the ordinary easterly strike, though at a low angle (N. 15° E., < 10°.)

Turtle Creek.

Between the settlement of Prosser Brook and that of Roseville, a distance of six miles, the southern border of the Lower Carboniferous belt is marked by a slight depression, bordered on the one side by high hills of slate and felsite, and on the other by lower ridges of conglomerate. It is probable that much of this valley is occupied by shales. These are, however, first met with about three miles west of Roseville, and about three-fourths of a mile west of a by-road which descends from the summit of Caledonia Mountain. The shales here flank the base of the felsite hill, and extend northward for about eighty rods, having near the corner by John Stewart's, a dip N. 10° W., < 15°. From this point they are exposed along the road eastward to Turtle Creek, with a very regular northerly dip at a low angle, and again, along the whole length of the road running east from Turtle Creek to Roseville in Baltimore. The succession of rocks in Turtle Creek itself is as follows:—

Section.

	FEET.
1. Hills of felsite and slate, mostly felsite	.....
2. Hard, green rubbly conglomerate	.....
3. Albert shales; massive, deep brown to lead-coloured, with oil-bearing bands. Dipping N., to N. 10° W., < 10° to 20°, and extending from 80 to 90 rods	650
4. Thin bed of soft, greenish-grey conglomerate, apparently containing much shaly *debris*. Dip, N. 20° E., < 5° to 8°. This probably belongs to the overlying millstone grit series	40
5. Coarse and massive, reddish conglomerate. Dipping N. 10° W., < 10°, extending down the valley for a mile or more; and directly capped by No. 6	1,750
6. Greyish limestone; in heavy beds, nearly horizontal	50
7. Millstone grit, also nearly horizontal	.....

Proceeding east from Turtle Creek, the northern limit of the shales cannot be determined along the road, being covered over by high hills

Baltimore.

of Millstone Grit; but in the settlement of Roseville, in Baltimore, good exposures are seen in Baizley's and Forsyth's Brooks. On the latter brook the following section has been measured:—

Section on Forsyth's Brook.

Hard slates and schists, forming mountains south of the Lower Carboniferous belt.

1. Albert shales, of different characters; some thin and papery, others massive, and containing bands of hard, calcareous ironstone; extending down stream with a northerly dip, varying from N. 10° E. to N. 10° W., < 30° to 80°; changing gradually to hard, quartzose and shaly bands at the top, for a distance of one hundred rods.
2. Greenish-grey, grindstone grit. Dip, N., < 40°,—only a few feet in thickness.
3. Fine, red, rubbly shales, overlain by
4. Red conglomerate. Dip, N. W. < 20°.

Baltimore oil shales.

The shales of this section were formerly distinguished by the name of "Baltimore shales" from the so-called "Albert shales," owing to the supposed rich yield of oil. Several heavy bands of these dark oil-bearing strata are seen on Baizley's, where they appear to be more extensively developed than elsewhere, though strata of precisely similar character are found on Turtle Creek and at the Albert mines, as well as at Memramcook.

Notwithstanding the great thickness of the Albert shales, exposed, as is shown in the above section, on Forsyth's Brook, we have been unable to trace the direct continuation of these beds to the eastward for more than a very limited distance. They may be followed on the course of their strike along the northern slope of the metamorphic hills, from the upper part of the last-named stream to another, about a-quarter of a mile further eastward, flowing into Weldon Creek; but beyond this point no sign of them could be discovered until within a short distance of the Albert mines, the place which they should occupy being filled either with conglomerate or the brownish-red marly beds of Division 4. We can only explain their absence upon the supposition that throughout this area—occupied for the most part by the valley of Weldon Creek, and having a total length of four miles—the shales have been dropped out of view either by faulting, higher and lower beds being thus brought into contact, or by their being covered over by the overlying beds of No. 3. Indications of faulting were observed in the thickly-wooded country about the sources of Weldon Creek, the nearly-vertical shales being here apparently wedged out between two beds of con-

Weldon Creek.

Faults.

glomerate, of which the more northerly dips S. 80° E. < 15°, while the dip of the southern is obscure; but much better illustrations of the same thing may be seen in the immediate vicinity of the Albert mines. We now pass to a more particular description of this latter interesting locality.

Albert mines.

The bituminous shales of the Albert mines occupy an irregular area, imperfectly quadrangular in outline, and embracing an extent of about 250 acres. Their general arrangement, as well as their relations to the associated strata, will be best understood by reference to the accompanying plan, based upon measurements made by us during the past season, and wherein all such data as we have been able to obtain have been carefully laid down upon a scale of four chains to the inch. It will be seen that the tract in question lies almost immediately to the eastward of an easterly projecting spur of the metamorphic hills, which, extending across the valley of Peck's Creek, approaches within five-eights of a-mile of the western workings, but which thence falls off to the south and west, bordering a considerable area of Lower Carboniferous rocks about the headwaters, and along the valley of Demoiselle Creek. It seems altogether probable that this position has had something to do with the profound disturbances which have evidently affected the region, as well as the numerous and extensive faults by which it is everywhere broken. The former are well exhibited in the extremely irregular dip of the shales, both at the surface, and in the underground workings, while the latter are evidenced by the relations of the shales to the enclosing beds, as well as by the distribution and mode of occurrence of the Albertite veins.

Extension.

The most westerly point at which we have been able to detect the occurrence of the shales in this area is about fifty-five chains northwest of the main shaft, and near the head of a small brook, taking its rise on a ridge separating the valley of the Albert mines from that of Peck's Creek. In tracing the shales in this direction they are found to be bordered on either side by beds of conglomerate, the one of which (and probably the older) skirts the flank of the metamorphic (slate) hill referred to above, while the other, of coarser character and more varied composition, lies to the eastward, where, in the form of a rather prominent ridge, it is crossed by the roads leading northward from the Albert mines to Weldon Creek. It would appear that these conglomerates, in the direction referred to, by convergence along what are probably lines of fault, have nipped or cut out the shales to some extent,

Faults.

for not only do these exhibit a very rapid diminution in bulk in crossing the ridges in question, but in the valley of Peck's Creek beyond, where similar conglomerates may be seen in unconformable contact, and where an almost continuous section of Lower Carboniferous rocks is exposed, no trace whatever of the Albert shales is to be met with. It is further remarkable, that while over the greater portion of the area occupied by the shales, these do not usually have a higher dip than 60° or 70°, and are often inclined at a much lower angle than this, at the only point where actual contact with the conglomerates has been observed, viz.: on Frederick's Brook, below the mill pond,—both these and the shales are very nearly vertical. On the southern and eastern side of the mines the succession is more regular, the shales being in this direction directly overlain by red conglomerates, and there by the red sandy shales and limestones of Divisions 4 and 5.

Contact of shales and conglomerates.

The Albert Mine is situated on the upper part of Frederick's Brook, a branch of Weldon Creek, which, just below the west shaft, divides into two small streams, in both of which fine sections of the Albert shales, with their associated and overlying rocks, are exposed. It occupies the bottom of a valley which is enclosed on all sides by high hills and ridges of grey and red conglomerate. A section measured on the branch to the south shows the following ascending series of beds :—

Section at the Albert mine.

	FEET.
Albert shales, having a surface breadth of twenty-one chains, on a course magnetic north from the southern ridge to the anticlinal axis on the west branch. Dipping uniformly to the S.W., < 45° to 50°, and giving an estimated thickness of about................	800
Oil-bearing sandstones and grey and red, marly shales; overlying the Albert shales unconformably, and with several folds, having an exposed breadth of 920 feet, and an estimated thickness of.......	450
Red conglomerate to the top of the hill.........................	...

Structure of Albert mine.

The general structure at the Albert Mines is an anticlinal. The ridge of metamorphic slates, which ends a few rods to the north-west of the mine, forms an axis, around which the shales and underlying conglomerates sweep; the shales on the northern flank being cut out or covered over by unconformable beds of conglomerate. These also on the south side, where the metamorphic rocks form a basin extending to the west for about one and a-half miles, cover over the Albert shales a short distance west of the mine, and occupy a large part of the valley of Demoiselle Creek, to the south and east.

The anticlinal structure of the locality is well exhibited in the two branches of Frederick's Brook, before mentioned. The shales in the southern branch dipping to the south-west, while in the other the dip is to the north-west until near the summit of the ridge separating the mines from Peck's Creek, where, in the north-east slope of the metamorphic ridge, a small exposure of bituminous shales is seen dipping to the north-east at the usual angle of fifty degrees. The axis of the anticlinal may be seen on the west branch near the dump heap from the west pit; where, at the surface, the shales, with interstratified bands of calcareous ironstone, form a moderately steep arch. This point is also fixed by the under-ground workings; where, in the tunnel driven north from the bottom of the west pit 1,260 feet from the surface, a corresponding anticlinal structure is seen in the rocks, which are here very hard and compact, and correspond exactly in vertical position with that at the surface. This point is 420 feet north from the pit.

Anticlinal axis.

The shales in the western portions of the area are unconformably overlain by micaceous and bituminous, oil-bearing sandstones; the former dipping S. 50° W., < 70°, while the latter dip S., < 80°. In the eastern area, the shales, as seen in Frederick's Brook, as well as in the East Shaft, are overlain by a greenish-grey conglomerate having very nearly the same dip, but this may be only an apparent conformability, as the two series in other localities show marked unconformability.

Contact.

The chief point of interest attached to the Albert Mines is the existence of the only known workable deposit of Albertite that occurs throughout the whole extent of the formation, though explorations now being prosecuted with the diamond drill may reveal the presence of other deposits elsewhere. The value and importance of this mineral has been frequently alluded to in reports by various geologists, and in an appendix to this report several analyses by various persons are given. It has been thought by some to occupy the axis of an anticlinal, but while at a few points the dips of the strata in opposite sides of the vein seem to favour this view to some extent, careful observations along the course of the vein, of its enclosing walls, show that for the greater part of its course the vein cuts almost directly across the strike of the shales. This is especially seen at the extremities of the workings. In the western part, while the shales dip uniformly to the south-west, the course of the vein is north-east; while at the eastern end, where the beds dip ten to fifteen degrees south of east, the course of the vein is only twenty degrees north of east. In traversing the underground workings, for which privilege we are indebted to the courtesy of the President of the Company, Mr. Gilbert, of St John, the dips were found to sweep in regular order from west to east; changing from south-west at the western limit, to south at the central area, and around to S. 60° E. near the east shaft. The vein

Albert mine

Character of vein.

is very irregular in size, thickening from a few inches to ten or fifteen feet in a few yards, and is also much fractured and broken by numerous faults, being suddenly and repeatedly thrown sometimes to one side and sometimes to the opposite. Near the west shaft and extension to the south-west it follows an almost vertical course downwards to the lowest workings, while at the central and eastern area, by an apparent twist, it inclines rapidly to the south. The mine is now being worked at a depth of 1,260 feet; and a trial-hole put down in the western area one hundred feet further, showed the continuance of the vein in that direction. It has, however, become thinner at greater depths than near the surface. A very interesting feature, showing the vein structure of the deposit, is seen in one of the lower levels, extending south-east from the bottom of the west shaft, 1,260 feet down. The southern side of the vein is here filled with Albertite for about one foot, much compressed, while the remainder is occupied by a breccia, composed of angular fragments of shale cemented with a paste of Albertite—the vein occupying at this point a nearly vertical position, and being from three to four feet thick. In extent, the vein from west to east is 2,800 feet long in a straight line, and its course from end to end is twenty-three degrees east of north. In some parts in the upper levels it had a thickness of fifteen feet. In the area to the north of the west shaft, several leaders of Albertite are seen running in the usual north-east direction, but as these have not been proved for any depth, but little can be said of their economic importance.

Albertite breccia.

Remarks on the characters and mode of occurrence of Albertite will be found under the head of Economics.

Between the Albert mines and the Petitcodiac River, no trace of the Albert shales has been anywhere met with. Over portions of this area, the Lower Carboniferous rocks are altogether concealed from view by the overlying grey beds of the millstone grit, but where these are exposed in the intervening valleys, and along the west bank of the Petitcodiac River, they all appear to belong to the higher members of the formation, being red conglomerates, with red and brown shales and limestones. These beds exhibit, through the town of Hillsboro, several low undulations, as well as numerous breaks or faults of greater or less extent, but it is probable that they are throughout underlain by the Albert shales, at greater or less depths beneath the surface. This is, in part, indicated by the extension across the area of veins of Albertite, and the occurrence of petroleum springs, both of which, probably, have their origin in the shales in question, but is rendered still more evident

Petroleum springs.

by what is seen on the eastern side of the Petitcodiac River, in the County of Westmorland.

Shales occupy a geosynclinal basin.

It has been stated, on an earlier page, that in the county last named two belts of Albert shales may be distinguished, apparently forming the sides of a broad geosynclinal basin—the one belt, in continuation of that last described, extending across the peninsula, between the Petitcodiac and Memramcook Rivers, whilst the other, a possible continuation of the more northerly or Elgin belt, crosses the Petitcodiac at Dover, and thence bending southward, tends to unite with that first described.

Beliveau settlement.

The first exposures to be noticed in the more southerly of these two belts occur in the lower portion of the Beliveau settlement, and almost directly opposite to Edgett's Wharf, in Lower Hillsboro. They are here exposed over an area of about one hundred acres, of approximately triangular outline, being bounded on the western side by the river, on the south-eastern by a high ridge of millstone grit, which unconformably caps the shales crossing their strike, and on the northern, by the brownish-red and red marly sandstones and shales of Division 4. As at the Albert mines, the beds throughout this area are highly disturbed, being seldom inclined at a lower angle than 50°, and at times nearly or quite vertical, while they exhibit also, at various points, abrupt corrugations and evidences of more or less extensive faults. It has been supposed that there exists at this place an anticlinal axis in the exposed shales, but of this we have failed to find any distinct evidence, for although the general structure of the Lower Carboniferous formation of Albert and Westmorland indicates a series of anticlinal and synclinal folds, any foldings of the strata, through lateral pressure, which are sometimes met with, appear to be altogether local, not usually affecting more than a few yards of beds, while the exposed formation, as a whole, dips quite uniformly to the northward. We are inclined to believe that the series here observed forms the southern rim or margin of a broad basin, of which the opposite side is formed by the beds in Dover. It is, however, probable that portions of the series may be doubled by local twists, or repeated by one or more faults.

Supposed anticlinal axis.

The following section, measured across the strike, and along the course of several ravines, by which the shales have been exposed, will serve to render the structure at this point more apparent. The succession is an ascending one:—

Section at Beliveau.

1. Hard, greenish-grey basal conglomerate, underlying and near the contact, interstratified with "Albert shales," dipping N. 10° W. $< 50°$, and covered unconformably to the south by millstone grits

	FEET.
and conglomerate, dipping S. 10° E., < 10°. Thickness unknown	...
2. Albert shales, thin bedded and massive, including sharp fold, and several faults, by which the beds are repeated, the whole series dipping from N. 20° W. to N. 20° E., < 50° to 90°, and showing a surface breadth of	1,780
3. Bituminous oil-bearing sandstones, lying unconformably on the slates, and dipping N. < 50°	...

Taylorville.

Beds much disturbed.

Oil shales.

The position of the Albert shales on the lower part of the Memramcook River, corresponds very nearly with the course of the beds at Beliveau, and indicates that the two, though in part covered and concealed at the surface by the millstone grit ridge, to which reference has been made, are continuous beneath the latter. They are best exhibited on the shore of the Memramcook, in the settlement of Taylorville. An examination of the shales at this locality illustrates well the extent to which the series has been here, as elsewhere, dislocated and broken, rendering any computations of its thickness well nigh impossible, and shows the general anticlinal structure of the formation, also the beds at the northern end of the section dipping to the northwest, and at the southern end to the south—numerous faults being visible along the whole length of the exposure. Their section along the bank of the river has a surface of twenty-three hundred feet, and in its southern slope contains several very rich bands of oil shale, which were formerly mined to a limited extent. From the richness of the bands, and their proximity to a place of shipment, these shales should be very valuable.

Dover and Stony Creek.

We now pass to the consideration of the beds at Dover, before referred to as probably forming the northern side or margin of the geosynclinal basin, of which the beds at Beliveau form the southern. These, as exposed on the banks, and in the bed of the Petitcodiac, at and opposite the mouth of Stony Creek, consist in part of shales, of the usual dark-grey and bituminous character, but have interstratified with them hard silicious and calcareous sandstones, which also separate them from an overlying but conformable mass of greyish and reddish conglomerate, holding pebbles of red jasper, syenite, quartzite, limestone, gneiss, mica-slate and other metamorphic rocks, together with numerous pieces of limonite, imbedded in a paste which is highly calcareous. Both the shales and sandstones are very irregular in dip, their basset edges forming a double or sigmoid curve, with, however, a general inclination to the southwest, at angles of from 5° to 30°.

From Dover post office, near which these exposures occur, the shales appear to bend to the south-east, being well exposed at the saw mill on Colpitt's stream, where they are thin-bedded, with calcareous bands, and dip S. 30° W. $<$ 20°. They may also be seen, and in continuation of the same general trend, about the head of a small brook flowing into the Petitcodiac, about two miles south of Colpitt's, their dip here varying from S. 40° W. to S. 20° W. $<$ 25°. Finally, and in further continuation of the same belt, they may be seen immediately in the rear of the College of St. Joseph, along the course of a small brook connected with the Memramcook River. Their dip here is W. 10° N. $<$ 60° at the head of the brook, changing, however, a few rods down to S. $<$ 45°, and then to S. 10° E. 80°, this being probably the effect of a local twist. From the vicinity of the academy they extend to and across the Memramcook River, acquiring at the same time a more westerly dip, and tending to close around and unite with the beds of Taylorville. Actual union, however, of the two belts is not visible, owing to the passing of the strata beneath the unconformable beds of the millstone grit, which at a short distance eastward of the stream last named, completely encircle and form the eastern border of the Lower Carboniferous basin.

St. Joseph's College.

Eastern edge of basin.

Division 3.—Red Conglomerates.

It has been stated that at various points the calcareo-bituminous schists or Albert shales, which form the second division of the Lower Carboniferous formation, are overlain by beds of conglomerate of a brighter red colour, as well as of more varied composition than those which are known to underlie the last mentioned group. Beds which are believed to occupy this position, may be seen in connection with both of the belts of shale alluded to in the preceding section, but are somewhat variable, both in their distribution and their thickness.

Relations.

Along the more northerly or Elgin belt of Albert shales, the best exposures of the conglomerates in question are those afforded by the Pollet River, which, to the south of Elgin corner, flows through a very remarkable and picturesque gorge, composed of these rocks. They are of very coarse character, embracing pebbles of all sizes, from an inch or less up to two or three feet, usually well rounded, and embracing a great variety of rocks (grey and purple slates, red syenite, protogene, red jasper, quartz, epidote, feldspar-porphyry,) all of which appear to have been derived from the Coastal and intrusive rocks which may be seen a little higher up the stream, and against which the conglomerates repose. At the upper part of the section, and for 150 yards below, the dip is

Pollet River.

northerly (N. 30° E. < 20°), but in descending the stream this becomes considerably reduced at the Gordon Falls, while about 200 feet below, it becomes reversed (S. 20° E. < 10° to 15°) and, subsequently, S. 30° E. < 60°, indicating a synclinal. It is with a similar southward inclination, though at a still higher angle, that the conglomerates on the left bank meet, as already stated, a narrow band of Albert shales, the two sets of beds being strictly conformable along the line of contact. It is believed, as before mentioned, that these shales here indicate a line of fault as well as an anticlinal, for while on the left or western bank the dip is southerly (S. 20° E. < 60° to 80°), on the right the dip is again to the northward, the shales (which here also include red marly shales, etc., not seen on the other bank) being in this direction once more covered with heavy beds of coarse conglomerate, very similar to those about the falls, and dipping N. 30° W. < 60°. Further down the stream, at and below the bridge, these become finer, and are followed by the red marly sandstones and grits of Division 4.

Synclinal at Gordon Falls.

Both to the eastward and westward of the Pollet River, heavy masses of conglomerate are almost everywhere interposed between the shales and the metamorphic hills. As they are, however, in general thickly wooded, and afford but few exposures, while the structure on the Pollet River renders it certain that they are broken by extensive faults, their relations to other members of the series cannot in all cases readily be made out, and it is probable that at some points they include beds which are older, as well as others that are newer, than the Albert shales. To the westward of the Pollet River, they are best exposed along the southern side of the brook flowing through Elgin Corner, where they form a chain of high hills; and again, on the upper part of a deep ravine, known as Montgomery Hollow, traversed by a branch of the Kennebecasis River. On the east of the same stream they are believed to include a portion of the beds flanking the high hills just south of Mapleton and on the Coverdale River.

Distribution near Elgin Corner.

Of the large area of Lower Carboniferous rocks which lies about the headwaters and to the eastward of Prosser Brook, being the western limit of the second, or southerly belt of Albert shales, a large portion appears to be occupied by conglomerates of the type above described, and which are more recent than the shales. Their position is to the northward of the latter, and as they also dip in this direction, it is probable that the sequence is here a regular one. It is certainly so at Turtle Creek, where the Albert shales, dipping at a low angle (N., < 15°), are overlain by red conglomerates having a nearly similar dip (N., < 10°), and possibly, at

Baltimore.

Baltimore, where the fine-grained sandstones forming the upper beds of the shale series—here of a grey colour, and suitable for grindstones—are again overlain, first by fine red shales, and then by red conglomerates. Here, however, there is between the two a discordance in the dip, probably through the effects of a fault, the sandstones dipping N., < 40° ; while the overlying beds, at a distance of only two chains, dip N.W., < 20°.

Faults.

It has already been remarked, that at a very short distance to the eastward of the settlement of Baltimore, the Albert shales, which are here so largely developed, disappear between converging ridges of conglomerates, of which one is older, and one, probably, more recent than the latter group, and that a similar relation probably holds good through the whole distance between this point and the Albert mines. In exploring the different brooks which traverse this region, and which are tributary to Weldon Creek, the brownish-red shales which occupy the valley of this stream were everywhere found to be bordered on the south by conglomerates, which, as at Round Hill, rise into considerable eminences. How many of these pertain to the lower, and how many to the upper group of such rocks is, in the absence of good exposures, not easily determinable. Their relations are, perhaps, best seen on the upper part of Peck's Creek, where ledges of reddish conglomerates, filled with a variety of Coastal pebbles, and dipping E., < 20°, are abruptly met by a hard, greenish-grey conglomerate, made up almost entirely of grey slate fragments, dipping N. 10° W., < 20°. The relations of these conglomerates to the shales of the Albert mines has already been described.

Relations to basal conglomerates in Peck's Creek.

Between the Albert mines and the Petitcodiac River, red conglomerates, which are probably those of Division III., occur at various points along the course of the mines' railway, and in the town of Hillsboro. As, however, they are throughout this area intimately associated with the red, sandy and marly beds of Division IV., and have, with the latter, been extensively folded and faulted, they may be most advantageously considered in connection with that group.

Division IV.—Red and Grey, Sandy and Argillaceous Beds.

The red and grey conglomerates, which, as stated in the previous section, ovelie at various points the Albert shales, are, when present, themselves followed by a series of red and grey sediments, which are somewhat coarse at the base—consisting of frequent alternations of

Characters.

rather fine conglomerates, with grits and sandstones, but which become above very much finer, and embrace a considerable body of soft and easily disintegrated, grey and brownish-red shales. Even where the conglomerates are wanting, these sandy and argillaceous beds are very generally present, exhibiting very similar characters throughout the entire Lower Carboniferous district of Albert County, and affording a valuable guide in the determination of the relations of its several members.

Calcareous bands.

A noteworthy peculiarity of this group, in addition to the prevalence of fine sediments, is the great amount of calcareous matter which it contains; many of the so-called sandstones being in reality calciferous sand rocks, while actual beds of limestone, of greater or less extent, are not unfrequently met with. Indeed, the great beds of limestone and gypsum, to be hereafter noticed as occurring at the summit of the series, may properly be regarded as a portion of the latter, although for descriptive purposes, and on account of their economic importance, it has been thought better here to treat them as a separate division. Another noticeable feature in the same group, is the extent to which the latter has been affected by disturbing forces; the coarser beds, by their frequent and abrupt changes of dip, indicating the occurrence of numerous faults, while the softer beds are filled with innumerable sharp corrugations, the evident results of lateral pressure. Owing to these disturbances, it is extremely difficult to arrive even at an approximate estimate of the thickness of the group, but from a comparison of the measurements made at different points, we have reason to think that the amount stated in the synopsis on page 355 is not far from the truth.

Disturbances.

The best exposure of the group in the northern, or Elgin division of the Lower Carboniferous belt, is that afforded by the streams in the eastern part of the settlement of Mapleton, and has been already described (section page 359). To the westward of this locality, the beds are for the most part concealed, partly under a covering of drift, and partly by overlying and unconformable millstone grit. They may, however, be seen to some extent along the course of the Pollet River (between the bridge at Elgin Corner and that on the Mapleton road, about two miles further down), and still better, on the stream which, passing through Elgin Corner, flows into the Pollet River a short distance eastward of the latter. This stream, in its upper portion, flows very nearly on the strike of the beds, which here consist mostly of fine conglomerates and grits, together with some sandstones; holding, occasionally, stems of plants and even thin seams of ordinary bituminous

Fossils.

coal; the general dip being north-westerly (N. 45° to 50° W., < 50° to 75°), but in approaching Elgin Corner, by a change in its course, is made to cross the beds obliquely, and thus to afford greater facilities for measurement. The following traverse, extending from a little above the bridge on the Anagance road to that on the road from Elgin to Petitcodiac, will afford an idea both of the nature of the beds and the irregularities of their dip. The measurements are made on a course north magnetic from the bend in the brook above the Anagance road:—

Section near Elgin Corner.

	FEET.
Grey grits and conglomerates to Anagance Road. Dip, N. 35° to 40° W., < 70°	1,100
Reddish-grey conglomerate	150
Measures concealed	825
Conglomerate with limestone pebbles. Dip, S. E., < 5°	230
Measures concealed	420
Soft, reddish-brown sandstone and shales, S. 75° E., < 5°	60
Measures concealed	470
Reddish-grey conglomerate. Dip, S. 75° E., < 5°	60
Measures concealed	220
Reddish-grey conglomerate and sandstone. Dip, N. 10° E., < 7°; changing at end to N. 30° W., < 20°	60
Measures concealed to Elgin R. R. Cutting in red, crumbling conglomerates and grits, with thin layers of red and grey sandstone and shale. Dip, N. 65° E., < 45°	660
Measures concealed by Millstone Grit deposit	.....

Between the settlement of Mapleton and that of Prosser Brook, the arenaceous and marly beds of Division 4 are seen but at few points, being, apparently, concealed by the grey sandstones of the millstone grit, which here approach the metamorphic hills.

Passing to the second, or Hillsboro, belt of Lower Carboniferous rocks, the beds of Division 4 are again, for the most part, wanting or concealed in that portion lying to the westward of the settlement of Baltimore, as also in this settlement. To the eastward of the latter, however, they again come prominently into view, and through the remainder of this parish include the larger part of the Lower Carboniferous sediments. They are well exposed along the course of Weldon Creek, which, for the greater part of its length, has been channeled from the softer beds (brownish-red shales), but the most complete section is that afforded by Peck's Creek, one of its principal tributaries. This stream, in its descent from the metamorphic hills, flows obliquely to the strike of the beds, which, as thus exposed, exhibit the following succession, measured on a course magnetic north:—

Weldon Creek.

Section on Peck's Creek.

	FEET.
Metamorphic slates of Caledonia Mountain, N. 10° E. < 40°	...
Hard, greenish-grey conglomerate of Division 1; dip, N. 10° W. < 20°	400
Grey conglomerate; N. 35° E. < 10°	230
Red and grey conglomerates and grits; dip, E. < 20°	1,000
Red flaggy sandstones and grits, with thin beds of red brown shales and impressions of plant stems; dip, N. 60° E. < 30° to bridge	330
Brown red sandstone and shale; dip, N. 60° E. < 45°	360
Do. do. sharply corrugated	80
Soft, brown, and marly sandstone and shales, in places much contorted; dips from S. 80° E. < 40° to N. 60° E. < 45°	1,000
Soft, sandy shales, and reddish conglomerates; dips from N. 35° W. < 40° to N. < 80°	740
Brown-red shales; S. 60° E. < 40°	750
Measures concealed; probably red, marly shales, to Weldon Creek	600

The rocks of Division 4, upon the eastern side of the Petitcodiac River occupy the triangular area lying between the two bands of Albert shales, described in previous pages as traversing respectively the settlements of Beliveau and Dover. They are best exposed along the river bank, and especially in the first-named settlement, where the following section has been made. It will be noticed that here, as elsewhere, the group is remarkable for its exceedingly broken and irregular character.

Section on Petitcodiac River at Beliveau.

	FEET.
Section on shore opposite Hillsboro, beginning at small Creek, below Beliveau's, and going north. Bituminous Albert shales. Dip, N. 20° W. < 20°	...
Measures concealed; covered over by millstone grit	2,000
Grey, micaceous, bituminous sandstone, probably oil-bearing band, to fault, N. 10° E. < 60°	330
Reddish-grey conglomerate, very coarse at base, full of limestone pebbles, black slate and jasper, in a grey or reddish calcareous and sandy paste, in some parts almost a limestone; dip, N. 5° E. < 30°; becoming sandy and finer in middle, with thin marly beds and purple shales, and again coarser in upper half, with pebbles of slate, epidote, etc., and one or two small veins of Albertite, the dip changing to N. 50° E. < 25°	660
Reddish and grey, sandy and marly beds, N. 50° E. 25°	40
Do. do. do. including an anticlinal fold	27
Do. do. including sharp synclinal, in brown-red, sandy beds	27
Reddish and grey, nearly vertical to fault; beds on south side dip S. 5° E. < 85°; on north side dip northerly. Much crumpled and nearly vertical	68
Grey grits and sandstones; S. 10° E. < 60°, to fault	70

	FEET.
Brown, red, marly sandstones; S. 10° W. < 85°	76
Do. Do. irregular and broken; N. 65°	40
Grey, micaceous sandstone, and sandy shale, including beds of dark-grey shales, much broken; dip at end; N. W. < 65° to fault	225
Grey, brownish and purple, lustrous, highly corrugated shales; N. 35° W. < 50°	250
Grey, rubbly shales; N. 5° W. < 40°	120
Grey, rubbly shales. Dip, W. 10° S., < 35°; bending gradually round and over a fold to north-west	27
Grey, fine-bedded and lustrous, highly corrugated shales. Dip, at end, N. 65° W., < 35°	165
Nearly along the strike of grey, purplish and brownish-red beds; often ripple-marked and pyritous. Dip, N. 60° W., < 50°	500
Over similar beds. Dip, at end, N. 25° W., < 63°	380
To creek	300
Brownish-red, marly shales, N. 30° W., < 30°	1,850
Measures concealed, probably same to creek	150
Measures concealed,—marshy	2,600
Brownish-red, marly and micaceous sandstones, and shales with grey bands, N. 50° W., < 20°	550
Similar beds,—N., < 20°	175
" Numerous small downthrows,—N., < 10°	140
" Fault,—N. 10° E., < 40°	22
" Fault,—N. 10° E., < 10°	330
" Dip,—gradually increasing N. 80° < 15°	500
" Small faults,—S. 20° E., < 25°	225
" Small faults,—increasing S. 10° E., < 45°	55
Ravine and fault, anticlinal	....
Brown-red, marly sandstone and shale. Dip, irregular. Red beds meet grey beds abruptly at end	210
Grey sandstones, and bluish-grey shales,—N. 40° E., < 45°	55
Grey thin-bedded and flaggy shales, irregular in dip. Showing successions of bends along strike Seams between the beds filled with thin veins of sparry limestone	135
Similar beds	175
Measures concealed	95
Grey, sandy shales. Dip, N. 40° E. < 40°	10
Measures concealed to	440
Grey, sandy, micaceous shales,—N. 20° E., < 30°.	110
Grey, sandy, thin-bedded; changing to N. 35° E., < 20°	
Brown shales—fine—N. 30° E., < 55°	190
Coarse, brown-red conglomerate, pebbles of syenite, chlorite, gneiss, grey slate, quartzite, calcareous paste in crystals of spar,—N. 30° E., < 55°	660

The representatives of the fourth division of the Lower Carboniferous mcook.

enite.

sediments in the valley of the Memramcook River, are less fully exposed than are the same beds along the Petitcodiac. Over much of this area they are concealed from view by remarkably heavy deposits of drift, which, being mostly derived from the grey sandstones and grits which lie to the northward, afford little or no indication of the character of the rocks beneath; while at other points, and especially about the summits of hills and ridges, they are directly covered by these same arenaceous rocks *in situ*. Of the several localities in which they are exposed, perhaps the most interesting is that near Calhoun's Mill, on the Intercolonial Railway, about four miles above Memramcook Station, and near the north-eastern limit of the Lower Carboniferous belt, the beds occurring here presenting some peculiar features not elsewhere met with. A short distance south of this mill, the railway in question, following the left bank of the river, has been for a distance of about half-a-mile constructed upon and through ledges of red syenite; partly fine, but mostly coarsely crystalline or porphyritic, and which are evidently intrusive—being remarkable as the only rocks of this character met with to the eastward of Prosser Brook, in the parish of Elgin, Albert County. No exposures are to be seen to the northward of this syenitic belt, but immediately to the southward occurs the following succession, the characters of which have evidently been determined by the nature of the source from which the materials of the beds have been derived:—

Section on Intercolonial Railroad below Calhoun's Mill.

	FEET.
Syenitic conglomerate, very coarse, and imperfectly stratified, being made up entirely of well rounded, red and green syenitic pebbles, varying in size from two inches up to three feet; imbedded in a syenitic, gravelly paste. This conglomerate rests directly against massive ledges of unstratified syenite, and, taken apart from the succeeding beds, might readily be mistaken, from the size and irregular distribution of the pebbles, for a mass of unstratified drift. Dip, S. 20° W., < 80°. Thickness....................	20
Space, without exposures; probably occupied by beds like those following..	210
Recomposed granitic grits; rocks of granitoid aspect, but of fragmental origin, varying from fine to coarse, of a reddish-grey colour, and distinctly stratified, with thinner included beds of dark-purplish red shales, dip, S. 20° W. < 80°. Thickness..	200
Measures mostly concealed, but including several beds of purple sandstone, nearly vertical..	500
Purple and purplish-grey sandstone, with thin beds of conglomerate, the latter made up of red syenite *debris*; also including several beds, ten to twenty feet wide, of purple slate. The lower beds	

	FEET.
are nearly vertical, but the dip becomes reduced. S. 10° to 15° W., 60°	300
Grey, flaggy sandstones and shales	210
Measures concealed	765
Grey, sandy beds, and brownish-red shales. (Dip as above.)	200
Measures concealed	...

To the southward of the above locality there are but few exposures directly along the course of the river and railway, but to the westward of these they may be readily found along the various streams and ravines which are connected with the former on its western side. On the more northerly of these streams, at Smith's mill, the beds are red conglomerates, resting upon red, marly sandstones, and overlain by red sandy and shaly beds, and are remarkable as well for their incoherence as for their nearly horizontal attitude, being but little more consolidated than many post-tertiary gravel beds, while the dip does not exceed five degrees. (N. W. < 5°.) Resting directly upon these beds, and in apparent conformity with them, are the grey, micaceous sandstones of the millstone grit. A similar succession may be seen along almost any one of the numerous ravines lying on either side of the post-road from Memramcook to Moncton, for a distance of three miles from the former; and yet again, along the lower part of the Memramcook River, on either side of the band of Albert shales extending through the settlement of Taylorville. At the latter point, bright-red conglomerates, made up, like those at Smith's mill, very largely of syenitic *debris*, imbedded in a highly-calcareous and often concretionary paste (traversed by veins of Albertite), rest directly upon the Albert shales, and are succeeded upwards by brownish-red, marly sandstones, and grey bituminous grits (also holding thin veins of Albertite), the latter belonging to the millstone grit formation, and with the red beds beneath, dipping southerly, at an angle not exceeding eight or ten degrees.

Upper Memramcook.

Horizontality of beds.

It is remarkable, that throughout nearly the whole of this Memramcook region, in contrast with what is seen on the Petitcodiac River, the higher members of the Lower Carboniferous series should be so nearly horizontal, while the shales beneath are so generally and so greatly disturbed. A parallel instance has, however, already been referred to in the case of Edgett's Bluff, in Lower Hillsboro, and again in the valley of Demoiselle Creek, south-west of the Albert mines. These facts, together with the very sparing occurrence of the Albert shales over the extensive area occupied by these red rocks in the parish of Hillsboro, where the latter are very variously inclined, would almost lead one to suppose that they are two unconformable groups. Indeed, at Taylorville, the one does actually rest unconformably upon the other.

Limits at Memramcook.

The rocks of Division 4, along the eastern side of the Memramcook Valley are but poorly exposed, but so far as seen, present no features of special interest. They may be seen along the roads running eastward of Memramcook Station, where they consist of reddish-brown shales and grit, and hold at one point a considerable vein of barite, and again along the course of Chapman's mill brook, two miles north of Dorchester. An irregularly curving belt of low hills, composed of coarse, grey millstone grit, and extending from near Calhoun's mill, north of Memramcook, to Dorchester village, marks, in this direction, the limits of the entire Lower Carboniferous formation.

Division V.—Limestones and Gypsum.

It has been stated on previous pages, that the Lower Carboniferous rocks of Albert and Westmorland Counties, in addition to being highly calcareous throughout, contain at various points extensive deposits of limestone and gypsum.

Two sets of limestones.

There would appear to be two distinct sets of these limestone strata, differing at once in their character and associations, as well as in their stratigraphical relations; the one being massive, of pale grey or white colours, but slightly bituminous, and not unfrequently containing large quantities of chert and jaspar; while the other is much more markedly, as well as more regularly stratified, often flaggy, very bituminous—and, therefore, of grey and dark-grey tints—destitute of chert and jasper, but associated with extensive deposits of gypsum. The latter alone properly constitute the fifth division of the Lower Carboniferous succession, though, from their lithological characters, the two are here considered together. The former, which appears to occupy a somewhat lower horizon, is usually highly inclined and much contorted; while that last mentioned exhibit but a low inclination, and, except where covered by beds of gypsum, or, occasionally, of red shale, is directly and conformably overlain by the millstone grit.

Limestones of Mapleton.

In the Elgin, or western belt of Lower Carboniferous sediments, limestones are less conspicuous than in that to the east. They may, however, be seen in limited exposures on either side of the Pollet River, near where the latter is crossed by the Mapleton road, and again near Prosser Brook, (in this latter case dipping N., $< 10°$.) In the eastern part of the Mapleton settlement there are also beds of limestone, lying just south of the valley occupied by the Albert shales, but these are, apparently, of much older origin, being associated with a narrow belt of very hard and obscurely stratified conglomerate, quite unlike that of the Lower Carboniferous formation (which appears, with its usual characters, only a few rods to the south); while the limestone itself is metamorphic, being in part distinctly crystalline, of a dirty-white colour, with clouds and bands, which appear to be due to finely disseminated and impure graphite. The dip of these beds is N. 10° W., $< 45°$.

Pre-silurian crystalline limestones of Pleasant Valley.

In the eastern, or Hillsboro belt, the most westerly exposures of limestones noticed by us are on the west side of Turtle Creek, and not far from the house of widow Fillmore. They here form cliffs, having a thickness of about fifty feet; resting on red conglomerates, and capped by millstone grit. They are much contorted, containing shaly beds, with local twists, and abound in deep crevices and pits, some of large extent. In colour they are reddish-brown and grey, and contain numerous shells of *Terebratula.*

Turtle Creek.

To the eastward of Turtle Creek, and about the settlement of Baltimore, the limestones of the Lower Carboniferous series, if present, are concealed by the millstone grit, which here extends southwards so as almost to meet the metamorphic hills; but in the eastern part of the parish they are again visible near the Albert mines and at various points about the village of Hillsboro. The beds near the Albert mines occur a little to the east and south-east of the latter, along the coal track, and about the upper part of one of the branches of Demoiselle Creek. Here, as at Turtle Creek, they directly overlie red conglomerates, filled with pebbles of Coastal rocks, and are overlain by a very soft, grey, and not very coarse conglomerate, which appears to be the basal member of the millstone grit; all these beds being conformable and dipping S. 40° E., $< 10°$. Both the limestones and the overlying grits are remarkable for their highly bituminous character, and, the latter especially, are seamed with small veins of Albertite.

Bituminous conglomerates and grits at Albert Mine.

Going south from the Albert mines, and crossing over the high hill of reddish conglomerate which bounds it in this direction, we find on the southern slope, in a small branch of Wilson's Creek, the conglomerates overlain by limestones similar to those of Demoiselle Creek; and these in turn, a little lower down, and along the main brook, by hills of plaster, forming cliffs from fifty to 150 feet in height, and extending for a distance of one and a-half miles.

Plaster of Wilson's Brook.

Between the valley of Demoiselle Creek and that of the Petitcodiac River, there intervenes, as has been before stated, a high ridge of millstone grit. On the eastern side of this ridge a succession, similar to the above, may again be seen along almost any of the several ravines lying to the south and east of the principal plaster quarries, and especially along the course of the tramway by which this mineral is removed to Hillsboro for calcination and export. They here appear to form a series of low undulations (one of which, a low synclinal, occupies nearly the position of the point of bifurcation of the tramways leading respectively to the eastern and central quarries), while a little to the westward their dip is more uniformly southerly or south-westerly. In the ravine, near the old and now abandoned quarry, in Lower Hillsboro, the limestones, resting directly upon red conglomerates, and exhibiting their usual well stratified and flaggy character, have an exposed thickness of eighty feet, the dip being S. 10° E. < 10°. Followed in this direction, they may be seen to form the nearly flat summits of the various hills overlooking the highway in Lower Hillsboro, while beneath them, as at the East Albert mine, and in the ravines to the south, appear the red conglomerates upon which they rest. They appear, however, here to be successively let down by a series of faults, having a general east-west course. It is a noteworthy feature of the conglomerates, that though beneath the limestones, they contain, as at Elgin, in addition to their other ingredients (fragments of feldspar and syenitic *debris*), numerous blocks of this same material of grey, pink and brown colours.

Millstone grit ridge.

Bituminous limestones of Lower Hillsboro.

No available means of measuring with accuracy the thickness of the gypsum beds in either of the above localities has been found, but from a general study of their relations, we think it probable that this does not greatly exceed, at a maximum, one hundred feet. In the principal quarry the face exposed is about seventy feet, but this does not include the actual base, while the beds themselves, though distinctly stratified, are very irregular in dip. The lower half is mostly hard plaster or anhydrite, while that above is ordinary gypsum. The two are, however, at different points, very irregularly distributed, or even variously intermingled in the same mass. No contact of immediately overlying beds was anywhere observed, but from the occurrence of brownish-red shales on the slope of the steep hill lying immediately in the rear of the principal quarry, but at a height of fully 150 feet above the summit of the gypsum beds, it would seem that at least a thin deposit of these red sediments here intervenes between the latter and the overlying millstone grit.

Thickness of plaster beds.

Some further observations on the extent, character, and varieties of the gypsum deposits above referred to, are again given beyond in connection with the consideration of their economic value.

The limestones occurring at the several localities above described, are those before referred to as occurring at or near the summit of the Lower Carboniferous series, and constituting its fifth member. In addition to them, limestones of quite a different character, and apparently occupying a somewhat lower horizon, may be seen in the upper part of Hillsboro proper, where they are exposed along the course of a small stream and ravine, just north of the Salem road. They are massive, impure and concretionary, rather than flaggy, having above them beds of fine-reddish shales and limestones, with jaspery bands and nodules, and dipping N. 25° W. < 52°. Though not markedly bituminous in aspect, borings made many years ago in their neighbourhood resulted in a yield of small quantities of oil.

Petroleum of Upper Hillsboro.

On the eastern side of the Petitcodiac River, the only points at which we have observed any limestones are in the upper part of the Beliveau settlement, near the road leading thence to Dover, in Taylorville, and on the eastern side of the Memramcook road, about three miles above Dorchester. At each of these localities they occur in connection with the red, sandy, and shaly beds of Division 4, but while those of Beliveau are red and massive, and like the corresponding beds in Hillsboro, contain bands and nodules of chert and chalcedony, those near Dorchester are dark-grey, flaggy and bituminous. These latter are also peculiar in lying but a short distance to the southward of the Albert shales, and in having, like the latter, a nearly vertical attitude—(N. 5° W. < 85°.)

Bituminous limestones of Dorchester.

No deposits of gypsum have been met with in connection with this portion of the Lower Carboniferous area.

The Millstone Grit Formation.

This group of rocks, forming the basal member of the true Carboniferous formation, may be very readily recognised in south-eastern New Brunswick, as compared with the Lower Carboniferous rocks, by two marked points of contrast: viz., first, the possession of a grey, or, rarely, a pale purple, instead of a red or reddish-brown colour; and secondly, in being but little disturbed, the inclination of the beds in the district examined rarely exceeding eight or ten degrees, and being often much less.

Characters.

As in other Carboniferous districts, and as indicated by their name, these rocks consist largely of coarse or fine, silicious sandstones or grits, affording valuable materials for architectural purposes, but, especially near the base, contain many coarser beds or conglomerates, made up usually to a great extent of rounded pebbles of white quartz, in a gravelly paste, which is but slightly calcareous. In many places no other beds are seen, the contrast between the grits and the underlying strata being very marked; but at others, and especially about the Petitcodiac and Memramcook regions, where both series are nearly horizontal, and, apparently, conformable, there is not infrequently a gradual transition between them, both in colour and character, making it difficult to determine the exact line of separation.

Distribution.

The general distribution of these millstone grits is sufficiently indicated by the accompanying geological map, their southern border through the greater part of Albert County being approximately parallel to the metamorphic hills, but with numerous irregularities; while in the eastern part of the same county and in Westmorland they reappear to the southward and eastward of the Lower Carboniferous belt, enclosing great basins, or capping more or less isolated areas occupied by rocks of this formation. Their exceedingly irregular distribution, as well as their relations to the underlying rocks, exhibit well the extensive denudation to which the entire district has been subjected, as well as the fact that a portion of this denudation must have been antecedent to the deposition of the millstone grit.

Disturbances.

Though far less markedly disturbed than the underlying formation, the millstone grit rocks are still not without evidences of movements and fracture. These, however, are much more marked about the eastern extremity of the metamorphic belt, in Lower Hillsboro, Hopewell and Dorchester, than along its northern side, or at points considerably removed from it, and evidently indicate a relationship between the existence of this firm and unyielding axis and the location of the disturbances in question. It may be added, that in the same region (the Albert mines, Lower Hillsboro and Beliveau) the lower beds of the millstone grit are highly charged with bituminous matter, and contain numerous small veins of Albertite.

USEFUL MINERALS OF THE LOWER CARBONIFEROUS FORMATION.

Economic products.

Having now described, as far as possible, the distribution, succession, and relative thickness, of the different members of the Lower Carboniferous formation, we proceed to consider the mode of occurrence, extent and value of its economic products. These embrace the mineral *Albertite*, the richer bituminous and oil-bearing shales, liquid petroleum, limestone, and gypsum, to which may be added, in the millstone grit formation, extensive beds of freestone.

The Albert Coal or Albertite.

The general geological position of this important mineral—the most valuable at present known to occur in New Brunswick, and to whose mode of occurrence, and probable extent, the labours embodied in this report have been specially directed—has been sufficiently indicated in preceding pages, where it has been described as limited, so far as the larger deposits are concerned, to the so-called Albert shales, though also occurring in small quantities in the overlying Lower Carboniferous rocks, and even in the basal beds of the millstone grit. Geographically, it has been further shown to have a distribution coincident with the shales, occurring, to a greater or less extent, throughout the entire belt of these rocks, but with possibly a single exception in the County of Kings, never at points except where there is reason to believe that these rocks exist.

Distribution.

The question of the occurrence of workable deposits of this mineral other than that so long and so profitably followed at the Albert mines, near Hillsboro, involves, in our opinion, the consideration of the following principal subjects, viz.:—

Mode of occurrence.

1. The physical and chemical characters of Albertite and its relations to other minerals, as bearing upon the question of its *origin.*
2. The lithological and chemical characters of the associated beds, as bearing upon the question of the *source* of the mineral.
3. The relations of the Albertite to the associated strata, whether as occurring in *veins* or true *beds.*
4. The relations of the Albertite deposits to the general geological structure of the region, as indicating the *time* of its formation.

The Physical and Chemical Characteristics of Albertite.

Dr. Dawson, in his Acadian Geology, (second edition, page 236,) gives the following summary of these characteristics:—

Characters.

" The substance has, externally, an appearance not dissimilar from the ordinary asphalt of commerce in its purest forms; but it is very much less fusible, and differs in chemical composition. Its fracture is conchoidal, its lustre resinous, and splendent or shining. Its colour and the powder or streak on porcelain, black, and it is perfectly opaque; it is very brittle, and is disposed to fly into fragments; its hardness is 3, nearly, of Moh's scale. Its specific gravity is 1·08 to 1·11 (according to Jackson and Hayes.) It emits a bituminous odour, and when rubbed becomes electric. In the flame of a spirit lamp it intumesces and emits jets of gas, but does not melt like asphalt. In a close tube, however, it can be melted with some intumescence."

Structure.

To these observations of Dr. Dawson, we may add that the mineral is remarkable for its perfect homogenity; no appreciable difference being observable between specimens obtained at or near the surface, and those taken at greater depths, whether from one part of the vein or another, no division into grades or qualities being therefore possible. It exhibits no trace whatever of lamination, but at times shows in its fracture a tendency to a columnar structure, the columns, as in certain dykes, being at right angles to the enclosing walls. Though usually of the hardness above stated, and brittle, it is occasionally found sufficiently soft to admit of being bent and chewed. Under the microscope it exhibits no traces of vegetable structure.*

Nature.

As regards its chemical characteristics, we have had no opportunity either of verifying or of disproving the many and often-times entirely contradictory statements, which have at various times appeared in the published reports referring to this mineral. A number of analyses by different authors are given in an appendix. While admitting of various interpretations, we do not think that they contain anything which would necessarily militate against the view here adopted, and based upon the structure and geological relations of the Albertite, that the latter is in no sense a true coal, but rather an oxidised hydrocarbon, related to, though not identical, with asphalt, and at one time existing, like petroleum, in a condition of partial or complete fluidity.

The Characters of the Albert Shale.

Characters.

The more important of these characters, as distinguishing this group of rocks from those with which they are associated in the Lower Carboniferous formation, have already been described. Their most marked features, as bearing upon the origin and occurrence of Albertite, are: 1st, the extreme fineness of the great bulk of the sediments in question, together with their perfect stratification; 2nd, the large quantity of bitumen, as well as lime, which they everywhere contain; and 3rd, the abundance of fossil fishes entombed in many of the beds, together with a comparative paucity of vegetable remains.

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* Dr. John Bacon, sr., in a report submitted at the time of the great trial, as to the ownership of the Albert Mine, in 1851, stated that he had detected, under the microscope, contorted fibrous tissue, cells and vessels in Albert coal, but these have not been recognized by other observers, and the authors believe that the specimens examined by Dr. Bacon must have included a portion of the accompanying shales, or have been derived from some other locality.

From the first of these peculiarities, together with the thickness of the beds, we can only infer the continued deposition of the latter through a lengthened period, and under conditions of general quiescence—with a freedom, that is to say, from powerful currents, or such other influences as ordinarily determine the production of coarse sediments. Such conditions would be afforded, in the case of fresh water deposits, by a lake, or among those of strictly marine origin, only in sheltered bays or in somewhat deep off-shore soundings. It seems hardly probable that strata of such extent and thickness should result from a purely lacustrine mode of deposition; while the occurrence of ripple-marks, mud cracks, and other similar impressions, as clearly indicate that the beds are of shallow-water origin. Moreover, were they entirely marine we would naturally look for some evidence of the fact in the occurrence of marine shells, such as are elsewhere met with in the Lower Carboniferous formation. In the Albert shales, by far the most abundant fossils are the remains of fishes, which, in certain beds, rest in almost incalculable numbers, and in a most remarkable state of preservation. They have been referred to the genus *Palæoniscus*, and have even been described as embracing several species; but, so far as we are aware, these descriptions have in no instance been based upon such critical examinations as would suffice to indicate with certainty either their true relationship or the conditions of their entombment. On the other hand, the associated vegetable fossils, though in part distinctively terrestrial, are also insufficient to decide this point with certainty. Among those most commonly occurring, are *Lepidodendron elegans* and *Cyclopteris Acadica*—both characteristic forms of the Lower Coal formation of Dawson; but both are rare, usually in small fragments, and so inclosed in the shale as to indicate that their present position is the result of drifting. In addition to these, there is one fossil, found by us at Beliveau, which would seem to point to at least a partially marine origin for a portion of the shales—being apparently a true seaweed, branching dichotomously, and bearing much resemblance to some species of the modern genus *Polysiphonia*. Upon the whole, we are inclined to the belief that the beds are of estuary rather than of either marine or lacustrine origin; and that they were successively laid down in a shallow, but subsiding trough, abundantly tenanted by fishes, and receiving occasional accessions of vegetable *debris*, but subject at times to such changes, through the production or removal of barriers, as would, by the alteration of the contained waters either in depth or purity, lead to the somewhat sudden destruction and entombment of its contained species. It should be added, that, in the opinion

Mode of deposition.

Fossils.

Marine plants.

Origin.

of Dr. Dawson, who now also regards the Albertite as an altered petroleum, the entire series of shales represent beds of mud, charged with a great quantity of finely comminuted vegetable matter, of the nature of a peaty muck, which has become perfectly bitumenised; a view strongly favoured by some portions of the shales, which, especially when weathered, often exhibit an appearance forcibly recalling some varieties of lignite or brown coal, or even of ordinary unaltered wood.

Bitumen

The amount of bitumen contained in the Albert shales, though everywhere large, is much greater at some points than at others. Among those where it is especially abundant may be mentioned the locality at Baltimore, the Albert mines, Beliveau and Taylorville, on the Memramcook, particulars of which, in reference to this point, are given below. They are the same, with the exception of that first named, in which the Albertite has been most abundantly met with, as well as those in which the associated sandstones are most highly impregnated with petroleum or inflammable gases,—facts which evidently point, as regards these various products, to a community of origin.

The Mode of Occurrence of the Albertite, and its Relations to the Associated Strata.

Proofs of the vein structure of the Albert mine.

From the description of the Albert mine given upon page 366, there can, we think, no longer exist a doubt that the deposit, here so extensively worked, is a true *vein*, occupying irregular fissures among highly disturbed strata, and in no way presenting any analogy to an ordinary coal bed. The principal facts, in part exhibited therein, and upon which this statement is based, may be briefly summarised as follows:—

1. An entire want of correspondence between the course of the deposit, as a whole, and that of the enclosing shales; the latter exhibiting a succession of folds and a general sweep in the trend of the beds; while the course of the Albertite vein is approximately uniform, cutting these folds at a variety of angles.
2. The frequent want of conformity between the inclination of the vein and that of the enclosing strata; the former, while at times approximately parallel to these strata, being at others in direct contact with their edges.
3. A general anticlinal structure in the shales, together with frequent faults; these being conditions favourable for the production of fissures and the formation of mineral veins.
4. Great variability in the thickness of the vein, both horizontally and vertically, and even within short distances; these variations being

apparently determined in all cases by the movements affecting the associated beds.

5. The occurrence of what may properly be termed Albertite breccias, *i.e.*, of masses of shales, often extensively and minutely broken and shattered, but of which the angular fragments have, subsequently, been re-cemented by Albertite.
6. The absence of any true under-clays in connection with the vein though at some points thin layers of clay, analogous to the selvage of ordinary veins, intervene between the latter and the bounding walls.
7. The occurrence of divisional planes in the Albertite transverse to the course of the vein, and perpendicular to the bounding walls.
8. The occurrence of "horses" or detached masses of the wall rock, enclosed by Albertite; while the latter, in some instances, fills the angular cavities from which such "horses" have fallen.

Period of formation.

In addition to the indications thus afforded as to the general vein-origin of the deposit in question, we think that the same facts point also to the further conclusion that the latter is of subsequent origin to the associated beds. Indeed, the one conclusion is a necessary consequence of the other. It is probable that the infiltration of petroleum or bituminous matter began simultaneously with the first movements of the shales which opened the beds, or which by slipping gave rise to faults and dislocations, and may have been mostly confined to the period immediately subsequent to the deposition of the shale. That it continued, however, to a very much later period, and to a time when these movements had for the most part ceased, is conclusively shown by the occurrence of the mineral in the overlying and unconformable millstone grit, not merely in scattered grains, but in the form of well defined veins, similar in character and coincident in general direction with the principal vein at the Albert Mines.

Former views as to the source of the bitumen.

And here it may be well to say, that the facts observed by us give no countenance whatever to the view advanced by some authors, that the Albertite has not been derived from the bituminous shales in which it is now contained, but from underlying Devonian strata. Against such a supposition it is only necessary to say that no strata of Devonian age are known to occur anywhere in the vicinity, or within many miles of the Albertite deposits, those once referred to that position having since been shown to be of much greater antiquity; and further, that whatever the age of the slates and schists against which the Lower Carboniferous rocks repose, their metamorphism, taken in connection with their unconformability to the latter group, wholly disprove the idea that they have been the source from which the bitumen of the Albert shales and the associated strata have been derived. So marked is that metamorphism, even in the case of the nearest undoubted Devonian strata, those of St. John County, that these, similarly unconformable to the Lower Carboniferous sediments, have lost all trace of bituminous matter, the contained tree-trunks having been converted into anthracite, and the fronds of ferns into graphite. The only facts known to us giving any countenance to the idea that the Albertite may have been derived from subjacent strata are those furnished outside of the limits of this report, at a locality in the Mechanics' settlement in King's county, and these we believe to be capable of a different interpretation. At two points in this settlement, viz., on the Martin's and Owen's properties, small veins of Albertite have been observed in the old grey slates and chloritic schists, but at both, their occurrence is at or near the line of contact between these metamorphic rocks and the overlying Lower Carboniferous strata, while over the extensive area to the southward, occupied by similar rocks, no such veins have been anywhere met with. On the Owen's property at least, it can hardly be doubted that the source of the Albertite veins occurring here is to be sought in the Lower Carboniferous formation, for in addition to a small vein (1-16th of an inch) contained in the slates, there is a narrow belt of conglomerate, similar in every way to one of those near the Albert mine, and, like the latter, containing also irregular veins of Albertite. It is apparently enclosed between parallel walls of slate (dipping N. 20° W., < 55°), and has the appearance of a conformable bed, but is wholly different in character, and probably constitutes the upper member of the Lower Carboniferous formation, which here occupies an irregularly shaped basin in these older rocks. At neither of these points are any shales visible, but their absence may be accounted for on a similar supposition.

Mechanics' settlement.

Albertite in metamorphic rocks.

Adopting, then, the view above advocated, that the Albertite deposits represent true veins of bituminous matter, derived from, but subsequent in origin to the associated Albert shales, we have now to consider the important question as to whether the original deposit of this mineral, so long and so profitably worked at the Albert mine, is the only considerable deposit of this character, or whether others, of equal extent and value, may not reasonably be looked for.

In answer to this question we may, in the first place observe, that so far as correspondence of conditions may be regarded as implying similarity of results, there is every reason to believe that various deposits of Albertite do actually exist. It would be difficult to say in what way the shales of Elgin, of Baltimore, of Beliveau, or of Memramcook, differ from those of the Albert mines, whether in character, in thickness, in the amount of contained bitumen, or in the physical disturbances they have undergone. At Baltimore the proportion of contained bitumen would appear to be even greater than at the latter locality. At all these points the beds have been profoundly disturbed, are full of abrupt folds and corrugations, and have been broken by numerous faults, such as would naturally result in the production of more or less extensive fissures, to be subsequently filled up with extraneous matter. And that the special conditions required for the production of Albertite itself, existed to a corresponding extent, is proved by the actual occurrence of small veins of this mineral at three of these widely separated points, while at the Mechanics' Settlement, in King's County, similar veins are met with, and even still more remotely, near Apohaqui station, in the same county, a distance from the extreme easterly veins on the Memramcook, of not less than sixty miles. It is true that at the Albert mines the evidences of an anticlinal structure are more marked than elsewhere, and much importance has been attached to this fact; but it is not true, even there, that the fissure occupied by the Albertite corresponds with the axis of such anticlinal, and it may be in no way connected with it. If any difference exists it is to be found in the peculiar position of the Albert mine, at the extreme eastern end, and in immediate proximity to the great belt of metamorphic rocks, extending eastward from near St. John to Caledonia Mountain, which has, probably, had a determining influence in connection with the physical movements to which the region has been subjected; but whether this circumstance is one entitled to much weight, in connection with the occurrence of Albertite, we are not prepared to say. The fact that the course of the vein at the Albert mines, and its apparent extension eastward through the East Albert mine to Memramcook, coincides very nearly with that of the axis of this chain, may possibly have some bearing upon the subject.

Existence of Albertite at different points.

Probabilities of its occurrence.

It is obvious, from what has now been stated, that in any future explorations for the mineral, these should, as far as possible, be confined to the Albert shales, the original source of the Albertite, or to their immediate vicinity. It is true that veins of the latter, of small size, are known to penetrate the overlying red sediments, and even the millstone grit, but only at points where there is reason to believe that these rest upon the shales beneath, while in the case of its occurrence in

Future explorations should be confined to the Albert shales.

conglomerate and slate, at Mechanics' Settlement, above noted, it is probable that a like association exists. It is further evident that the points where it is most likely to occur are those in which there are the most abundant evidences of physical disturbances, such as folds and fractures. The positions of some of the more important of these folds and lines of fault, so far as we have been able to determine them, are laid down upon the accompanying maps, but in the present thickly-wooded condition of much of the country in which these occur, they are, necessarily, only approximations. Some weight is also probably to be attached to the relative amount of bitumen contained in the shales at different points, as well as to the presence of petroleum springs and jets of inflammable gas. These latter are almost entirely confined to the more easterly portions of the belt, and it is here, also, as above stated, that the bitumen has most extensively penetrated the overlying strata. Upon the whole, we are disposed, after a careful survey of the entire field, to look upon these easterly portions, and particularly the district lying between the Albert mine and the Memramcook River, as affording the best field for exploratory efforts, though deposits of Albertite may reasonably be looked for in any portion of the shale belt, and especially where the latter has been extensively disturbed. Such explorations should be made by borings, with the employment of diamond drills, as affording, upon the whole, the cheapest and most expeditious method of testing numerous points, but in each case only after a careful study of the ground, and under competent direction.

Methods of investigation.

Yield of Albertite at the Albert mine.

It may be worth while, in this connection, to say a few words about the present status of the Albert mine itself, and the probability, or otherwise, which it affords of a continued remunerative supply of Albertite. That there has been a great diminution in the actual yield in the course of the last eight or ten years, is sufficiently indicated by the fact that, while between the years 1863 to 1869, inclusive, the amount raised annually was, upon an average, over 17,000 tons, it has since averaged not more than 6,000 tons. This falling off, however, is, in part, to be ascribed to the existence of a less urgent demand for the mineral, and its more restricted applications in consequence of the discovery of such extensive deposits of natural oils in Pennsylvania and elsewhere. A more important consideration is the fact, that while in the earlier workings the thickness of the seam removed was at some points not less than sixteen feet, the maximum thickness now worked is only six to seven feet, while much of the vein is still thinner. But even this fact should not be looked upon as necessarily indicating the immediate

Thickness of vein.

or even the approximate failure of the mine. Apart from the fact that there is a very considerable reserve, even in connection with the present workings, in which the Albertite is known to occur, and in quantities sufficient to meet the demand for some years to come, there are still large areas occupied by the shales and forming a portion of the same tract, in which, as yet, no explorations whatever have been made.

Bituminous Shales.

Yield of gas and oil per ton.

In addition to containing, at various points, veins of Albertite, the so-called "Albert shales" themselves contain a sufficient quantity of bituminous matter to make them an available source both of oil and of gas. The amount of this matter varies considerably, even among beds of the same locality and but little removed from each other; but in the case of the richer beds, such as occur at Baltimore and on the Memramcook, the yield has been as much as sixty-three gallons of oil per ton, or 7,500 feet of gas. At the last named point, works for the manufacture of oil were some years ago erected, but subsequently abandoned, in consequence of the impossibility of competing with the natural production of oils in Pennsylvania and elsewhere. At present it is doubtful whether any of these shales can be profitably worked, but that they will in time again become of value, as the supplies of petroleum become reduced, can hardly be questioned. It is possible, also, that they may be made available for other applications, as, for example, the manufacture of paving materials or cements—the lime, as well as bitumen, which they contain, seeming to adapt them well for this and kindred uses.

Future economic importance.

The amount of shale exported from Taylorville, on the Memramcook River, in the year 1865, was about 2,000 tons; which was sold in the United States' markets, in the raw state, at the rate of $6.00 per ton.

Petroleum.

Springs.

The localities at which fluid petroleum has been observed to occur, within the region to which this report relates, are the Albert mines, Upper Hillsboro, Beliveau, Memramcook and Dover. At each of these points its source would appear to be the Albert shales, or rather the somewhat sandy beds which are associated with the latter; although, at Upper Hillsboro, it has been obtained from the overlying red beds, (Division IV.,) and at Dover rises to the surface in connection with ordinary springs. It is especially abundant in the sandstones overlying the shales, and it is from these, if anywhere, that it is likely to be obtained

Former borings for oil.

in available quantities. Several attempts have already been made in this direction, as at Dover, Memramcook and Hillsboro, but although oil was in each case obtained, the flow proved to be too small to allow of profitable collection. It may, however, be questioned whether the particular points selected for trial were really the most favourable, and also, whether the adoption of a somewhat different method of obtaining the oil might not result more favourably. So far as we are aware, little or no attention has been paid, in the choice of boring sites, to the geological structure of the region,—such as the occurrence of faults, basins, and the like,—whereas this is all important in its bearing on the success or failure of any such attempts. It is also a well known fact, that, in the case of many oil wells, a somewhat powerful and prolonged suction will originate and maintain a flow of oil, where in a simple open hole this will be altogether insignificant or wanting. The experiment might be worth trying whether a similar result could not be obtained in the present instance. It is, at least, certain that the strata in question are at many points saturated with oil, and it is difficult to assign any reason why the latter should not, under favourable circumstances, be present in available quantities.

Gypsum and Anhydrite.

Thickness of beds.

The position and geological relations of the plaster beds have been described in preceding pages. They are at once the most extensive and the most valuable, if not the purest, of the plaster deposits of New Brunswick, and exhibit a thickness of from thirty to 150 feet.

Character of the plaster.

Much of the rock is a pure white, snowy alabaster, quite soft and readily cut or ground; while other portions are of a pale cream-colour, or a light shade of grey or blue, and translucent. With these there is more or less of hard plaster, or anhydrite; but the bulk of this is generally beneath the gypsum, or runs through it only in irregular streaks or veins. Selenite or crystallised gypsum is rare, and mostly confined to veins; though small crystals, of a dark colour, are not infrequently scattered through the other varieties. No instance of Albertite veins penetrating the gypsum was observed by us or is known to the present proprietors of the quarries; but a specimen in the museum of the University of New Brunswick, brought from near Hillboro, shows crystals of selenite cemented by this material.

The first quarries opened for the removal of plaster were those of Lower Hillsboro. The material thence derived was, however, employed only for exportation in the raw state, works for calcination having been first erected in 1861. These are mostly supplied from what are known as the New Quarries, about one and a-half miles north-east of the Albert mines and three miles from Hillsboro, with which they are connected by tramway, The total face of rock in these quarries is about one hundred feet, of which seventy is composed of soft plaster, this resting upon hard plaster or anhydrite of unknown thickness. The works at Hillsboro have a productive capacity of about 600 pounds per day, and, with the quarries, give employment to about one hundred hands.

Hillsboro plaster works.

NOTE ON MAP.—Limestones are indicated by three short parallel lines along line of strike.

Note on map.

The patch of purple at the western border of the map, is not intended to represent the outline of Albert shales at this point.

APPENDIX I.

COMPOSITION OF ALBERTITE—AS COMPARED WITH COAL AND ASPHALT.

ULTIMATE ANALYSES.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.	Analyst.
Albertite..................	86·04	8·96	1·97	2·93	*trace.*	0·10	Wetherill.
Caking coal, South Wales.....	82·56	5·36	8·22	1·65	0·75	1·46	Noad.
" " Northumberland.	78·69	6·00	10·07	2·37	1·51	1·36	Tookey.
Block coal, Indiana.........	82·70	4·77	9·39	1·62	0·45	1·07	Cox.
Cannel coal, Wigan.........	80·07	5·53	8·10	2·12	1·50	2·70	Vaux.
Cuban asphalt..............	82·33	9·10	6·24	1·91	*trace.*	0·40	Wetherill.

PROXIMATE ANALYSES.

	Volatile Matter.	Fixed Carbon.	Ash.	Analyst.
Albertite....	58·48	40·86	0·66	T. R. Chilton.
"	61·0	38.5	0·5	Penney.
"	57·2 (combustible.) 0·4 (water.)	42·4	....	Dawson.
"	58·8	41·2 (coke.)	....	Chas. T Jackson.
Whitby jet...	57·1 (combustible.) 1·5 (water.)	42·4 (coke.)	....	Dawson.

TABLE OF SPECIFIC GRAVITIES,

FROM REPORT ON ALBERT MINE BY PROFESSOR R. C. TAYLOR.

Albertite,	1·095, 1·096, 1·091	—R. C. Taylor.
"	1·096	—Charles E. Buck.
"	1·097	—Professor Penny, Glasgow.
"	1·097	—Wetherill
"	1·106	—J. Robb.
"	1·107	—C. T. Jackson.
Chapapote, Cuba	1·142, 1·197, 1·189, 1,153	—R. C. Taylor.
Asphalt, Dead Sea	1·160	—Phillips.
" "	1·148	—Taylor.
" Peru	1·080	—Bouringalt.
Petroleum, Ayer's Farm, N.B.	1·301	—Taylor.
Asphalt, Trinidad	1·378	— "

APPENDIX II.

[*Special Report referred to by Mr. Selwyn, page* 4.]

Hon. A. E. Botsford,
President of "Beliveau Albertite and Oil Company."

Sir,—Having been requested by you to prepare, for the use of the Beliveau Albertite and Oil Company, a report on their property at Beliveau, with a view to assist the proving and development of the latter, and having received from the Director of the Geological Survey permission to make such report, we beg leave to submit the following:—

The subject upon which (according to our letter of instructions) our opinions are especially desired being two-fold, a similar division may be adopted here.

I.—A comparison of the Beliveau property, with that of the Albert mine, as to their general geological structure and relations, and the occurrence of Albertite.

The justly celebrated Albert mine lies at the eastern end of a range of highlands, composed of crystalline rocks (micaceous and chloritic slates, felsites, &c., with intrusive syenites) of undetermined age, and which, in the immediate vicinity of the mine, terminate somewhat abruptly, the land falling off rapidly from an elevation of 1,000 or 1,200 feet to abou 250 feet. The rocks in which the mine is opened belong to the Lower Carboniferous formation, and consist chiefly of a series of shales, now generally known as the "Albert shales," lying at or near the base of that formation. These shales are mostly fine-grained, in parts soft and thinly bedded, readily splitting into thin and flexible layers and sheets, and in others, hard, tough and compact, breaking only with difficulty, and with a broad conchoidal fracture. They are, generally, of a dark-grey colour, sometimes approaching black and brown, and in addition to much calcareous matter, are highly charged with bitumen, imparting to the rock, especially when freshly broken, a strong bituminous odour, and yielding, under the influence of heat, large quantities of combustible oil and gas. Beds more sandy than the ordinary shales, not infrequently alternate with the latter, and also overlie them at each end of the mine; these are also bituminous, and contain petroleum, which at some points may be readily collected in small quantities.

The attitude of the beds at the Albert mines is very irregular, and indicative of profound disturbances, as having affected the region in which they occur, the beds being thereby thrown from their originally horizontal position, and pressed into numerous folds, as well as being extensively fractured and faulted. Some of these folds are limited in their extent and local in their character, being mere corrugations affecting small masses of strata, while others are more extensive, and apparently include the whole series. It is in openings, or fissures produced by such movements, that the mineral Albertite has been collected; probably by a process of slow segregation from the enclosing shales. The course of this principal fissure, which varies in width from one to sixteen feet, is about fifteen degrees to the north of east, or not far from that of the axis of the belt of highlands already referred to as approaching the mine upon the western side, and which probably assumed their present position at the close of the Devonian age, or in the period immediately preceding that of the Albert shale deposits. So far as our present knowledge goes—our underground examinations not being yet completed—it has no direct connection with the attitude of the strata, to which it at some points conforms, while at others it intersects them obliquely, and at others again presents both these fractures at the same point on the opposite walls. Jags or lateral dislocations in the vein are of frequent occurrence, as well as "nips" or points where the walls, by approaching, reduce or destroy the latter. Leaders of Albertite of various proportions ramify from the main vein, and in some cases have been profitably worked, but in the majority of instances have been found to lessen, as the distance from the main vein is increased.

Passing now to the property at Beliveau, we may observe that with the exception of the proximity of the ridge of metamorphic rocks to which references has been made at the Albert mine, the general geological conditions are similar to those of the latter locality. The shales, which present precisely similar characters and varieties, are here largely developed, having a surface breadth in places of not less than one-fourth of a mile. They are also, as at the Albert mine, highly disturbed, the strata being tilted at various angles up to verticality, besides exhibiting at several points lateral corrugations and evidences of extensive faults. They are, as at the Albert mines, highly bituminous; the associated sandstones are saturated with petroleum, and jets of inflammable gas arise from crevices and fissures of the rock.

It has been suggested that at Beliveau, as at the Albert mine, an anticlinal structure prevails, *i.e.:* the formation as a whole has been doubled by folding, the two sides of the fold, like the sides of a roof or boat, inclining in opposite directions from a central axis. Of such an anticlinal structure we have failed to find any distinct evidence; for though the beds, as at the Albert Mines, exhibit local twists and corrugations, the strata over nearly all portions of the property dip northerly, and at no points more than two or three degrees from verticality in the opposite direction, and then only for a few feet. The strata also which appear on the northern side of the supposed axis, and which, in the case of an anticlinal, should reappear on its southern side, are, so far as we have been able to ascertain, wholly wanting. We are rather inclined to the opinion that the beds form a continuous series, dipping northerly, but several times repeated by faults.

As to the probable occurrence of Albertite at Beliveau, we can only express the opinion that the conditions there existing, and to which reference has been made, are such as to fairly warrant the judicious expenditure of such sums as may be necessary to practically test the question, either by boring or by sinking a shaft. While having no decided advantages over some other point where the same shales are met, the locality is one certainly worthy of being proved, and may contain valuable deposits of the mineral desired. The character of the shales, impregnated, as at the Albert Mines, with bituminous matter, the occurrence of petroleum in the sandstones, and of inflammable gases, as well as small leaders of Albertite itself, all indicate the operation of causes similar to those which prevail at the first mentioned locality. It is true we have no distinct anticlinal structure at Beliveau, but it may be doubted how far such structure is really essential, and as already observed, it is not, even at the Albert Mines (so far as our present knowledge goes), in the axis of such an anticlinal that the principal vein of Albertite occurs. Disturbances, such as have evidently taken place at Beliveau, would be amply sufficient for the production of the necessary fissures in which the Albertite might collect.

II.—The relative merits of shafting and boring.

So far as our examinations have extended, we can find no veins of Albertite on the Beliveau property, with the exception of a small leader from one-fourth to half-an-inch thick in its eastern area. This being the case, the operations to be carried on in this place are simply for the discovery of veins of this mineral, in which the speediest and most economical methods, adopted to ensure a thorough testing of the property should be adopted. By shafting, it is true, we can obtain a better view of the formations passed through, as regards the dip of the beds, &c., and if veins of Albertite are met with, the company is in a position at once to commence its extraction; but if, as is the case, there is a large area to be proved, the putting down of a single shaft will not be sufficient test of the property; and if the first attempt be unsuccessful in meeting the desired veins, unless the company is prepared to invest large sums of money, financial difficulties and delays may prevent the further prosecution of the work, and, as a consequence, the value of the property still remains undetermined. The great expense also of a shaft and tunnels, estimated at from $30,000 to $40,000, with the length of time necessary to execute the work, are important considerations in merely exploratory researches. Boring with the diamond drill, on the other hand, has, of late years, come into almost general use for testing valuable properties, and with uniformly satisfactory results. It is speedy, and compared with shafting, very economical. From our knowledge of the Beliveau property, we have very little hesitation in saying that the proving of the shale beds can be done quite as efficiently by boring with the diamond drill as by shafting. Having an area of several hundred acres, it will be an easy matter, if the first attempt should not prove successful in finding Albertite, to transfer the drill to another portion; and it would be quite as advisable to prove the eastern area of the property as the western—the shales on the Memramcook, in Taylorville, being apparently more disturbed than in Beliveau, and quite as favourably situated for the occurrence of Albertite. In regard to objections made to boring, on the ground that the drill may pass very close to veins and pockets of Albertite without disclosing their existence, we do not see but the same objections will, to a certain extent, apply to a shaft, the difference being measured by feet instead of inches. In the boring of the hole, which can be made of any size, from two inches to four, everything passed through by the bit is brought at once to the surface, and if Albertite exists its presence and locality are at once determined; and as the veins of Albertite, so far worked, occupy a vertical position, the thickness, at the point of boring, can be easily ascertained, while with a good core bit, a complete section of the shales and associated beds can be taken out, showing, at a glance, the character of the rocks passed through. The economy of the diamond drill is seen in the fact that holes can be bored to a depth of 1,000 feet at a cost of $1.50 to $2.00 per foot, against a cost of $20 by shafting, and the bore-hole should, under favourable conditions, be put down at a rate of 100 to 150 feet per week. Success in boring, however, depends largely on care and skill, with a judicious selection of localities for operations.

It is highly probable, also, that bore holes carefully put down in that part of the property containing the oil-bearing sandstones, would, by the application of pumping machinery, result in productive oil wells, as the rock in places is completely saturated with petroleum. This is a point in connection with operations at Beliveau that would be worthy of attention.

The accompanying plan and section will show the area of the shales in the Beliveau property and vicinity, and confirm the statement that operations should not be entirely confined to the present location of the works.

We have the honour to be,

Sir,

Your obedient servants,

L. W. BAILEY,

R. W. ELLS.

REPORT

ON THE

GEOLOGY OF PART OF THE COUNTIES OF VICTORIA, CAPE BRETON AND RICHMOND, NOVA SCOTIA,

BY

HUGH FLETCHER, B.A.,

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F. R. S., F. G. S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Country surveyed.

SIR,—Explorations and surveys were made by your instructions during the summer of 1876 in that part of Cape Breton Island which lies between Loch Lomond, Salmon and Mira Rivers on the east, and the Great Bras d'Or and St. Patrick Channel on the west, embracing the whole of the Little Bras d'Or Lake, with the northern coast and East Bay of the Great Bras d'Or Lake. Although not within this region, the iron, copper, and argentiferous galena deposits of Loran, Gabarus, and the North River of St. Annes, the coal of Hunter's Mountain, and the gold of Middle River, were also examined.

Acknowledgment of assistance.

It gives me great pleasure to acknowledge the valuable services of my assistants, Messrs. William Fletcher, B.A., and E. A. Bowes, of Toronto. For information and other kindness we have again to thank many persons, among whom Messrs. F. N. Gisborne and H. R. McKenzie, C.E., of Sydney; Alexander Cameron, County Treasurer, etc., of Baddeck; Simon Gillis of Ben Eoin; H. V. Bown and Hugh McPhee of Escasonie, and Rev. Neil McLeod of East Bay deserve special mention.

Bras d'Or lakes.

The Bras d'Or lakes occupy deep basins, excavated in soft Carboniferous strata, encompassed by hills of syenite and other pre-Silurian rocks, flanked here and there by newer sediments. They are connected with each other by Barra Strait, or the Grand Narrows, and with the Gulf of

St. Lawrence by the Great and Little Bras d'Or; whilst, by means of the St. Peters Canal, water communication is continued to the Atlantic Ocean. The maximum depth of the smaller lake is fifty-four, that of the larger forty-six fathoms; the extreme length of the Great Bras d'Or Lake is forty-four miles; its width, from Portage Creek to Soldier Cove, twenty-one miles.

Scenery of the lakes.

Reference has already been made to the occurrence of plaster, limestone, building stone, and iron on the shores of these lakes. But, apart from this, the lakes have an interest of their own in the surpassing beauty of their scenery; and when greater facilities for travel exist in Nova Scotia, hundreds of tourists will be attracted to the beautiful inland sea, which ramifies in the heart of the island, "running away into lovely bays and lagoons, leaving slender tongues of land and picturesque islands, and bringing into the recesses of the land the flavour of salt, and the fishes and molluscs of the briny sea."* It is not the height and grandeur of the hills, nor the wide expanse of water, that gives to these lakes and their surroundings their peculiar charm, but the countless combinations of land and water, which afford new scenes of beauty at every turn. Variety is everywhere found in the irregular shore; in the bold, rocky headlands which roll back the lazy waves, and in the long, graceful outlines of the sand and shingle beaches up which they sparkle, until they break into white quivering lines of surf upon the shore. Here the restless motion of the Atlantic, and the thunder of the waves that encircle the island are unknown; and in the sheltered bays, on a calm day—there are many such in summer—the whole surface is alive with bright-coloured jelly-fishes of every size, expanding and contracting their umbrella-shaped disks as they move in search of food on the warm, tranquil water, in which the swimmer also longs to bathe. Cod and mackerel, herring, skate and halibut are caught on the banks and shoals; oysters of excellent quality are found in the bays and ponds, and in the brooks which flow into them on every side, salmon, trout, smelt and gaspereaux abound.

And if the seal and otter come seldom into its coves, the sportsman may find ducks, loons and cranes in the ponds and low marshes on the coast, sea pigeons in the rocky cliffs, plover on the beaches and dunes, the fox and rabbit the mink and wild cat in the woods. The partridge, of which there are two species—one frequenting the groves of spruce, the other those of birch—are so seldom molested that they are not

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* "Baddeck, and that Sort of Thing." By Charles Dudley Warner. Boston: 1874.

careful to avoid the traveller on the backlands road, who may often kill them with stones.

When weary of the sea, the lover of nature in her sterner moods may turn toward the hills, whose tops, clothed with scraggy spruce, stand near the water; following the grassy banks of the brooks as they sparkle over a pebbly bottom in their winding course through the plain, widening here and there into shallow lakes or ponds, in which the beaver and muskrat build their homes; and afterwards, where they rush madly down from the hills in wild rocky valleys and ravines, he may sit in the shade of the overarching trees, at the foot of the waterfall, to watch the stream dash itself into foam over the jagged edges of the rocks, or gaze into the deep pool and wait for the silver flash of the fish as it springs to the offered bait.

The country is rugged and often barren, except in the fertile Carboniferous belts which fringe the base of the hills; but it is not more so than many places that with fewer advantages, and without the equable sea climate of Cape Breton, have become famous as summer resorts; and it needs but a moderate degree of enterprise to turn the stream of sportsmen, tourists, and seekers after health, towards its forests, brooks and lakes. For invalids, too, whom the delightful, bracing air of the Bras d'Or is powerless to invigorate, there is the mineral spring of East Bay, the therapeutic properties of whose waters are equal to those of the wells of St. Catharines, in Ontario.

Map.

To mark the geological and geographical features of as much of the country surveyed last summer as could conveniently be represented, a map has been drawn on a scale of an inch to a mile. The roads, coasts, brooks and lakes on this map are mostly from our own surveys, made with prismatic compass and chain, or by pacing, kept in position by the coast surveys of the Admiralty, supplemented, occasionally, by their charts and by the plans of the Nova Scotian Department of Crown Lands. A chained traverse of the St. Peters road, from Forks Bridge to Red Islands, was made for us by Mr. Hugh R. McKenzie, C.E., of Sydney.

Geographical and geological features of the country.

In this district we recognise the same geological formations and the same dependence of geographical on geological conditions which were adverted to in last year's report. Feldspathic and gneissoid rocks form the surface over a large area, and constitute hill ranges, seldom exceeding 600 feet in height, two of which, the Coxheath and Boisdale Hills, have been already mentioned. The Coxheath Hills may be said to terminate at the mouth of Macintosh Brook, where the Carboniferous syncline, of which the Sydney Harbour coal basin forms a part, and which runs up the French Vale, dies out or coalesces with the East Bay basin. The Boisdale Hills extend as far as Benacadie Pond: they form, in reality, two ridges, separated by the Valley of McLeod and Indian Brooks, in which Lower Silurian rocks are contained by walls of syenite and felsite. A third range skirts the shore of East Bay, and is separated from a fourth, the Mira Hills, by the valley of Grand River, Loch Lomond and the Gaspereaux and Salmon Rivers. The Washaback Hills lie between two basins of Carboniferous rock. The central portion of Boulardrie Island has been already characterised as a basin of millstone grit, in which isolated patches of the underlying Carboniferous limestone appear—a description which applies equally to the southern part.

Subdivisions of the rocks.

The following are the only groups of rocks which have been observed:—

1. Syenitic, gneissoid and other feldspathic rocks. } Laurentian.
2. George River limestone. }
3. Lower Silurian rocks.
4. Carboniferous conglomerate. }
5. Carboniferous limestone. } Carboniferous.
6. Millstone grit. }

1. Syenitic, Gneissoid, and other Feldspathic Rocks.

These rocks, occupying more than two-thirds of the land area to which this report refers, resemble in general characters and modes of occurrence the members of the same group met with further north, and described in the report for 1875-76. From a careful examination of all the facts observed, the conclusion is almost irresistible that the opinion there expressed as to the relation of the syenite and felsite masses is correct, and that the two series are intimately associated as part of the same group of crystalline rocks, differing not so much in composition as in the degree to which they have been crystallised. There is no evidence that the laminated felsites are higher in geological position than the unstratified porphyry and syenite; they will still, therefore, be considered as one series, without reference to their probable origin.

Gneissoid rocks of the five hill ranges.

The Washaback Hills consist of gneiss, mica-schist, syenite, diorite, hornblende-rock, quartzite and felsite; all more or less foliated, and sometimes in exceedingly thin laminæ; the Boisdale and Mira Hills, chiefly of obscurely bedded syenite, with limited areas of other rocks; the Coxheath Hills, of alternations of syenite, quartzite and compact felsite; and the East Bay Hills, of felsite, syenite, and granite, in every gradation of colour and texture.

Washaback gneisses.

Schistose rocks are well seen on the Washaback anticline in the cliffs of Little Bras d'Or Lake, between Burnt Point and Boulaceet Harbour, where the following sequence is presented, the beds being contorted, and variable, but running approximately parallel to the shore:—

SECTION OF ROCKS BETWEEN BURNT POINT AND BOULACEET HARBOUR.

1. *Carboniferous rocks*, including grey, hard, compact conglomerate, chiefly composed of pebbles of clear quartz; red conglomerate, with pebbles of different kinds, veined with white calcspar in all directions; coarse, grey sandstone, red marl, arenaceous bituminous limestone, somewhat crystalline, and in places radiated, containing cone-in-cone concretions of iron pyrites.
2. Blocks of red and grey syenite, streaked with bright-green epidote, fine-grained hornblende rock, banded quartzite and porphyry.
3. Red syenite; the quartz, feldspar and hornblende well mixed.
4. Brownish-grey fine felsite, much decomposed.
5. Grey syenite, sometimes mixed with red, and containing large veins of quartz. The component minerals are so intimately blended as to be almost indistinguishable. Cliffs thirty feet high.
6. A rock, composed essentially of hornblende and quartz, containing scales of mica, and passing in places into grey syenite.
7. Red syenite and laminated, steel-grey, finely-crystalline quartzite, sometimes micaceous.
8. Grey and red syenite, often largely composed of hornblende.
9. Red and grey banded syenite, and dark grey quartzite, greatly contorted, and containing scales of silvery mica in abundance.

Mine.

10. Grey micaceous, laminated quartzite, and an intimate mixture of quartz and hornblende, holding large crystals of hornblende. Veins of quartz, and crystals sometimes a quarter of an inch in length occur among these rocks. The veins contain scales of white mica, as well as traces of galena, copper and iron pyrites; one of these was mined to some extent a few years ago. Cliffs seventy or eighty feet high.
11. Quartz and red syenite, often micaceous.
12. Thick-bedded, red and grey syenite.
13. Measures concealed. Mouth of a large brook.
14. Steel-grey quartzite, mixed with hornblende, and stained with hematite. Cliffs.
15. Gypsum, (*Carboniferous*) in cliffs twenty feet high, decomposed and crumbling, with dark seams and blotches, dipping at a high angle into the water; laminated, or fibrous, the fibres being often an inch long, sometimes radiated; of every variety of colour—rose-red, sea-green, lemon and brownish-yellow, grey-pearly and waxy in lustre; crystals of selenite arranged in all directions.

These schists rise again from beneath the Carboniferous strata into a cliff fifty feet high at a small pond a mile and a-half further south, where they consist of syenitic and hornblendic rock, and grey quartzite, containing large crystals of feldspar and mica. Although waved and contorted, the dip is generally about N. 48° W., at variable angles. Bands of pure quartz occur, passing in places into a syenite, so divided by joints as to break into large rectangular blocks; and layers of mica give to some of the laminated rocks a steel-grey, oily, pseudo-metallic lustre, resembling that of the gold-bearing slates of Middle River. Veins and streaks of metalliferous quartz everywhere penetrate the schists. In one of these, which cuts a mixture of epidotic hornblende rock, red syenite and felsite, a rich pocket of copper and iron pyrites, sulphide of silver and gold was discovered and mined by Mr. Cameron, of Baddeck.

Silver mine at Boulaceet Harbour.

Underlying micaceous Carboniferous sandstone, limestone and marl, on the hills near Lieutenant Pond, is a red and grey coarse syenite, in layers one inch thick, which strikes N. 60° E. Crystals of quartz and feldspar stand out in bold relief on the surface.

Lieutenant Pond.

On the Boisdale anticline this series is represented principally by bluish and grey syenite, but also by other rocks well worthy of notice. The syenite contains seams of a serpentinous mineral, and passes frequently into granite, quartzite, felsite, and a fine-grained porphyry, with interspersed crystals and flakes of hornblende, feldspar and mica, sometimes a-quarter of an inch long.

Boisdale felsites.

The Carboniferous conglomerate of Maigh Brook, Boisdale, is superimposed in horizontal bedding upon a mixed syenitic and granitic rock of a red or grey colour. The hornblende is greenish, and often occurs in crystalline aggregations as large as hazel nuts. In Beaver Brook, at the mill near the shore road, a similar rock, containing bronze-coloured mica and garnet-red feldspar, is traversed by red bands and veins of quartz, inclined steeply N. 12° E., and passing into red syenite. At its contact with these quartzose bands, the syenite is itself full of quartz blotches. A series of well-defined planes dip S. 30° E., whilst a belt of layered red syenite, with quartz veins, one of them an inch thick, between the layers, runs S. 32° E. vertically, and other veins or beds run N. 84° E. to S. 70° E. Higher in the brook a prussian-green felsite or fine diorite, traversed by films of quartz and calcspar, runs N. 36° E., and is confusedly mixed with red syenite and banded calcspar. The syenite and diorite in places seem to merge into each other; at other points they are distinct, the syenite being sharply cut off by the diorite, which appears to intersect it in veins varying from an inch upwards. A

Maigh Brook.

Quartz veins in Beaver Brook.

greenish, soft, fine-grained, cleavable, altered diorite, with films of calcspar, runs N. 31° E. in the red syenite which follows; and this is succeeded by a grey and red syenite and granite. Similar rocks occur on the Beaver Cove road with a contorted gneiss, having quartz, feldspar, mica and hornblende in distinct layers.

Contact of Carboniferous and Laurentian rocks in Fox Brook.

Fox Brook has forced its way through syenitic rocks which dip S. 14° E. at their junction with the Carboniferous conglomerate. Ascending the brook, we come upon a bluish, soft felsite, and a bed or vein of limestone, varying in thickness from one inch to a foot, which dip S. 23° E. at a high angle. Rocks of the same character and attitude underlie the Lower Silurian slates of McLean and McNeil Brooks, and in the picturesque gorges of the Shenacadie brooks, syenite, mica-schist, quartzite and soft, friable, crumbling rocks are well displayed.

Garnet.

On the Bourinot road, near Steele Brook, a quartzite, intermixed with compact and granitoid felsite and granite, contains crystals of hornblende, mica and garnet.

On Christmas road, and in the brooks which cross it, the syenitic and feldspathic rocks are largely developed, although, owing to the manner in which the Carboniferous rocks rest upon them, and the obscurity of the dip, there is some doubt as to the relation of the various outcrops, some of which, perhaps, belong to the overlying Lower Silurian series. For convenience in description, however, an attempt has been made to present them in a continuous descending sequence, as follows:—

SECTION OF PRE-CARBONIFEROUS ROCKS ON CHRISTMAS ROAD..

Dip N. 34° *W.* $<$ 60°.

		FEET.	IN.
Slaty felsite.	1. Bluish felsite and white or colourless, pyritous, vitreous quartzite, in bands, often finely-laminated, twisted, and more or less argillaceous and slaty; seen in Benacadie Brook above the mill; of indefinite thickness	..	..
Brick-red felsite.	2. Reddish, compact, splintery, dull and amorphous felsite, with minute, highly-crystalline grains of transparent quartz and light-coloured mica; vugs lined with crystals of calcspar, which is also found at times in the mass; on weathering, resembles burnt brick. It seems to dip in thick beds conformably with the banded felsites, which do not appear more altered near the junction; and beginning at the top of a high bank, is soon at the level of the millpond, forming a cliff between the mill and dam. The point of contact with the underlying felsites was nowhere seen, the two series being separated by five or ten feet of *debris*. The outcrop cannot be traced far from the edge		

		FEET.	IN.	
	of the pond, and its extent in this direction is, consequently, unknown. Thickness perhaps	50	0	
3.	Bluish and greenish, compact, splintery felsite and quartzite, with streaks of quartz and calcspar; generally thick-bedded, but often more or less shaly and slaty. Associated with beds of greenish felsite and limestone, intimately mixed, and resembling the Lower Silurian rocks of McLean and McNeil Brooks. Strike north-easterly	476	0	
4.	Measures concealed	886	0	
5.	Greenish and grey, layered, pyritous, jointed felsite, intermixed and interbedded with thin bands of crystalline limestone; much soft, soapy matter and hematite in the joints. The colour is variable as well as the thickness of the layers. Some of the calcareous beds are three inches thick, and give a ribboned appearance to the rock by their different shades of colour. The rocks are highly altered, none of them resembling the fossiliferous Lower Silurian rocks, yet as little like the lower feldspathic group. Thickness undetermined; included in 4	..	..	
	[The exact relations of the foregoing rocks to those which follow, and were seen in Hare Brook, are obscured by the overlapping of blue and red Carboniferous marl, sandstone, and egg-conglomerate, containing a bed of greenish and reddish nodular limestone, at least three feet thick, which run N. 20° E., apparently vertically.]			Carboniferous outlier.
6.	Measured concealed	340	0	
7.	Greenish felsite and diorite	18	0	
8.	Red syenite, and greenish granitoid felsite, mixed	7	0	
9.	Red syenite	20	0	
10.	Greenish fine-grained felsite, with specks of hornblende	5	0	
11.	Red syenite	6	0	
12.	Greenish compact felsite, intimately mixed with a greenish fine-grained felsite, and also with a coarse-grained variety, containing grains of quartz	4	0	
13.	Grey and light green compact felsite, containing much calcspar; no signs of bedding	121	0	
14.	Red, coarse syenite, forming a gorge and waterfall	130	0	
15.	Bright-red syenite	225	0	
16.	Bluish and red, coarse, coherent syenite	114	0	
17.	Greenish, fine-grained, slightly porphyritic felsite	25	0	
18.	Greenish and bluish friable syenite	60	0	
19.	Bluish, rather friable syenite, granite and compact felsite	26	0	
20.	Felsites concealed by an unconformable covering of reddish Carboniferous sandstone and conglomerate, containing pebbles about the size of a hen's egg. Large pieces of			Carboniferous outlier.

	FEET.	IN.
George River limestone were found in the brook, but as this formation was not seen in place, it may be concluded that they came from the conglomerate.................	173	0
21. Red syenite...	78	0
22. Greenish-grey, compact, essentially feldspathic rock.... ..	95	0
23. Syenite and granite, forming a rocky gorge and waterfall..	130	0
24. Greenish-grey granite and syenite; silvery mica..........	16	0
25. Red syenite and granite, with patches of calcareous diorite and friable talcose granite..........................	94	0
26. Yellow-weathering, friable syenite and compact felsite....	200	0
27. Red coarse syenite, sometimes without a trace of hornblende	164	0
28. Measures concealed; probably syenitic rocks.............	260	0
[Owing to the indefinite nature of the outcrops, it is not impossible that the rocks which follow, seen on the Christmas road, may be out of place in the section. This, however, seems to be their position.]		
29. Green, red and variously coloured, compact felsites, indistinctly seen. In the distribution of their colours they resemble the rocks of Coxheath.	1,845	0
30. Grey and reddish decomposed felsite, sometimes porphyritic.	300	0
31. Reddish mixture of red feldspar and whitish quartz.......	200	0
32. Compact and granitoid felsites of different colours........	314	0
33. Whitish coarse syenite, diorite and felsite, with a mixture of feldspar and quartz; finely granular and compact, mixed, and passing into one another....................	285	0
34. Bluish, fine diorite, sometimes nearly compact, passing into fine-grained felsite, and into a coarse grey syenite, which is sometimes intersected by irregular veins of red feldspar...	143	0
35. Greenish, coarse and fine hornblende-rocks, sometimes almost wholly composed of hornblende, with a little quartz in small grains..................................	170	0
36. Bluish-grey fine-grained diorite............................	772	0
37. Grey and bluish granitoid rocks, abounding in hornblende, which occurs as large distinct crystals, or in a fine mixture, with rather foliated, fine-grained feldspar. Of indefinite thickness	686	0
Total thickness........................	8,438	0

Benacadie Brook.

At Christmas road the north branch of Benacadie Brook flows in a broad Carboniferous valley between gently sloping hills. Higher up, the hills come together, and the brook rushes over the older rocks in gorges of great beauty, and falls with deafening roar from a height of thirty feet, making a pleasant breeze by the motion of its spray. These older

Falls.

rocks consist of greenish granitoid and compact, calcareous and quartzose felsite and diorite, with a north-easterly strike, sometimes laminated like the shales at Murdoch McNeil's.

The road which ascends Benacadie Brook to John McNeil's, passes over red coarse syenite, grey and black, compact, laminated felsite, and grey and dark-green, rusty-weathering, compact or fine-grained mixtures of felsite and diorite, veined with quartz, and in places a coarsely-crystalline quartzite. Succeeding these are bright-green, pyritous felsite, streaked with quartz and red syenite; bluish, gneissoid rocks, red syenite and granite; a light-green, soft, soapy rock; a calcareous, talcose rock, and a finely, foliated, bluish gneiss.

Calcareous and talcose gneiss.

From John McNeil's to Hugh McPhee's the land is wet and barren, the prevailing rocks being bluish, greenish and white, mottled, compact felsite, with quartz and chlorite; granular and obscurely granular, quartz-veined felsite; contorted, foliated, quartzo-micaceous rock, containing chlorite, and not unlike a gneiss of the George River series; bluish quartzite, grey syenite and granite, often with golden mica, coarse and fine diorite, veined with quartz. Calcareous matter is often found, as well as small traces of copper pyrites.

Copper ore.

A curious outlier of syenitic rock occurs at Piper Cove, dipping, apparently, N. 16° W. < 63°. It consists of red and grey, very micaceous syenite, overlain by four feet of dark-green diorite, strongly seamed with quartz and calcspar, sometimes a foot thick, and holding hematite, overlain in turn by syenite.

Syenitic outlier of Piper Cove.

In a brook which flows into Little Amaguadees Pond, red syenite is in place above the road, and in the bed of the brook are large blocks of granite, greenish diorite, soft, soapy, calcareous rock, grey and yellowish quartzite and felsite, a purple, compact Coxheath felsite, and a foliated grey gneiss. The parent beds, from which these blocks were torn, might probably be found higher up, but the brook was not traversed.

Amaguadees Brook.

In Christmas Brook, associated with the syenite, granite, diorite and felsite, which form the gorges and cascades near its source, is a narrow belt of crystalline limestone, generally compact, with soft, honey-yellow, asbestiform fibres. In colour it is variable; the dip is about N. 64° E., < 45°; some of the beds hold iron pyrites, talc, and a soft, blackish mineral, as well as large masses of white and colourless, vitreous quartz. With this belt is found a dark-brown and bluish, granular, calcareous rock; a white, syeno-granite, and dark-reddish spotted, hematitic, soft, trappean rocks, like those of Gregwa Brook. This group is succeeded

Crystalline limestone of Christmas Brook.

by obscurely granular, friable syenite, which extends to the East Bay road.

Indian Brook.

The wild and beautiful valley of Indian Brook displays at the East Bay road, cliffs of red, coarse, epidotic syenite. This is overlain near the bridge on the Indian Brook road by the Lower Silurian rocks of McLeod Brook and Long Island. Higher still, at the crossing of the Beaver Cove road, a dyke of bluish felsite, spotted with iron pyrites, and sometimes porphyritic, cuts the red syenite. The hills between this bridge and Bown's are composed of a grey and red syenite, which passes in places into granite. The most noteworthy variety is a porphyritic mixture, in which the crystals of quartz are a-quarter of an inch in length; those of hornblende an inch; and in which large crystalline masses of golden mica are also present.

Golden mica.

Junction of Laurentian and Lower Silurian rocks.

Above the bridge, in a small tributary on the left bank, greenish Coxheath felsite and diorite, crystalline or compact, form cliffs, seventy-five or a hundred feet high, from which contorted black slate, with quartz veins, dips away at a high angle. This slate is associated with grey and reddish grit, like the primordial rocks of other localities.

Gregwa Brook.

In Gregwa Brook, a tributary of Indian Brook, these rocks present many of the varieties of the Coxheath series; and occurring, as they do, among the syenitic and granitic series of these hills, afford an additional proof of the identity of the two series.

SECTION OF FELDSPATHIC ROCKS IN GREGWA BROOK.

Dip N. 86° *W.* $<$ 45°.

	FEET.	IN.
1. Greenish, compact, slaty felsite, with a little quartz and calcspar. Of considerable thickness....................	..	..
2. Compact felsite, with one thin band of compact, pyritous limestone; occasionally, compact quartzite and brecciated felsite and quartzite..................................	13	0
3. Granitoid rocks and compact felsite and quartzite.........	31	0
4. Serpentine limestone, of indefinite thickness.............	5	0
5. Mottled quartzite..	2	0
6. Friable granite..	2	0
7. Whitish, yellowish and bluish crystalline limestone, generally saccharoidal, but sometimes compact; sometimes pyritous and brown-weathering; greenish streaks of serpentine. Associated, like the limestone of the North River of St. Annes, with greenish compact felsite, and with a bluish hornblendic schist..................	17	0
8. Granular felsite and white syenite........................	52	0

	FEET.	IN.
9. Compact, friable felsite, intersected by a whitish-grey granitoid vein	12	0
10. Bluish, compact, splintery felsite	27	0
11. Compact, micaceous felsite, often obscurely granitoid, and passing into granite and syenite, like the felsite of Cossitt road	30	0
12. Syenite	29	0
13. Granular felsite, quartzite, diorite, syenite and granite, mixed in the same specimens with compact felsite and quartzite	14	0
14. Whitish, granular and fragmental felsite, with compact felsite and quartzite, full of quartz veins	12	0
15. Soft, pyritous, obscurely granular rocks	5	0
16. Compact and granular, feldspathic and quartzose, chloritic and calcareous, pyritous rocks, in thick beds, merging into coarse syenite and granite	18	0
Total thickness	269	0

It must not be supposed that this section is absolutely correct. The dip was taken from the limestone band, and is even there obscure.

Dugald Brook

In Dugald Brook, from the bridge on Hugh McPhee's farm road to the confluence with Indian Brook, the feldspathic rocks and the overlying primordial series are well displayed.

SECTION OF PRE-CARBONIFEROUS ROCKS IN DUGALD BROOK.

Laurentian rocks.

	FEET.	IN.
1 Red syenite; purple massive amygdaloid, full of calcspar, and often vesicular, resembling some of the rocks of Long Island; compact, calcareous and feldspathic rock, in thick beds, full of hematite, dipping doubtfully to the northward; compact, greenish, bluish and variegated felsite, resembling that of Cape Rhumore	277	0
2. Crumbling, white granite, associated with decomposed diorite and greenish-yellow, soft, calcareous, soapy rocks. Seen at the bridge on the Indian Brook road	33	0
3. Coarse syenite mixed with compact, bluish felsite	9	0
4. Amygdaloid, with black hornblende in long fibres	23	0
5. Dark-purple, crumbling, fragmental rocks	17	0
6. Mottled red and purple compact felsite, often fragmental, in high cliffs; lines of vertical jointing or bedding, S. 56° E.; full of calcspar, and stained with hematite	96	0
7. Purple amagdaloids, full of calcspar. A beautiful fall of twenty feet, with a large clear basin at the bottom	25	0
8. Greenish and purple calcareous rocks, often soft and shaly	18	0

Fall.

Potsdam rocks.

Laurentian syenite.

	FEET.	IN.
9. Limestones, like those of Gillis Brook and Long Island, soft and crumbling. A small fall	55	0
10. Greenish, shaly, feldspathic sandstone, containing many impressions of *Obollela*; associated with feldspathic grit	36	0
11. Purple, bluish and grey feldspathic shale and sandstone, crowded with shells	20	0
12. Light coloured, nearly compact quartzite, grit and sandstone. Not well seen	32	0
13. Mottled, fragmental felsite, or conglomerate. Not well seen	49	0
14. Black and grey argillite, red and grey quartzite, etc., seen in Indian Brook	990	0
15. Red syenite of the hill extending to the Escasonie shore	..	..
Total thickness	1,680	0

In this section the rocks are assumed to be vertical; the strike being about N. 40° E. At one point they dip to the northward, but this may be overturned.

Coxheath Hills.

Considerable difference exists between the feldspathic rocks to the north of the Lower Silurian area of the Coxheath Hills and those to the south of that area, as will be seen by a comparison of the rocks now to be described with those described in the Report for 1875-76, pages 371 to 374. The more compact and laminated nature of the felsites of Escasonie made it at first doubtful whether they might not belong to the Lower Silurian series; but there can now be little doubt that they are interstratified with the syenite, and of pre-Silurian age.

Cossitt road.

Quartz and calcspar veins.

On the Cossitt road, near Macintosh Brook, bluish-grey, crystalline, granitoid quartzite and compact felsite are followed by syenite and compact and granitoid felsite and quartzite, often porphyritic, like the rocks seen on the Gillis road. A greenish and red syenite comes to the shore at McDonald Pond, seamed, and in part replaced by veins of white quartz and calcspar, which dip S. 64° W. at a low angle. The character of the rocks of the Gillis road and the brook to the eastward will be best understood by reference to the following descending section:—

SECTION OF FELDSPATHIC ROCKS BETWEEN EAST BAY AND MACINTOSH BROOK.

Dip S. $<$ 53°.

	FEET.	IN.
1. Greenish, very compact, layered felsite, often calcareous, and containing films of hematite in the joints; thread-like quartz veins. Seen at and near the mill dam in the brook at the school house on the East Bay road. A rocky brook with several falls	368	0
2. Measures concealed, but probably similar to the preceding	232	0

	FEET.	IN.
3. Mottled, red and green compact felsite, mixed with granitoid rocks, one of which is traversed by a vein of red compact felsite	150	0
4. Grey and greenish syenite, with little hornblende, which is often distributed in streaks. The feldspar is, in places, bright-red, and forms a striking contrast with the white quartz	122	0
5. Green compact felsite, obscurely bedded, and veined with quartz	160	0
6. Compact felsites and greenish granitoid rocks, apparently passing into one another	80	0
[The last rocks measured in the brook.]		
7. Reddish and greenish felsite, forming a steep hill. At first sight this rock resembles syenite, but on closer examination is found to consist essentially of very compact feldspar, occasionally vesicular, with small veins and blotches of quartz	800	0
8. Greenish, compact, splintery felsites, in thin beds, resembling those of Shenacadie and Benacadie	700	0
9. Red syenite	360	0
10. Greenish compact felsite, not well seen	220	0
11. Red syenite	548	0
12. White crystalline quartz	88	0
13. Measures concealed. Red syenite *debris*	576	0
14. *Carboniferous conglomerate* of Macintosh Brook	..	..
Total thickness	4,404	0

Spruce Brook.

In Spruce Brook, about two miles nearer the head of East Bay, greenish compact felsite, often streaked with calcspar, bluish and red syenite, bluish, soft, soapy, calcareous rock, slickensided in the joints, which are coated with hematite, are associated with a coarse grey mixture of quartz and feldspar, containing a little hornblende, and with a green diorite. These rocks are overlain by Lower Silurian strata, which conceal them between this point and the Bourinot road.

Extension of the Cow Bay anticline.

The East Bay range of hills may be regarded as the south-westerly extension of the anticline which divides the Glace Bay and Cow Bay coal basins, although between Cow Bay and East Bay it ceases to be prominent, and the two basins coalesce.

East Bay felsites, Morley road.

The most easterly development of the feldspathic rocks of the East Bay Hills, which resemble, for the most part, those of Coxheath, is seen on the Morley road, near Mira River, where they are capped with Lower Silurian and Carboniferous sediments. They consist of dark-grey, indian and flesh-red, fine-grained, white-weathering felsite, with small seams of clear quartz, followed by a very compact conglomerate; of red quartzite, and red and green hematitic felsite, so coherent in places as to obscure the form of the component pebbles, except on weathered surfaces, which are roughened by the quartz, whilst the feldspar appears as small white specks, succeeded in turn by a fine-grained quartz felsite, which differs from the preceding only in being more granular. The quartz is green, red and white, the feldspar green and red, splintery and close in texture.

McMillan's.

Not far from Mr. James McMillan's, on the road from East Bay post office to Mira River, is an outcrop of dark-blue, fine-grained, nearly compact feldspar-porphyry, containing iron pyrites, and striking N. 85° W.; of greenish and red felsites, flesh-red and dark-grey porphyry, and crystalline quartz-feldspar rock, with grains as large as wheat. Similar alternations continue as far as the boundary of the millstone grit. On the path leading from the school house near McMillan's to the Chapel road, dark-blue and reddish, compact and granular felsite and porphyry, and purple, red and green, compact and granular quartz-felsite, are associated with dark-green fine-grained syenite, composed of intimately mixed crystals of feldspar, short flakes and crystals of black glittering hornblende and grains of quartz.

Chapel road.

The Chapel road crosses red porphyry and other felsites, dark-grey coarse diorite, and flesh-red syenite, with little hornblende, to the millstone grit of the Loch Lomond basin. A branch of this road, running towards Salmon River, displays a felsite so meshed with syenite as to simulate a conglomerate, a red syenite, a bluish-grey porphyry, with light-coloured feldspar veins, and a dark flesh-red, blackish and greenish-grey granitoid rock, in large streaks and blotches, sometimes fragmental, veined with feldspar and syenite, and consisting—the red, of quartz and fedspar; the black, of hornblende and feldspar, and the grey of fine-grained porphyritic felsite.

St. Peters road.

The St. Peters road, between the East Bay chapel and Gillis mill, is chiefly occupied with red and grey syenite, whilst from the mill to the Meadows road, bluish-grey, green, red and purple porphyritic felsite, purple, greenish and whitish, compact and fragmentary, quartz-veined felsite, and greenish, compact, porphyritic felsite, with black scales, prevail. Many of these rocks are in thin layers; others present no appearance of stratification. In Gillis millbrook is a soft, soapy, variegated, red and green rock, like that of which an analysis was given by Mr. Hoffmann, in the Report for 1875-76, page 423; also, a red and green compact, porphyritic felsite.

Altered felsite.

Westward, towards the Glengarry road, compact and fine-grained quartzite and massive felsite, coloured green with a soft, unctuous mineral, and red with hematite, of which they contain small crystals, form precipices sometimes a hundred feet in height. Occasionally the felsite, containing crystals of sea-green feldspar, becomes porphyry, or, by the addition of quartz and hornblende, grey and red syenite. The strike is, apparently, S. 73° E. On the shore, grey, greenish and reddish, fine and coarse syenite, with blotches of epidote, delicate crystals of hematite, and quartz veins, subjacent to a Carboniferous conglomerate, containing masses of hematite, is mixed with and passes into a dark-green compact felsite, with pale, porphyritic spots.

Glengarry road.

Porphyry and syenite.

Epidote.

Laminated felsites, compact, slaty felsites with specks of hornblende, reddish compact porphyry and red and greenish felsite, containing quartz, and more or less granitoid, cross the Ben Eoin road; and on the Meadows road, near the iron location of Messrs. Gillis and Matheson, an endless variety of felsites, including compact, Indian-red porphyry, soft, greenish, pearly, soapy shales, and coherent, fragmentary rocks, strike N. 34° to 49° E. Between the L'Ardoise and Glengarry roads purple felsites occur; and between the Glengarry road and the mineral spring bluish-grey syenite, diorite and felsite, containing grains of mica, are overlain by millstone grit and Carboniferous limestone. At the mineral spring the syenite is cut by a dyke of bluish-grey felsite two feet thick.

Ben Eoin road.

Meadows road.

Mineral spring.

The strike of the rocks crossing the L'Ardoise road between Big Pond and the Loch Lomond Carboniferous basin being variable, no estimate of the relative thickness of the beds has been made; the succession, however, is as follows:—

L'Ardoise road.

1. Light-bluish compact felsite, streaked and spotted with hematite; small vugs, lined with pink vitreous quartz: has a north-easterly vertical trend.
2. Red felsite.
3. Red porphyry and red and grey syenite.
4. Red porphyry, diorite and syenite.
5. Red porphyritic felsite, and red and bluish mottled felsite.
6. Red compact felsite.
7. Red and white close-grained felsite, in short, thin, and seemingly lenticular bands,—three feet.
8. Red felsite, diorite and syenite.
9. Light indian-red and white, banded, close-grained felsite; the bands very thin and running into one another; also in thick beds: white quartz in blotches several inches square, or in bands.

Porphyry, syenite, diorite, and banded felsite.

10. Mottled red and green banded felsite and quartzite mixed. Strike N. 20° E.
11. Bluish and greenish, friable, fissile, contorted felsites, talcose in the joints.
12. Bluish-grey laminated argillite or slate; hard and slightly unctuous on smooth planes of cleavage. Dip S. 58° W., but greatly contorted.
13. Bluish and greenish felsite in thin and thick beds, not distinct, but the jagged edges of one band fitting into those of another; white quartz veins from an inch downwards.
14. Rock composed of a mixture of feldspar and quartz; the latter standing out in small rounded protuberances against the weathered feldspar.
15. Felsite, weathering light-brown, seamed and dotted with quartz.
16. Greenish-grey and light-brown, streaky felsite, with a soapy feel; bedding not evident.
17. Bluish-grey felsite.
18. *Millstone grit.*

Glengarry road.

St. Peters road.

Syenite, granite and felsite.

Nature of the contact.

Crossing the Glengarry road in a direction of N. 69° E., is a greenish, compact, or finely granular, pyritous felsite, often porphyritic, with quartz in veins, blotches and vugs, and spots of hematite. Interstratified with this felsite are mottled greenish, purple, grey and red shales and light-grey, pearly, slightly granular, laminated felsite, with thin interlocking plates. The first rocks seen on the backlands road, which leaves the St. Peters road near the Big Pond chapel, are red compact felsites, streaked with grey, and bluish-grey and purple slaty felsites dipping N. 51° W. These are succeeded, in a small brook, by red syenite and granite, intermixed with greenish, fine-grained and compact felsite, cut by thin veins of iron pyrites. The line of contact of the felsites and syenite is an irregular one. Greenish and red, slaty felsite, and a very coarse mixture of granite and syenite follow immediately in the road; and on the hill at the end of the road, a whitish or cream-coloured, compact felsite seems to be mixed with red syenite, greenish porphyry and mottled, granitoid and fragmentary felsite.

Junction of Carboniferous and Laurentian rocks.

From the Big Pond chapel the line of contact of the Carboniferous and feldspathic rocks follows the mail-road to the post office at McPherson's, where the latter come to the shore in the bold headland of Cape Rhumore. The following section contains, in descending order, the rocks seen on this cape, between Lochan Fad and Irish Cove:—

SECTION OF FELDSPATHIC ROCKS AT CAPE RHUMORE.

Dip S. 46° *to* 70° *E.* < 70° *to* 90°.

		FEET.	IN.	
1.	Greenish-grey and red fine-grained porphyry, veined with quartz	20	0	
2.	Measures concealed. The sand and shingle beach of Lochan Fad begins	348	0	
3.	Red and green, mottled, fragmentary felsite, containing fragments of a compact mixture of feldspar and quartz	181	0	Felsite-breccia.
4.	Greenish, calcareous, saccharoidal felsite, mixed with flesh-red compact felsite and porphyry	73	0	Granular and compact felsite.
5.	Red and green mottled felsite	28	0	
6.	Red, compact, porphyritic felsite, with veins and blotches of greenish feldspar	19	0	
7.	Red granular felsite, containing grains of hornblende, and resembling syenite	66	0	
8.	Red and mottled red and green compact felsite	404	0	
9.	Red and green mottled felsite	29	0	
10.	Greenish fragmentary felsite	19	0	
11.	Red and green mottled felsite, the spots of each colour large and distinct; a white and black brecciated vein	66	0	
12.	Measures concealed	150	0	
13.	Cliffs of felsite, spotted bright flesh-red, green, grey and blue, essentially compact, but often resembling a conglomerate, and sometimes assuming a granitoid texture in the presence of small grains of quartz; porphyritic. In some places lamination is well displayed, and is contorted, waved, and broken in the most wonderful variety	151	0	
14.	Red and green, compact, quartz-veined, epidotic felsite and porphyry	47	0	
15.	Measures concealed	28	0	
16.	Banded, purple, greenish and other coloured, porphyritic and fragmentary feldspathic rocks, like those at Louisburg lighthouse	103	0	Louisburg felsites.
17.	Greenish soft, granular, porphyritic rock, stained with hematite	75	0	
18.	Greenish blotched grits and conglomerates; green, purple and white compact felsite; bright indian-red band of soft argillite, resembling a rock found near the source of McKeagan Brook*; white granite, containing large fragments of bluish porphyry; greenish and purple epidotic porphyry. Indistinctly seen	10	0	Argillite. Granite.

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* Report for 1875-76, p. 375.

		FEET.	IN.
	19. Bright-red and green, mottled, compact felsite	60	0
Gypsum.	[Traces of red and green Carboniferous marl, and gypsum here appear.]		
	20. Felsites, externally dark-purple, but exhibiting, when broken, great variety of colour; often porphyritic, the feldspar of the crystals being paler in colour than that of the base; at times granitoid; frequently laminated, the laminæ being smooth and pearly; veins and films of quartz	200	0
	21. Greenish porphyry	85	0
Epidote.	22. Indian-red, grey and purple porphyry, thickly spotted with crystals of light-coloured feldspar, and blotched with calcspar and epidote. A white quartz vein, an inch or more in thickness, dips N. 70° W. < 60°, and if this is also the dip of the surrounding felsites, there is a repetition of some of the beds of this section	100	0
Altered felsite.	23. Greenish, finely saccharoidal, soft rock, probably altered felsite, with small sparkling surface crystals and stains of hematite	5	0
Serpentine.	24. Purple compact porphyry, sometimes shaly and stinking, with crystals as large as peas; occasionally resembles a coarse conglomerate, composed entirely of feldspar; large blotches of epidote, a small lenticular bed of cream-coloured serpentine, and a wedge of flesh-red compact felsite, holding small grains of quartz	20	0
	[The feldspathic rocks are here concealed by a small pond and beach, and the next rocks seen to the southward on the coast are Carboniferous.]		
	Total thickness	2,287	0

Irish Cove.

The felsites, which now retreat from the shore, are again met with in the large brook at the head of Irish Cove, intermixed with syenite. Combining this exposure with those of the Irish Cove road and Snake Brook, we obtain the following section:—

SECTION OF FELDSPATHIC ROCKS BETWEEN IRISH COVE AND LOCH LOMOND.

		FEET.	IN.
Conularia.	1. *Carboniferous limestone*, in thick, undulating beds; full of *Conularia*, and other fossils	..	..
	2. Measures concealed; blocks of syenite and porphyry	..	..
	3. Greenish and white, mottled, laminated felsite	300	0
	4. Greenish and red, mottled, granitoid felsite	180	0
Felsite and syenite.	5. Greenish felsite and red syenite	100	0
	6. Bluish soft porphyry	85	0
	7. Purple and bluish laminated felsite	233	0

	FEET.	IN.	
8. Red granitoid mixture of feldspar, quartz and hornblende. The feldspar is most abundant, and sometimes prevails to the exclusion of the other ingredients; the quartz is in blotches or small grains	35	0	
9. Red syenite	141	0	
10. Red syenite and a greenish, soft, granitoid rock	106	0	
11. Greenish and reddish, more or less granitoid rocks, stained with hematite; often nearly pure feldspar	269	0	
12. Felsite and syenite of variable composition, with blotches and veins of white crystalline calcite	130	0	
13. Red granitoid felsite, diorite and syenite. A waterfall, pot-hole and cave	160	0	Diorite.
14. Purplish felsite and syenite, not well seen	445	0	
15. Syenite mixed with soft, soapy rock	28	0	
16. Syenite, or in places, reddish, dark-spotted, granitoid felsite	35	0	
17. Syenite; a band of prussian-green felsite at one point traverses it in a direction N. 67° E.	290	0	
18. Greenish, slightly granitoid rock, containing much calcspar. Sometimes soft, with blothches of hematite	92	0	
19. Red and green mottled, granitoid felsite, with a little quartz	78	0	
20. Red and greenish granitoid felsite	50	0	
21. Red syenite, overlain in places by Carboniferous conglomerate, most of the pebbles of which are of syenite	85	0	
22. Red syenite and granitoid felsite, principally the former; not well seen	990	0	
23. Greenish fine-grained felsite in thick beds	954	0	
24. Red and grey, coarse and fine syenite, seen at intervals on the Irish Cove road	2,333	0	
25. Grey and red syenite, and greenish, compact and granitoid, often porphyritic felsite	71	0	
26. Syenite	42	0	
27. Syenite and pale prussian-green felsite	7	0	
28. Syenite	60	0	
29. Greenish, fine-grained, nearly compact felsite	25	0	
30. Syenite and greenish fine-grained felsite; one band of the latter, a foot and a half in thickness, running N. 74° E., in grey syenite	28	0	
31. Grey and red syenite	85	0	
32. Measures for the most part concealed, but, probably, syenite and felsite	636	0	

(The foregoing members of the section have been assumed to dip S. 22° E. < 45°. The section is now transferred to the source of Snake Brook, where the dip is north-westerly, a syncline apparently interven-

Snake Brook.

Syncline.

Syenite.

Nacreous shales.

Quartz-felsite and diorite.

Calcspar.

Quartzite.

	FEET.	IN.
ing. The position of the axis of this fold is unknown, but it does not occur before No. 24. The same angle of dip is assumed.)		
33. Measures concealed : low land, mossy pitfalls, small muddy ponds, dead trees and underbrush, red syenite *debris*....	275	0
34. Grey syenite, containing little quartz..................	43	0
35. Grey syenite interbedded with greenish, nacreous, aluminous shales, in layers from three to six inches thick ; not well seen..	14	0
36. Greenish, soft, laminated, nacreous, aluminous shales ; containing calcspar, and resembling those which are associated with the iron ore of Big Pond. Strike, N. 35° E.	21	0
37. Grey quartz-felsite..................................	163	0
38. Greenish, finely granular and compact felsite and diorite, sometimes porphyritic ; associated with a nearly compact quartzite or quartz-felsite ; calcspar is abundant in the joints..	70	0
39. Greenish and-pale grey, compact and fine-grained, porphyritic felsite, quartzite and quartz-felsite, with rusty spots ; in thick beds, covered in the joints with thin plates of talcose hematite and films of greenish serpentine........	64	0
40. Grey and greenish syenitic rocks........................	71	0
41. Finely granular rock ; essentially felsite, but often containing quartz, hornblende and mica. In places it is a red and grey syenite, composed of feldspar, quartz, hornblende and mica ; the last two being the least abundant. At times it is a mottled red and green, compact and broadly crystalline felsite ; sometimes porphyritic, with grains of quartz and hornblende, or of hornblende alone, sparingly disseminated ; and in one place a granular quartzite takes its place. The uppermost beds comprise greenish granitoid felsites, striking N. 32° E. in irregular layers of variable thickness, having a large quantity of a soft, blackish, glistening mineral in the joints and bedding planes. Hornblende, hematite and calcspar are often present, and quartz occurs in grains, streaks and small veins, or as delicate, sparkling crystals in the joints, which break the rock into small angular pieces. A decomposed rock, yielding readily to the knife, is also intermixed.........	56	0
42. Bluish, generally compact felsite, of indefinite thickness....	50	0
43. *Carboniferous rocks* of Loch Lomond..................	..	..
Total thickness..............................	8,900	0

Intermixture of the different rocks.

Here, it will be observed, the laminated felsites and red and grey syenites are again inseparably associated, as is also the case in a small brook flowing into the lake a mile north of Irish Cove. Immediately below the Carboniferous rocks in this brook, bluish-grey, soapy, papery shales, including layers of quartz, mixed with a talcose, chloritic porphyry, strike N. 44° E. A little higher in the brook, although the contact is not visible, red syenite appears, but is replaced within a few yards by the laminated rocks.

Soapy shales and red syenite.

The mottled red and green, granitoid, laminated and thick-bedded felsite at John Cash's, differing from that of Cape Rhumore only in its more granular texture, is sometimes veined and blotched with quartz, and dips S. 41° E. The rocks which form the precipitous cliffs which extend from Cash's to McLeod's mill brook, a mile and a-half to the south-west, are not dissimilar, consisting of laminated and thick-bedded felsite of every colour and texture, with softer beds. At the mouth of the mill brook the first rock below the Carboniferous limestone and conglomerate is a grey syenite, passing downwards into a felsite, in which the same inconstancy of mineralogical composition obtains. Quartz, epidote, chlorite and hematite spot the rock; which also contains porphyritic crystals half an inch in length. Two black varieties of rock, one soft and calcareous, resembling a sandstone, the other hard and ferruginous, are especially noticeable. The bedding is obscure, but, apparently, contorted: in one place it strikes N. 61° W., and in another dips N. 64° E. < 45°. In the brook, above the road, a purple, red and green mottled, compact felsite, holding small plates of mica, runs N. 45° E.

John Cash's

McLeod's Brook.

Syenite.

Porphyry.

Felsite.

Folded and waving felsite and porphyry, which might vie with any of the others in point of colour and texture, cross the St. Peters road at several points between the Red Islands chapel and the end of the Loch Lomond road; the general strike being, apparently, about N. 11° E., but in one place N. 44° E., and in another N. 44° W.

St. Peters road.

The Loch Lomond road follows a valley of Carboniferous rock, guarded on the north by hills, composed of the feldspathic and syenitic rocks of this series. Above the bridge over McNab Brook, on a farm road which runs southward from this road, a light-greenish and grey crystalline mixture of feldspar and hornblende, with little or no quartz, but a few leaves of mica, strikes N. 64° E., and incloses a blotch of white, fine-grained marble, six inches long. This is intermixed with softer, pyritous, crystalline rocks, containing much calcspar, and passes into diorite, quartz-felsite and compact felsite, which contain calcspar, chlorite, black magnesian matter and manganese oxide in the joints. Among the feldspathic rocks of Pine Brook, attention may be called to a syenite, often containing so little quartz as to become diorite, in which the hornblende

Loch Lomond road.

Calcareous rocks.

Minerals.

Pine Brook.

is arranged in long delicate needles; passing next, by the loss of hornblende, into a light-pink and green felsite; and by another transformation, into a reddish and grey compact quartz-felsite or quartzite. A greenish felsite and red, coarse syenite, with little hornblende, are associated in McCuish Brook near the road, whilst higher up, the stream falls over an escarpment of green granular felsite. Near the end of the Morrison road grey and reddish syenite underlies the millstone grit; but from this point to the Gaspereaux River road the syenite is overlain for the most part with Carboniferous conglomerate.

Mira felsites.

The Mira Hills also furnish examples of the blending together of the different constituents of the feldspathic and syenitic rocks that seem completely to demonstrate their identity. On the Salmon River road red, bluish and purple syenite, quartz-felsite and felsite are intermixed with grey porphyry. The syenite is sometimes very fine-grained, or nearly compact. In McDonald's fields, near the fork of the Salmon River and L'Ardoise roads, is a purplish-red, fine-grained, jointed and broken felsite, with specks of silvery mica; in succession to which is a red syenite, containing a little quartz and hornblende in small angular fragments, and close by, on the road, a coarse, red syenite, in which hornblende is abundant.

L'Ardoise road.

The road along Loch Lomond displays syenite and quartz-felsite in close proximity. At the foot of the lake, dark-blue, grey and red argillaceous, feldspathic and quartzose rocks, probably Lower Silurian, dip N. 74° E.

Baddeck felsites.

The felsites of the hills which rise conspicuously above the Carboniferous valley of Harris Brook, in Victoria County, have a close affinity with those of Coxheath, East Bay and Louisburg, presenting, among others, the following varieties:—

1. Greenish and pink, mottled, granitoid felsite, with garnet-red spots; weathers greenish-white.
2. Greenish and red, spotted, compact and fragmentary felsites, replacing one another in infinite variety, and sometimes resembling a greenish and red syenite, stained bright-red in the joints with hematite.
3. Greenish fragmentary felsite, with reddish spots; weathers rough, so as to resemble a conglomerate; stained with hematite. Many of the fragments measure a quarter of an inch in length, and have themselves a finer fragmentary structure, like mosaic.
4. Fine-grained and fragmentary, hematite-stained felsite, containing grains of every tint of green, from greenish-white to raven-black, only a few specks of red being present.
5. Greenish and indian-red, nearly compact, slaty felsite.

6. Blue, purple and pea-green felsite, the colours being in blotches, with white spots interspersed.
7. Large white quartz-veins or masses are also said to occur in the same hills.

From Hunter's Mountain to the bridge over Middle River, the rocks in the road are Carboniferous, but the pre-Silurian hills encroach upon them in several places. At the bridge, the road forks, a branch running up each bank. Carboniferous rocks containing gypsum are seen here, and within a few hundred yards of the gold mines on the left bank, rising on the slopes of the hills which skirt the river.

Middle River.

Carboniferous rocks.

Between Louisburg and Loran felsites prevail, similar to those described above, among which are :—

Loran.

1. Purple felsite, with green and red spots, compact and obscurely crystalline; small grains of chlorite; spots of iron pyrites.
2. Indian-red soft rock, resembling a fine-grained sandstone.
3. Grey compact felsite, with spots of different colours; obscure lines of bedding in hand specimens.
4. Light-green compact felsite, showing a fragmentary structure, the fragments being of different colours.
5. Grey felsite, weathering white and vesicular, with irregularly shaped fragments of different colours scattered over the grey ground. These fragments are all light-coloured and very coherent.
6. Compact, bluish-grey, purple and reddish felsite, with small porphyritic spots and crystalline granules.
7. Greenish rocks of looser texture, traversed in every direction by minute feldspar veins; pearly and scaly in places.
8. Bluish, fine-grained, soft, argillaceous rock, with coloured spots.
9. Purple, greenish and blue fragmentary rocks.
10. Light pea-green rock, half compact, half granular.
11. Laminated, highly crystalline felsite, not distinctly granular.
12. Indian-red and purple laminated argillite, interstratified in beds several feet thick among the harder rocks.
13. Light greenish-grey and sea-green laminated argillite, the laminæ generally papery, and the rock breaking into small pieces, but sometimes in thicker beds, and perhaps suitable for hones.

Hones.

These rocks run about N. 39° E., and generally have a south-easterly dip. They are traversed by veins and blotches of quartz and calcite, the quartz being often granular and containing small grains of feldspar; much of it also is in long delicate crystals, some of them beautifully transparent. Chlorite abounds in some of the cavities of the quartz,

Quartz, calcspar and chlorite.

2. George River Limestone.

The lithological characters of this formation have been given in sufficient detail in the Reports for 1874-76, so that the remarks which follow will relate principally to its geographical range.

Distribution.

From George River it has been traced in a narrow belt until it passes under the Carboniferous rocks of Macintosh Brook. Another band, beginning at the shore of East Bay, on the line of the Indian Reserve, runs in a north-easterly direction towards Indian Brook; but on the left bank of this brook an unbroken wall of red syenite appears on its line of strike. The finding of large blocks of this limestone in the conglomerate of Hare Brook points to a wider distribution; and evidence of this nature, taken in conjunction with the resemblance of the gneissoid rocks of Washaback to those which underlie the crystalline limestone in the Boisdale Hills, indicates a former probable extension in this direction also, which has been obscured by denudation and the overlapping of Carboniferous rocks. At the North River of St. Annes, an important exposure of crystalline limestone was discovered, but its limits were not defined.

Characters.

Where this formation crosses the French Vale and Bourinot roads, it comprises:—

1. White, grey, bluish and yellowish, granular and compact crystalline limestone, sometimes serpentinous, containing specks of silvery mica and iron pyrites, and weathering into a granular, crumbly rock. The limestone is cut by quartz veins one inch thick and downwards; some of them are tremolitic, as is well shown on weathered surfaces. (Tremolite.)
2. White and grey granite and syenite, and a mixture of feldspar in plates and quartz in erratic veins. The granite is often coarse. Quartz predominates, the mica being in dark-brown and silvery, lamellar, crystalline aggregations. In places, however, the rock is almost wholly composed of silvery mica, or of mica and quartz.
3. Variegated and ribboned, white and grey, fine-grained and broadly crystalline quartzite, with small cavities full of double prism-pyramids of quartz.
4. An almost pure felsite, which appears to pass into a fine-grained limestone, containing much golden mica. (Golden mica.)

These rocks strike N. 8° to 19° E., but are much contorted.

Iron mine.

At Lauchlin Curry's road we encounter the limestones and quartzites of the iron mine, underlain by syenite and granite, and overlain by reddish and grey, coarse Carboniferous sandstone and conglomerate. In Curry's fields there is associated with the limestones thirty feet or more of reddish-grey laminated quartzite, irregularly mixed with feldspar and mica, and often a mica-schist. The component particles of this rock are in flakes, often larger than peas.

Mica-schist.

Serpentine limestone.

Bluish, talcose, serpentine limestone, with light-grey protuberances, alternates on the Coxheath road with syenite, quartzite and granite, dipping N. 71° W. With these are associated a whitish, brown-weathering, saccharoidal limestone, ten feet of bluish and grey granitoid gneiss and compact, bluish, pyritous felsite, the whole being overlain by Carboniferous conglomerate. In the fields south of this road, laminated quatzite and syenite accompany a pyritous and micaceous serpentine limestone, a saccharoidal limestone with blotches of hornblende, and a fine-grained, pyritous mica-schist, containing chlorite, and strike N. 13° to 36° E. Near John McDonald's the Cossitt road crosses whitish-grey, coarsely crystalline limestone, with small specks of mica, and other schistose rocks; but beyond this the belt of crystalline limestone has not been seen.

Quartzite and syenite.

Crane cove.

In apparent unconformity with, and bounded on both sides by coarse syenitic and granitic rocks, the George River limestone runs in a band a quarter of a mile wide, from the eastern line of the Indian Reserve towards Indian Brook. Schistose, compact felsite and quartzite, with white and light-grey crystalline limestone, ranging in texture from compact to coarsely crystalline, and containing small vugs and veins, are again met with. A marble of considerable range of colour and texture, but generally white, with brown, blue, greenish and canary-yellow streaks, susceptible also of a fine polish, has been quarried to a very limited extent on the hill near Bown's. It seems to be interstratified with a three feet bed of red syenite.

Schists.

Marble.

North River of St. Annes.

Between St. Anne Harbour and North River, is a high syenitic mountain of remarkable grandeur and beauty, succeeded on the indented right bank of the river by red conglomerate, sandstone and marl, which may be seen in any of the brooks flowing into it. From the bridge at the head of tide-water, these Carboniferous strata extend a mile and a-half or more towards the hills on the north. A road runs four or five miles up the left bank of the river, and on the right bank there is a good road for a mile, and a track for a mile or two further, to the farm of John McDonald. Between the Carboniferous rocks and the hills in this vicinity, crystalline limestone, greenish, laminated, veined quartzite, hornblende-rock, and other strata similar in most of their characters to the George River series, include a marble, more or less white, but often greenish or cream-coloured, roughened and whitened on the surface by

Crystalline limestone.

Marble.

Serpentine. spots of serpentine. A bright emerald-green, soft, shaly variety, interbedded with a great thickness of greenish quartzite, contains a species of talc; and a soft, soapy mineral occurs in the joints of most of the rocks. Talc.

Quartz veins. To the northeast of the brook in which this limestone was found, a grey slaty rock, including small, barren, white quartz veins, is reported to occur.

3. Lower Silurian Rocks.

Extent. Among the most interesting geological results obtained last year are some additional particulars regarding the Lower Silurian fossiliferous rocks which we have already traced from Moore Point, on St. Andrew Channel, up the valley of McLeod Brook to the Bourinot road. Beyond this road they extend to the source of McLeod Brook, and into the equally deep valley of Indian Brook, which they follow nearly to the mouth, bordered on both sides by a zone of syenitic rocks, and preserving a general uniformity in character and distribution throughout their entire course.

At and for some distance east of the junction of the Boisdale and Bourinot roads is a bluish-grey and purple, fine-grained and compact, porphyritic and amygdaloidal felsite streaked with quartz and hematite in veins and vugs, and breaking into small pieces along the numerous planes of cleavage that pervade the rock. Porphyry and amygdaloid. The amygdaloid contains calcite, feldspar and quartz, of different colours, the amygdules ranging from the size of a pin's head to that of a pea. Grey, greenish and light-blue crumbling shales, generally too friable to show organic remains, Shales. but covered, on the more coherent layers, with *Obolella*, accompanied by obscure fragments of trilobites and *Dictyonema*, occur at the bridge over McLeod Brook on the Boisdale road. Fossils. These shales are greatly contorted, but strike N. 39° E. Higher in the brook they strike N. 47° E.; are accompanied by very fine sandstone, containing grains of red feldspar and quartz, and include elliptical and spherical nodules of bluish, plumbaginous, often cone-in-cone limestone, two or three feet in diameter. Cone-in-cone limestone. These shales and feldspathic sandstones often contain pebbles of feldspar, and clear red and amber-coloured quartz, and pass into conglomerates, one of which crosses the Bourinot road.

In Steele Brook, a tributary of McLeod Brook, Lower Silurian strata, dipping about S. 51° E. $<$ 45°, exhibit the following descending section :—

SECTION OF LOWER SILURIAN ROCKS IN STEELE BROOK.

Dip, S. 51° *E.* < 45°.

	FEET.	IN.	
1. Greenish, grey and white, feldspathic and quartzose sandstone, micaceous and contorted, like those of Young Point; associated with a few thin argillaceous layers, in which doubtful brachiopods occur, and with compact felsite. Nearly horizontal in places. Fucoidal marks on some surfaces, and knotty concretions, somewhat resembling *Arthraria antiquata**....................................	60	0	Fossils.
2. Bluish and purplish limestone and compact felsite.........	39	0	
3. Coherent, comparatively soft feldspathic rock, with bright spots. Not well seen. The soft black and grey slates seen in the main brook should be on the strike of this rock; but as they are not seen in the tributary, and are often found in immediate contact with the syenitic rocks, they are, perhaps, faulted............................	50	0	
4. Cliffs of greenish feldspathic sandstone, crowded with *Obolella*, and associated with compact, splintery felsite..........	27	0	Fossils.
5. Red, green and blue mottled, crystalline and sub-crystalline limestone; streaked with hematite; veined with calcspar and quartz, and spotted with black hornblende. Interstratified with felsite..............................	35	0	
6. Measures concealed..	106	0	
7. Conglomerate with large pebbles of prussian-green felsite or diorite, often indistinguishable from the matrix, which seems to consist of the same material. Hematite in streaks and drusy crystals. The pebbles are distinctly seen on weathering; but the rock has often the appearance of a finely granular felsite or diorite. Thickness unknown..	..	..	
Total thickness...........................	317	0	

McLeod Brook.

Another branch of McLeod Brook, on which, just below the road, is a wild and beautiful gorge, cuts through and exposes greenish-grey and bluish, coherent and porphyritic, flaggy, micaceous sandstone and argillite, cleaving into irregular pieces, with an inclination, varying from nearly horizontal to vertical. These rocks are fossiliferous and contain concretions of radiated pyrites, sometimes an inch in diameter. At the source of this brook, brown, grey and red, porphyritic felsite dips N. 26° W. < 39°. On the French Vale road, the strike is N. 58° E, the rocks consisting of bluish fine argillites, jointed and cleft, with

French Vale road.

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* "Palæozoic Fossils," Vol. III., Part I., p. 66.

iridescent tarnish in the joints, interstratified with grey sandstone. Another fruitless search for coal was instituted among these rocks.

Search for coal.

Beaver Cove road.

Following them thence down Indian Brook to the Beaver Cove road, we find an altered conglomerate occurring with finely-crystalline quartzite and felsite. Near the crossing of Indian Brook, laminated argillites, and fine micaceous feldspathic sandstone are met with, and further down is a hill of red altered conglomerate, containing pebbles of syenite, black slate, quartz and other rocks, which dips N: 76° E., nearly vertically. Associated with these is a bluish amygdaloid, with almonds of white feldspar, weathering vesicular; also, a compact, striped felsite, closely resembling syenite. The felsite becomes granular in places; it contains quartz veins holding spots of hematite, and passes into quartzite.

Amygdaloid.

Indian Brook.

Iron pyrites.

Limestone.

In Indian Brook, above Hugh McPhee's, is a slate containing nodules of iron pyrites several inches in diameter; and in Dugald Brook, in the immediate vicinity, a pyritous crystalline limestone, like that of Long Island. Between the bridge over Indian Brook, at McPhee's, and the road, a light-grey nut-conglomerate, composed of pebbles of syenite, felsite and porphyry, sometimes of very close texture, runs nearly vertically with bluish-grey and reddish fine sandstone and grit, which pass in turn into compact quartzite and felsite, or into an amygdaloid, with amygdules of calcite and feldspar. These rocks, seamed with minute quartz veins, and full of *Obolella* impressions, strike N. 19° E., and are continuous to the Beaver Cove road. At McPhee's bridge an exposure of light-green soft-weathering feldspathic sandstone, fine in texture, cleft, and containing minute grains of mica, dips N. 35° W. < 42°. Quartz veins, running in every direction, give a reticulated appearance to the rocks. Higher in the brook, micaceous, shaly argillites and slates, coloured red in places with hematite, are accompanied by arenaceous and argillaceous, soapy shales, striking N. 30° E. In the arenaceous strata, *Lingulæ* were found in great abundance, but none in the soapy shales.

Fossils.

Gregwa Brook.

In Gregwa Brook the following section is exposed at the junction of the Silurian and pre-Silurian rocks:—

Fossils.

	FEET.	IN.
1. Dark-purple fine-grained sandstone, containing *Obolella;* also bluish and reddish sandstone........................	..	..
2. Indian-red argillite, with white streaks and bands, easily cut by the nail, and marking like chalk................	3	6
3. Red fine conglomerate or breccia	5	0
4. Sandstone, containing *Obolella*...........................	10	0

	FEET.	IN.
5. Quartzose and feldspathic grit, of whitish, lavender and other colours; nearly compact, but often containing minute spots of decomposed feldspar; a few small pebbles, chiefly quartz	15	0
Total thickness	33	6

These are associated with contorted, plumbaginous rocks, and rest unconformably upon a white friable granite and other feldspathic rocks. Similar strata continue nearly to the mouth of Indian Brook, where the syenite hills, closing in from both sides, cut them out.

Bras d'Or Lake.

A broken, parallel belt of similar rocks, running from McLean Beach, on Little Bras d'Or Lake, to the vicinity of Murdoch McNeils, exhibits, at the former locality, the following section:—

SECTION OF LOWER SILURIAN ROCKS IN MCLEAN BROOK.

Dip N. 35° *W.* < 70°.

Search for gold.

	FEET.	IN.
1. *Carboniferous conglomerate* and related rocks	..	..
2. Feldspathic sandstone and impure limestone, of white, green, amber, red, and other colours, mixed, and in distinct beds of different thickness; sometimes associated with greenish, soft, soapy rocks, probably decomposed felsites; films of hematite in the joints	254	0
3. Blackish and grey slate, fine sandstone and argillaceous limestone; also, compact feldspathic rock, mixed with limestone of different colours. Not well seen	84	0
4. Dark and pale-grey slates, with thin layers of quartz; spotted with iron pyrites and mined for gold	66	0
5. Greenish-grey, fine-grained, pyritous rock, resembling sandstone, and yielding easily to the knife	19	0
6. Black and grey argillite, full of small twisted layers of quartz, which are sometimes so numerous as to constitute an impure quartzite, spotted with pyrites. Associated with and overlie dark-blue plumbaginous argillite, also full of pyritous quartz layers	65	0
7. Bluish-grey, pearly, papery slates, cleft in every direction, and traversed in the bedding and across it by streaks of calcspar and quartz	30	0
8. Bluish felsite, crystalline limestone and quartz, confusedly mixed in contorted beds	37	0
9. Bluish-grey coherent argillite	60	0
10. Greenish, decomposed, feldspathic rock, of uncertain thickness	110	0
11. *Red syenite* in steeply rising hills	..	..
Total thickness	725	0

In the hills to the westward, beautifully striped, compact, pyritous felsite and quartzite, of various colours, underlie the Carboniferous conglomerate, and in McNeil Brook are associated with greenish-grey nacreous slates, passing into felsites, with seams and blotches of quartz and calcspar. No fossils were found in these rocks, but their general similarity to those of Long Island and St. Andrew Channel leaves little doubt as to their true position. Near the northern brook of Shenacadie, feldspathic shales with quartz veins lie unconformably on the syenite. To the westward of this large brook they are overlapped by Carboniferous strata, but again appear in the southern brook. The banded quartzites and felsites at Murdoch McNeil's, and some of the rocks in Benacadie Brook, perhaps also belong to this series.

McNeil Brook.

Shenacadie.

Fossiliferous Lower Silurian strata are again exposed on the East Bay slope of the Boisdale anticline, where, in Bown Brook, felsite, limestone and red, green and white conglomerate, intersected by veins of calcspar, afford many fossils. Dipping under the Carboniferous conglomerate, which is formed from their *debris* in Macintosh Brook, Escasonie, is a series of brown-weathering, compact and highly crystalline, jointed quartzite and felsite, including a bluish diorite and quartz-felsite, with blotches of red hematite, calcspar and serpentine, and scales of hornblende and mica. The serpentinous matter is unctuous, copper-green and indian-red; sometimes in radiating, star-like forms. These rocks are grey, mottled red and green, violet and bright blue; extremely hard and coherent; contain grains of feldspar as large as beans, and present an amygdaloidal appearance. Within a short distance they form eleven cascades, ranging in height from two to twenty feet, down which the water rushes tumultuously, white with foam, into deep black pools. Above the falls, light and dark-blue fossiliferous argillites underlie these rocks, dipping S. 30° E., < 75° ; and higher still, light-grey and brown quartzite, in beds, varying from mere lines to a foot and a-half in thickness, occur with soft argillites.

Bown Brook.

Macintosh Brook.

Minerals.

Cascades.

Fossils.

Considered in regard to the occurence of animal life, the contorted, feldspathic shale, sandstone and limestone which underlie the Carboniferous limestone in isolated knolls at the mouth of Macintosh Brook, on the shore below Allan and Donald McAdam's, are of the highest interest. Many of the shales are blackened with impressions of brachiopod shells, while some of the limestone is almost wholly made up of them. Among the shells, phosphatic nodules were recognised by Mr. T. C. Weston, of the Geological Survey, whose description will serve to indicate their nature :—

Fossils of Macintosh Brook.

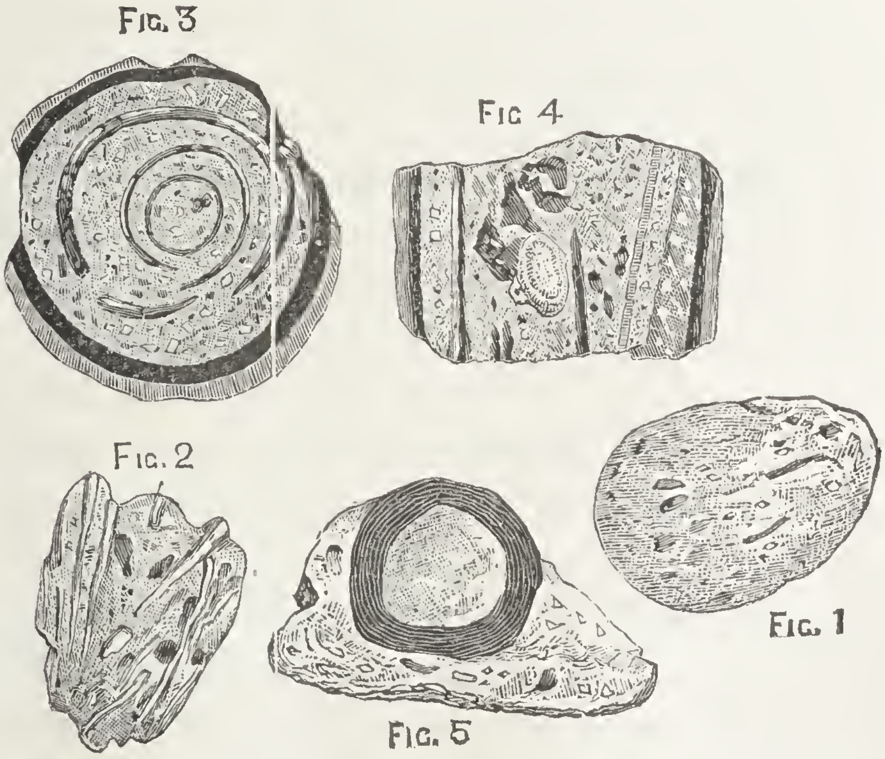
Phosphatic nodules.

Description by Mr. Weston.

"I have made and examined under the microscope several thin sections of phosphatic nodules from Macintosh Brook, East Bay, Cape Breton, where they are found in a limestone, which, according to Mr. Fletcher, occurs in layers of from half-an-inch to two feet in thickness, interstratified with shaly, micaceo-arenaceous limestone, sandstone and marl. This rock is, for the most part, composed of fragments of *Lingula*, and a few well preserved specimens of this genus, with numerous phosphatic nodules.

" These nodules vary in size and shape, and many of them seem to have been flattened by the pressure of the overlying beds. Two of the specimens examined, cylindrical in form, with rounded ends, were three-eights of an inch long, and less than an eighth of an inch in diameter. By transmitted light most of the thin slices have the appearance of a fine bituminous paste, inclosing numerous minute angular grains of silicious matter, and in some pieces, of iron pyrites, together with fragments of the *Lingula*, which is supposed to have formed the food of the animals which produced the coprolites, and which, as has been suggested, may have been some of the larger species of trilobites.

Origin.



"Fig. 1 represents one of these nodules cut through the centre and enlarged about seven diameters. Sections of others, as in Fig. 2, show portions of the *Lingulæ*, which appear to have undergone little or no digestion.

"Although a sufficient number of fossils have not yet been collected at this locality to determine the geological horizon, it is supposed, from the stratigraphical position of the rocks, that they belong to the Potsdam formation. Such coprolites, however, are not characteristic of any formation, but have been obtained, amongst others, in Lower, Middle and Upper Silurian rocks. At River Ouelle, on the Lower St. Lawrence, they occur chiefly in round grains, varying from the size of a large pea to that of a small shot, in a brecciated limestone, associated with green and red shales; which, according to Mr. Billings—owing to the discovery of zoophyte forms which resemble *Archeocyathus*—belong to the Lower Potsdam formation. One of the phosphatic nodules from River Ouelle, with a specific gravity of 3·15, yielded to Dr. Hunt:—*

Lower Potsdam coprolites.

Analysis.

Phosphate of lime	40·34
Carbonate of lime, with some fluoride	5·14
Carbonate of magnesia	9·70
Peroxide of iron, with traces of manganese and a little alumina	12·62
Insoluble silicious residue	25·44
Volatile matter	2·13
	95·37

"'The microscope shows, besides grains of quartz, small cylindrical bodies, resembling the spicula of sponges.'

Worm-tubes.

"With the coprolites of River Ouelle are found phosphatic tubes, with thick walls; the largest of which is about two inches long, and half-an-inch in diameter. These have been compared to the supposed worm tubes of the genus *Serpulites*, which has also been obtained with similar nodules from the lower part of the Chazy formation.

"Figs. 3 and 4 show a transverse and part of the longitudinal sections (magnified seven diameters) of these forms, collected by me at the mouth of River Ouelle. Fig. 5 is a transverse section of a larger specimen, evidently of another species.

Straparollus from Arisaig, N. S.

"While collecting fossils on the coast of Arisaig, N. S., I observed a number of black nodules in argillaceous limestone, belonging to the Upper Silurian formation; and in one of them which had been broken I found a convoluted shell, not unlike small species of *Straparollus*.

Menevian rocks of St. John, N. B.

"The calcareous sandstones of the Acadian or Menevian group at St. John, New Brunswick, are blackened with phosphatic matter, which consists of 'shells of *Lingulæ*, often entire, and lying close together in the planes of the deposit, of which, in some thin layers, they appear to

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* Geology of Canada, page 462.

constitute the principal part.'* In the limestones of St. Simon, Bic, and other places on the Lower St. Lawrence, the fossils *Hyolithes* and *Obolella* occur in great numbers, and these, with *Lingula*, are supposed to have formed the chief food of the animals from which the coprolites were derived. Bic shales.

"The phosphatic nodules from Macintosh Brook are about the hardness of apatite, while those from River Ouelle, Grenville, and other places, are much harder.

"As stated above, phosphatic nodules are obtained from several geological formations; they have not yet, however, been found in sufficient abundance to be of commercial value.

Spruce Brook.

The Lower Silurian rocks of the Coxheath anticline, are seen overlying the red syenite and other obscurely crystalline felsites in Spruce Brook, as brownish, fine-grained micaceous sandstone and compact layered felsite, like those of McLeod Brook, accompanied by blackish-red, micaceous sandstone, and greenish-grey argillite, more or less jointed and fissile, which dip N. 12° W. < 52°, and contain obscure impressions of small shells. Between this outcrop and Gillis Brook, grey argillite is displayed at several places on the East Bay road, and comes to the shore about a mile south of the crossing of the Bourinot road, associated with reddish arenaceous shale and limestone, veined with calcspar, and dipping N. 39° E. < 35°. From this point they stretch towards the Bourinot road, cover the Coxheath road between the Bourinot road and the head of East Bay, and extend as far as Gillis Lake. Plumbaginous slates, passing in places into impure plumbago, are characteristic of the formation in this district, and may, perhaps, be found to possess an economic value.

East Bay road.

Plumbago.

Fossils.

In the brooks which cross the East Bay road to the westward of the Bourinot road, Lower Silurian argillite and sandstone, holding shells and trilobites, are well exposed in conjunction with whitish limestone, which contains dark-coloured, thread-like and broad markings, and black, cylindrical concretions or fossils. Crystalline nodules of limestone also abound in the argillite.

McAdam Brook.

Carboniferous conglomerate unconformably caps the Lower Silurian strata, which dip steeply northward, near the crossing of the Coxheath and Bourinot roads. In a small tributary of McAdam Brook, which crosses both these roads, they consist of light and dark-green and yellowish, fine-grained, micaceous feldspathic and calcareous rocks, often

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* Dr. Dawson. Phosphates of Canada, "Canadian Naturalist," Vol, VIII., page 163.

in thin beds, so contorted, cleft and jointed as to break by a blow of the hammer into small pieces, covered with light-grey serpentinous matter. Veins of feldspar, quartz and calcspar penetrate these rocks, which are also spotted with hematite and epidote.

Fossils.

Ascending the rocky bed of McAdam Brook, above its confluence with Gillis Brook, we meet with grey and bluish, micaceous, fine-grained, feldspathic and calcareous *Obolella* sandstone, in flaggy layers, sometimes a foot in thickness, interstratified with argillaceous shale. The dip is variable, both in amount and direction, the rocks being greatly contorted. Up stream they become very compact, and are veined with threads of quartz and feldspar.

Gillis Brook.

Fossils.

On the Coxheath road, at the crossing of Gillis Brook, grey, white and reddish, micaceous, feldspathic, shaly sandstone, containing *Obolella*, dips N. 64° E., at a high angle. In the brook, at the bridge, the dip seems to be N. 13° W. < 26°, but higher up, bluish-grey micaceous argillite and feldspathic sandstone, with obscure marks of *Obolella*, and stems of sea weeds, again dip N. 64° E. < 32°, and extend as far as Gillis Lake, where they were observed in 1875. Below the Coxheath road, bluish and grey, soft, laminated argillite, and fine-grained, micaceous, contorted sandstone, strike approximately N. 54° E. They are associated with greenish and yellowish, compact, quartzose felsite, in which the laminæ of deposition are indistinct, and with greenish, flaggy, thick-bedded sandstone, running N. 15° W. vertically. In a tributary which enters Gillis Brook, about a mile below the road, soft, bluish-black and grey argillites dip N. 75° W. at a high variable angle, interbedded with bluish, almost compact, cleavable, laminated, micaceous sandstone, traversed by reticulations of quartz, feldspar and calcspar, and with impure, pyritous, blackish, plumbaginous limestone-breccia. In the main brook below the tributary these rocks are contorted in a most remarkable manner. With them are found the following strata :—

1. A highly crystalline limestone, in thick beds or without apparent bedding ; jointed and streaked with white or pink calcspar, as well as much soft, soapy matter. In places, a mixture of limestone, hematite and chlorite. Like the Long Island and Boisdale limestones, it is of every colour, but chiefly dark-red.
2. A seeming conglomerate or breccia, made up of pebbles of No. 1, of every size, without apparent stratification ; probably a concretionary limestone.
3. Greenish and brown, purple and red, mottled, compact felsite, mixed with limestone and a little fine breccia. Full of irregular white quartz veins, sometimes six inches thick, which occasionally contain films of purple copper pyrites.

Quartz veins with copper pyrites.

4. Grey, laminated, micaceous, feldspathic sandstone, with dark and light-grey limestone; arched, and dipping in thin laminæ N. 68° E. and S. 68° W. In one place a grey, granitoid mixture of quartz and feldspar, probably an altered grit.

On the left bank of Mira River the Lower Silurian rocks, of which mention has already been made, are seen to overlie the Laurentian felsites at the junction of the Morley and Mira roads, and to dip S. 58° E. Among them a series of grey, sandy, jointed, pyritons and micaceous, feldspathic shales, and a fine conglomerate, composed of pebbles of quartz in a quartzose matrix, with minute specks of silvery mica and small cavities filled with crystals of quartz, are well worthy of notice. Gold has been sought for in the shales. They extend across the Caribou Marsh road and Mira River, but have not yet been followed. In the brook at the Mira end of the Morley road the following is the section of these rocks:— Mira River.

LOWER SILURIAN ROCKS IN M'CODRUM BROOK.

	FEET.	IN.
1. Greenish, nearly compact, micaceous sandstone, slaty, or in even, flaggy beds. Forms curious gorges and falls, being cut on the strike for a great distance so that the angle of dip is the slope of the right bank of the brook. Dip, N. 50° E. < 33°	540	0
2. Greenish-grey, soft, somewhat soapy, shaly and flaggy argillite. Dip, N. 53° E. < 29°	59	0
3. Purple, pebbly, close-grained, quartzose grit; passing lower down the brook into reddish conglomerate, with pebbles as large as hazel nuts. Dip, N. 76° E. < 30°	1	0
4. White quartzite or grit, in which the grains are scarcely distinguishable. Becomes white quartzose conglomerate.	10	0
5. Reddish, fine, coherent, micaceous sandstone	16	0
Total thickness	626	0

These rocks occur repeatedly as far as the bridge on the Mira road, where they dip S. 29° E. Some distance above the bridge the dip is S. 64° E. < 35°.

4. CARBONIFEROUS CONGLOMERATE.

A portion at least of this division is probably contemporaneous with strata, which must be referred to the Carboniferous Limestone formation; but as the grouping is a convenient one for practical purposes, marking the absence of the great bands of limestone and gypsum, which are characteristic of the latter, it will be retained when possible.

Distribution.

The conglomerate and related rocks occur in largest volume in the southward extension of the Sydney Harbour basin and on the Boisdale and Washaback Hills. In other parts of the area surveyed they are found, chiefly, as a thin mantle on the pre-Carboniferous rocks. In addition to the red conglomerate, from which the formation takes its name, finer beds also occur, consisting of sandstone, marl, feldspathic shale, one or two unimportant layers of limestone, bituminous shales, and, occasionally, thin seams of impure coal.

Mackay Point.

At Mackay Point this formation is overlain by gypsum and sandy limestone. It consists of conglomerate, sandstone and marl, traversed by seams of white calcite, and dipping S. 65° E. < 51°. In Mackay Brook similar rocks are associated with thirty feet or more of light-grey, calcareo-micaceous, coarse and fine sandstone and arenaceous shale; stained with hematite, and containing many specks of silvery mica and hornblende, as well as thin nodular layers of a soft, argillaceous substance of waxy aspect. The dip is variable, but averages N. 10° E. < 33°. The calcareous bands are thick and close-grained, the argillaceous shales thin and friable, often exhibiting conical prominences on the surface. Bituminous shale and sandstone form cliffs twenty feet high, blackened with impressions, as of stems of plants, sometimes three inches in length, bearing opposite pinnules, and in places pass into a black coaly substance. Some of these black shales, associated with bluish-grey sandstone, have given rise to the belief that deposits of workable coal are to be found in the neighbourhood. A stream which empties into the main brook near a pit sunk through these shales in search of coal displays only conglomerate and red marl as far as its source, no syenitic rocks appearing on this side of the hills.

Plants.

Black shales mined for coal.

Upper limit of the formation.

A band of limestone, of variable thickness, which runs south-westerly from the neighbourhord of Mackay Point, may be taken as the upper limit of this formation on St. Patrick Channel. On the coast between Crow Point and Red Brook, in this brook, and on the adjacent hills, bluish-white, arenaceous, micaceous limestone, red and grey fine sandstone and marl dip under a conglomerate, which is in turn overlain by limestone. Both conglomerate and limestone are cupriferous near the junction. The former contains, in addition to pebbles of the schists, porphyries and granites of the hills, others of crystalline limestone; in places it is grey or light green, passing into purple sandstone with green blotches.

Cupriferous conglomerate and limestone.

Cam Brook.

The rocks of this division are again represented on Boulaceet road, near Cam Brook, by micaceous, clayey shales, covered with small marks, like shells of entomostracans, of an elongated, elliptical form, and by indian-red marls. Near the lake on Maccrutchie road, they again cross, and conglomerate is seen in various places. Following the line of contact above Washaback bridge, fine conglomerate, red and white sandtone, or compact felsite and bluish, slaty, feldspathic sandstone are found occuring; and on Duncan McKenzie's farm is a small exposure of limestone.

Shells.

Dog Brook.

The high, crumbling banks of red and green spotted conglomerate, and pebbly grit in Dog Brook are cut into grotesque shapes by the running water, and its picturesque waterfalls and deep pot-holes and pools owe their origin to the same agency. Half-a-mile above the road a reddish-grey sandstone displays beautiful markings of seaweeds, stems and leaves being imprinted on the stone. One of these, an inch and a-half in width, forks into two smaller ones. Similar rocks, including bluish calcareo-micaceous sandstone, mottled red and green, nearly compact, in beds of no great thickness—some of which might serve for whetstones—prevail to the top of the hill.

Seaweeds.

Lieutenant Pond.

From Boulaceet Harbour, conglomerate, marls and shales occupy most of the shore to Lieutenant Pond, red marl and sandstone generally forming the matrix of the conglomerate as well as separate beds. On the hills near this pond the sandstone and conglomerate which overlie the syenite contain holes, as if worn by stones rolled on an ancient sea beach. The dip of the coast rocks is inland, indicating a shallow fold between the shore and the hills.

Conglomerate of the French Vale.

To this division belong also most of the rocks exposed on the western and eastern slopes of the Boisdale anticline, between Boisdale and Benacadie Pond, and in less volume, from the French Vale to the mouth of Bown Brook. The colour, matrix, and pebbles of the conglomerate differ widely at different localities, and coarse sediments do not always preponderate; but all the rocks fall under one or other of the varieties already described. This formation is well exposed in overhanging cliffs on the shore and in many of the brooks.

Fox Brook.

Some of the finer deposits of Fox and McNeil Brooks and the neighbouring shore are full of nodules of impure limestone, and covered between the layers with greenish-white, generally circular spots, one of which, half-an-inch in diameter, exhibits a dark-grey zone, occupying one-sixth of the whole area, with a grey raised spot in the centre. The dip at the mouth of McNeil Brook is N. 62° W. < 26°, but changes higher up to S. 81° W., and further south on the shore to S. 70° W. The sandstone is often false-bedded, obscurely rippled, and marked with

McNeil Brook.

Fossils.

impressions of fucoids. Thin lenticular layers of red and green concretionary limestone are found both in the fine beds and in the conglomerate. Some of these near Kelly Point are four or five feet thick, and contain broken gasteropod shells and crinoid stems. Vertical sections of the rocks might easily be measured in the cliffs, but as they present no distinctive characters and contain few fossils it would scarcely be useful to examine them in any detail.

Benacadie Glen.

Near the mill in Benacadie Glen, on the Christmas road, the conglomerate dips S. 26° E. at a low angle. The isolated patches, shown on the map as resting on the older rocks in Benacadie and Hare Brooks, are intersected by joints covered with hematite—a circumstance which both here and elsewhere has induced a belief in its existence in workable quantity, and led to a search for it.

Hematite.

Benacadie Pond.

The precipitous cliffs of Benacadie Pond and Piper Cove, in which sea-pigeons build their nests, are composed of conglomerate with large pebbles of a crystalline limestone, which is not seen among the older rocks of the neighbourhood. Red, pink and green limestone, green and black hornblende-rock, grey and red syenite, red and blue mica-schist and shaly mica-felsite are held in a strongly calcareous paste, penetrated in all directions by veins of calcspar and hematite. One of these veins, about six inches thick, consists of a beautiful aggregation of Iceland- and dogtooth-spar. One or more bands of bluish-grey, columnar and nodular, contorted, bituminous, pebbly limestone, ranging from eight feet downwards, are interbedded with the conglomerate and associated marl; and a one-foot bed of nodular limestone adapts itself to the jagged edges of the syenitic outlier in this vicinity, accompanied by red and green mottled sandstone and a fine syenitic breccia.

The coarse conglomerate of the left bank of Benacadie Pond contains, in addition to limestone, epidotic diorite, quartzite and granitoid rocks, fragments of sandstone, conglomerate, and slate, covered with hematite, and holding indistinct Lower Silurian brachiopods, and of a talcose rock, like that found near the Christmas road. It contains much light-green, garnet-red or colourless, transparent calcspar, which often separates into beautiful crystalline aggregations, sometimes several inches in diameter. Although generally in rhombohedrons and scalenohedrons, hexagonal and other combinations are not uncommon, and long, tabular crystals of heavy spar also occur.

Hematite.

Calcspar and heavy spar.

Gillis Lake.

In the vicinity of Gillis Lake, and of the valley between this lake, McAdam Lake and Lauchlin Curry's, are grey and bluish conglomerate, pebbly sandstone and shale, which might easily be mistaken for millstone

Coal at McAdam Lake.

grit. The pebbles seldom exceed two inches in length, and consist chiefly of quartz and feldspathic sandstone, probably derived from the underlying Lower Silurian strata. On the Bourinot road, near Curry's, grey fine conglomerate, almost vertical, and striking N. 64° E., is associated with and passes into greenish-grey micaceous sandstone and arenaceous and argillaceous shales. These shales, in a small brook on the farm of Donald Gillis, McAdam Lake, are black and shining, from the presence of a considerable quantity of coaly matter and rootlets of trees.

Spruce Brook.

Gillis Brook.

The line of contact of the Carboniferous and pre-Carboniferous rocks follows the East Bay road for a great distance. Spruce Brook displays, below this road, a greenish-grey and reddish rusty conglomerate, and at its mouth, a limestone, superimposed upon a similar rock, stained in places with green carbonate of copper, derived from the decomposition of copper glance, which is found cementing together the pebbles. This conglomerate extends in high cliffs along the coast until the Lower Silurian rocks come from beneath it. The dip of this formation in Gillis Brook is S. 71° E. < 55°. It rests immediately against Lower Silurian feldspathic sandstone, limestone and argillite, yet none of its pebbles belong to this series, but consist of felsite, porphyry, syenite and other rocks of the Coxheath Hills, a fact which seems to indicate the proximity of the Sydney River fault.

L'Ardoise road.

Hematite.

At McNeil's mill.

At McDougall Point

On the East Bay anticline the two spurs of millstone grit crossed on the L'Ardoise road are separated by conglomerate, which also mantles over the felsite and syenite of the shore. Here at its contact with the older rocks, this formation is characterized by the frequent occurrence of hematite, in radiated, botryoidal masses, a foot or more in thickness, but very irregular; and it is not improbable that other deposits of iron ore, to which attention has been directed, are of the same nature. Hematite is found at McNeil's mill, a mile south of the crossing of Breac Brook, on the Glengarry road; but whether as the matrix or pebbles of the conglomerate, it is difficult to determine. Unless, however, the ore at the Gillis and Matheson location was deposited subsequently to this conglomerate the fragments are probably pebbles. Where seen on the shore, near McDougall Point, it does not appear to penetrate the syenite, but filling hollows in it, ramifies through the overlying conglomerate, constituting a cement for the lowest beds; although in one place it adheres to a large piece of grey syenite, as if both had been formed before the conglomerate, and subsequently torn off to form part of it.

5. Carboniferous Limestone.

Character.

This formation, which is characterized by the occurrence of important beds of limestone and gypsum, associated with marl, sandstone, conglomerate and, less frequently, heavy spar, celestite and spathic iron ore, occupies but a small part of the region to which this report relates. It attains its greatest development on the Washaback Peninsula, where part of it seems to be contemporaneous with the conglomerate. Limestone and gypsum are seen on the shore at many points between Mackay Point and Maccrutchie Cove—the former being somewhat largely quarried for the manufacture of lime in the vicinity and in the town of Baddeck. A remarkably persistent band of grey columnar and vesicular, shelly limestone, in thick and thin beds, runs up the right bank of Washaback River from Crow Point, near which it is ten or fifteen feet thick, and overlies the cupriferous conglomerate—giving rise in its course to several cold, clear streams of water. From tidewater, a high, broken ridge of gypsum keeps close to the left bank, rendering the country through which it passes unfit for cultivation by the sink-holes, marshes and abrupt cliffs which it forms, and giving to the water of the river a brackish taste, which is relished by cattle.

Mackay Point.

Limestone.

Gypsum.

Murphy Point.

The gypsum associated with the limestone of Murphy Point is pure white, or light grey with dark streaks; and from a similar rock, near Deadman Point, issues a cold, chalybeate spring, smelling strongly of sulphuretted hydrogen. Bluish-grey limestone and marl are here also in place; but this part of the coast is seldom rocky, being covered with long reaches of salt-marsh, full of green and bright-pink slime and seaweed.

Spring.

McKinnon Harbour gypsum.

Cliffs of gypsum or plaster whiten the coast between Lieutenant Pond and McKinnon Harbour. Essentially white, but tinted and spotted with many colours, it is broken, cleft and jointed in every direction, and occurs in waving, thick or shaly beds, alternating with limestone, arenaceous shale and sandstone. In structure it is minutely crystalline, or compact; but also fibrous, radiating and scaly. Little spots of sand and clay, and dark streaks and blotches, give it a mottled appearance. After long exposure to the air, a hard, white efflorescence covers the surface, or the rock crumbles into sandy or acicular fragments. Crystals of selenite, mostly tabular, arranged in all directions, give many of the beds a porphyritic appearance. At Plaster Cove gypsum is interbedded with twenty feet of limestone, of the usual character, as well as with marl, sandstone and conglomerate; and near McKinnon Harbour, is sub-

Gypsum-porphyry.

jacent to six feet of limestone and a marl containing nodules of rosy gypsum.

Between Uniacke Point and McKinnon Harbour a great part of the coast is occupied with gypsum similar to that just described. Scattered in great numbers through this rock are grey, circular aggregations of crystals, an inch in length, arranged in star-like groups. The gypseous marl intermixed with the plaster contains strings, crystals and veins of grey and rosy gypsum. The veins are composed of two sets of one-inch fibres, meeting in the middle, or separated only by a thin layer of compact, green clay. Minute encrinite stems and broken shells are said to have been found in these beds. Their contact with the limestones and accompanying rocks is observable in many places, as in the following descending section:—

Uniacke Point.

Star-like group of crystals.

Fossils.

	FEET.	IN.
1. Light-grey soft gypsum, with thin beds of green clay full of nodules of brownish gypsum	8	0
2. Nodular and compact, bituminous limestone, in thin and thick contorted beds, traversed by seams of crystalline gypsum, one inch thick. Sometimes arenaceous, and separated from the following bed by a layer of green clay. Thickness, five to fifteen feet	10	0
3. Grey coarse sandstone, sometimes absent	3	0
4. Gypsum	8	0
Total thickness	29	0

A red fine sandstone, with a north-westerly strike, is developed on the shore road between Uniacke Point and McKinnon intervale, and in a large brook on this road, grey, slaty limestone is underlaid by eighteen feet of purple conglomerate, with pebbles of limestone, quartzite and felsite, as large as hazel nuts. Higher in the brook is a coarse conglomerate, with layers of red and green spotted sandstone and indian-red pebbly marl. The distribution of these rocks in this and other localities on the peninsula is exceptional, the usual parallelism of the two series being wanting. They probably belong to the lower division, for although the gypsum of the higher formation runs far up some of the brooks, it does not seem to be continuous, but rather to occupy unconformable basins in the conglomerate, the only alternative that suggests itself being that the gypsum may be associated with it in lenticular masses.

Conglomerate.

Distribution of the gypsum.

At the south end of the backlands road, the shore exhibits the following section:—

Cupriferous conglomerate.

	FEET.	IN.
1. Grey shaly limestone	10	0
2. Brownish sandy limestone	3	0
3. Bluish nodular limestone	1	0
4. Red, grey and greenish coarse conglomerate, the larger pebbles a foot and a-half in diameter, composed of crystalline limestone, of bluish and other colours. Sometimes richly cupriferous, the green colour resulting from the weathering of a grey copper ore. Blotches of hematite, and veins and films of calcspar. Dip, S. 34° W. ∠ 42°, but somewhat variable. Of great thickness	..	..
	14	0

Further north on the backlands, red, flaggy, calcareous sandstone, greenish and bluish feldspathic flags and shales, red and purple crumbling grit, with green blotches, and greenish-grey and red, fine, micaceous, rippled sandstone, evenly bedded in layers one foot thick, and in rolls one foot in diameter dip S. 12° W. These beds should belong to the lower formation, but still further north is a bed of gypsum, continuous to Plaster Cove, the relation of which to the other strata has not yet been determined. On the Intervale road, purple, red, green, and grey, shaly, micaceous sandstone, nodular marl, with wedges and layers of coarse, pebbly grit, containing a few limestone nodules and streaks of calcspar, with grey and greenish blotches and layers, are frequently met with.

Intervale road.

Boulardrie Island.

On Boulardrie Island this formation occurs chiefly on the low headlands which project beyond the line of coast. It derives its principal interest from the gypsum which constitutes the greater part of the long promontory of Island Point, and standing between Big Harbour and the lake in beautiful white cliffs, adds a striking feature to the scenery.

Big Harbour gypsum.

On the north side of Big Harbour, grey sandstone prevails, underlaid here and there by red marl and limestone, so that the line of junction of the millstone grit and Carboniferous limestone evidently skirts its shore. At the head of the bay, on the south side, plaster cliffs begin. The gypsum is compact or finely granular, white, or striped and speckled white and grey, the grey being arranged in darker and lighter bands, with interspersed white spots of every size, which give the rock the aspect of a conglomerate with white pebbles dotted with crystals of selenite. The layers are thin and wavy, dip towards the mainland, and have a slaty structure at right angles to the bedding. A rusty streak pervades certain beds in the neighbourhood of the joints which divide the gypsum every fifteen feet or thereabout; and layers and wedges of brown sand- and mud-rock are also seen, full of large cavities inclosing ragments of gypsum. Some of these may be of recent origin and have found their way into the rock through openings from above, as landslides frequently take place through the funnel-shaped holes in the cliffs; but in some instances they follow the lamination, and are, therefore, contemporaneous with the deposition of the beds. This gypsum has been quarried to some extent by Mr. John McLeod, of Island Point. Plaster-quarry.

At the entrance of the harbour limestone blocks and reefs occur, as well as a mixture of red marl and gypsum. The limestone is reddish, grey and blue, compact, nodular and columnar, beautifully marked with white calcspar. It is contorted, and dips S. 71° E. < 20°. A greyish, rusty-weathering, heavy spathic iron ore is found near McLeod's house on the outer shore. Iron ore. The exposure was not sufficient to show the thickness, but it is probably two feet or more. On the same side beetling cliffs of laminated plaster dip inland in wavy, nearly horizontal layers, overlaid by largely botryoidal, bluish limestone. A shelly conglomerate or concretionary limestone, with a pisolitic limestone paste, also occurs on the point, whilst above the harbour, red and green marl, limestone and gypsum are seen at intervals. Concretionary limestone.

Between Point Clear and Kemp Head several isolated patches of contorted limestone of different kinds, red and green marl and gypsum have escaped denudation. Kemp Head. From Coffin Point, where coarse, rusty-grey, thick-bedded sandstone, covered with carbonized plants, dips S. 47° E. < 16°, northwards along the shore, millstone grit occupies most of the coast, as well as the interior; the limestone appearing only at distant intervals on low promontories.

The Amaguadees, and other large ponds, inlets and bays in their vicinity, on the Bras d'Or Lake, occasionally exhibit exposures of the soft strata of this formation, from which they have been excavated, although the shore is generally low, or covered with superficial deposits. Amaguadees Ponds. Near the mouth of Macintosh Brook is an outcrop of limestone, white, grey, pea-green and red, fibrous and crystalline gypsum and greenish and red gypseous marl. The gypsum of the marl usually occurs as nodules, which vary in size from six inches downwards, but also, in porphyritic masses, which are analogous to the limestone nodules and wedges of ordinary marls, and have probably had a similar origin. Gypseous marl.

At the mouth of Spruce Brook the following succession of these rocks was observed :— Spruce Brook.

Cupriferous conglomerate.

	FEET.	IN.
1. Cliffs of mixed marl, limestone and gypsum	..	..
2. Grey limestone in thick and shaly beds	17	0
3. Grey marl	8	0
4. Grey slightly nodular limestone	6	0
5. Flaggy limestone dipping N. 82° W. < 18°	4	6
6. Reddish and greenish, rust-spotted nut and egg-conglomerate, with streaks and stains of green carbonate of copper; pebbles of various feldspathic and syenitic rocks, especially a fine conglomerate of quartz and feldspar pebbles, like that seen in Macintosh Brook; many calcspar veins; beds of fine sandstone and marl. Forms high, bold cliffs on the coast	..	..
7. Lower Silurian rocks	..	..

East Bay road.

Shells and concretions.

East Bay Hills.

The East Bay road in the immediate vicinity of Gillis Brook crosses a red, blue and grey marl or soft limestone, which contains many impressions of shells. Much of this rock is concretionary; the concretions being of elongated oval form, the largest an inch in diameter. At the head of the bay, and on each side of it, limestone and gypsum, with their associated marl and sandstone, cross the streams; the former in glens, full of picturesque beauty; the latter in stagnant pools. They then lap round the East Bay Hills: a wild, woody mountain district, as yet only sparsely settled, and re-appear on the flanks of the Mira Hills. The high bluffs of the shore between the head of East Bay and Red Islands retain but a small portion of their original mantle of Carboniferous rock, and consequently, although surpassing it in point of grandeur, exhibit fewer of the charming coves which abound on the Little Bras d'Or.

Fossils of the Carboniferous limestone.

Irish Cove.

The limestones of this district are by no means deficient in organic remains, but, on the contrary, contain well-preserved specimens of most of the species met with elsewhere. Dr. Dawson mentions *Conularia planicostata*, *Productus cora*, *Terebratula sacculus*, *Spirifer glaber*, and a species *of Euomphalus*, as abounding in the limestone of Irish Cove; and a recurved *Conularia* has also been observed at Red Islands by Dr. Honeyman, the limestone at both places being in immediate contact with pre-Silurian felsites. At Irish Cove it is grey, in thick, undulating beds, which have a moderate easterly inclination, and is sometimes almost wholly composed of brachiopods and crinoid stems. Three miles to the south-west of the cove, at the mouth of a mill-brook, shaly, vesicular limestone, the lower beds botryoidal and radiated, is underlaid on the shore by greenish and red marl, and coarse, cupriferous conglomerate, which repose, in turn on the felsites. White and grey, laminated,

Cupriferous conglomerate.

contorted gypsum, and shelly limestone skirt the promontories near Red Islands and Johnson Harbour, most of the country being covered with pre-Silurian rocks.

Salmon River road.

On the Salmon River road, a mile and a-half east of the L'Ardoise road, is a bed of dary-grey, shaly, bituminous limestone, three feet thick, composed in part of stems of encrinites and other fossils; containing, also, small specks of galena, and cavities filled with scalenohedrons of clear calcspar. Its inclination is N. 26° W. < 21°. Around Loch Lomond the pre-Silurian rocks are often seen in contact with the millstone grit and Carboniferous limestone, the road running along the junction and exposing the limestones and their associated shales and sandstones, which often come from beneath the edges of the sandstones which occupy most of the basin of the lakes. On the McVicar road, a dark-grey, shelly, bituminous, vesicular limestone contains small crystalline masses of calcspar, conspicuous veins of quartz, concretions formed round quartz grains, and traces of red hematite. Blocks of hematite are also found in the fields at McDonald's post office, at the end of this road. On the west side of Loch Lomond, limestone is found occurring at several places; and in Pine Brook, a bed of compact, rather soft, bluish and grey heavy spar was also met with.

Fossils.

Galena and calcspar.

Loch Lomond.

McVicar road.

Iron ore.

Heavy spar.

6. Millstone Grit.

Extent.

The most southerly extension of this formation in the Glace Bay basin, found on Sydney River and the eastern shore of Forks Lake, is divided from similar deposits in the valleys of the Gaspereaux and Salmon Rivers by the East Bay anticline. On the roads between the head of East Bay and Mira River, the millstone grit appears sometimes to lie unconformably upon the pre-Carboniferous rocks, sometimes to rest against them along a line of fault. By far the most interesting and important feature connected with these rocks is the occurrence of the thin seams of coal, which will hereafter be described. The measures associated with the coal are similar to those which have been so often mentioned as characteristic of this formation in other parts of Cape Breton.

Coal.

L'Ardoise road.

On the L'Ardoise road, near Big Pond, light-grey and bluish, coarse and fine, false-bedded, micaceous, feldspathic sandstone comes against the felsites, dipping S. 52° E. Carbonized impressions of *Lepidodendron*, *Calamites* and other plants mark the surface of the beds. From this point the sandstone runs along the hills to the Glengarry road, where the dip is S. 41° E., the attitude being in both cases nearly vertical. Along

Plants.

the Gaspereaux River road, on which one of the coal-crops occurs, the millstone grit is well defined until it reaches the L'Ardoise road. Here, as well as on the Loch Lomond road, it seems to die out on the conglomerate.

Boulardrie Island.

The sandstone of this formation displayed in the cliffs and hills of Boulardrie Island, between Point Clear and Kemp Head, is of very varied texture, including beds of conglomerate composed of pebbles of felsite, quartz, granite and syenite, as large as a hen's egg, as well as fine-grained, micaceous, flaggy sandstone, approaching argillaceous shale in texture. The dip is inland at a low angle. Folding round Kemp Head similar strata, including one or two layers of blue clay, extend down the Great Bras d'Or, with a steep south-easterly inclination, rudely fashioned into fantastic figures by the waves on the bold rocky shore.

SUPERFICIAL GEOLOGY.

Amaguadees Ponds.

Magnetic iron sand.

The surface features of this region correspond closely with those of the country described in last report, being, however, more varied in proportion to the more irregular distribution of the different series of rocks. The prevailing scarcity of superficial deposits, other than those produced from the disintegration of the underlying rocks, is again worthy of notice. For a considerable distance east of Benacadie Pond, and in the immediate vicinity of Amaguadees Ponds, the banks are composed of stratified sand, clay and gravel, often wavy, the gravel at the bottom. At the mouth of Little Amaguadees Pond, black magnetic iron sand, apparently derived from these banks, is strewn along the beach in considerable quantity. Good sections are exhibited in the brooks and small runs of water which everywhere fall over them, cutting them in places into ravines with crumbling dangerous walls. Often the shores are low and occupied by sand beaches and ponds, the latter nearly dry, except in spring and autumn, and sometimes capable of being reclaimed as excellent hay-land. In many of the marshes an inferior kind of hay is produced, but is liable to be lost by inundation, there being no artificial boundaries to confine the water. Intervale lands of great fertility occur in the valleys of some of the larger brooks; amongst others, of Sydney, Mira and Salmon Rivers, Indian and Macintosh Brooks. The country, underlaid by the pre-Carboniferous rocks, is generally sterile. That occupied by millstone grit is characterized by the presence of slow-flowing brooks, lakes, marshes and barrens, and even on the high land, is too rocky for cultivation, except in the immediate neighbourhood of the lakes and

Character of the limestone districts.

rivers. The best farms of Baddeck, the Great and Little Narrows, Washaback, East Bay and other districts have a rich marl or calcareous Lower Carboniferous bottom. That part of the Escasonic reserve which is cultivated by the Indians, lies within the low Carboniferous belt between the shore and the hills, the scraggy timber on their precipitous flanks affording only wood for their baskets, tubs and boats, and the bark of the hemlock and birch for their wigwams and canoes.

Ice-grooves.

Glacial striæ were seen on the St. Peters road, near Gillis mill, East Bay, running S. 64° W. The action of ice in the transport of rock is exemplified on a small scale every year on the shores of the lakes. Huge blocks are carried away on the breaking up of the ice in spring, and ranged along the coast either on the beaches or in shallow water, thus making a slight change in the configuration of the shore, which the fishermen are quick to discover and profit by.

ECONOMIC MATERIALS.

Hematite.—The universal occurrence of calcspar and hematite among the rocks of every one of the formations referred to in this Report is remarkable. To the latter all the red rocks owe their colour, and in places it separates into veins and strings. Near McDougall Point, not far from the mine at Big Pond,* a limited deposit of excellent quality was seen at the junction of the Carboniferous conglomerate with the syenite; at Rory McNeil's mill, on the Glengarry road, traces have been met with in a similar position, and large pieces of this ore have been encountered in the fields at McDonald's post office, Loch Lomond. It is also present in the limestone of Boulardrie Island, in most of the Lower Silurian rocks, and in many of the pre-Silurian felsites, too much disseminated, however, to be available for commercial purposes. Neither the hematite of Big Pond nor that of the Bourinot road has yet been developed in such a manner as to warrant a positive opinion regarding its nature, mode of origin and extent. The purity of the former has already been referred to. Dr. Harrington's analysis of the latter gives:—

McDougall Point.

Glengarry road.

Loch Lomond.

Boulardrie Island.

Bourinot road.

Peroxide of iron........	85·037	= metallic iron, 59·526
Phosphoric acid.........	·032	
Sulphur.................	·075	
Silica..................	5·130	

Loran iron-ore

What at one time promised to be a valuable deposit of this ore was discovered some years ago at Loran, two or three miles east of Louisburg.

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* Report for 1874-75, p. 263, and Report for 1875-76, p. 415.

† Report for 1875-76, p. 414.

At Lauchlin McLean's, on the south side of the harbour, coarse red Carboniferous conglomerate, mixed with red marl, overlies the older rocks. The matrix of this conglomerate sometimes consists of hematite, which also discolours the underlying felsites. On the opposite shore, at Tutty's, large fragments of specular iron ore, brown and red hematite, occur in the fields, associated apparently, not with the felsites, which are exposed everywhere in the neigbourhood, but with the conglomerate, which once occupied the cove, as is attested by the low, red shore and scattered blocks. This opinion is strengthened by the fact that, intermixed fragments of hematite and felsite appear to merge into ordinary red conglomerate, and careful search near the shore will probably disclose at the same time the iron ore and Carboniferous rocks.

Boulardrie Island.

Spathic Iron Ore.—An analysis made by Dr. Harrington of a sample of clay ironstone or spathic iron ore from a bed associated with the limestone and gypsum of Island Point, Boulardrie Island, on the beach below Mr. John McLeod's house, yielded 32·58 per cent. of metallic iron; equal to 67·48 per cent. of carbonate of iron.

Fox Brook.

Bog Iron Ore.—A mixture of bog iron and manganese ores is found in an irregular surface layer, two feet thick, in a drain-cutting near John McSween's house, Fox Brook, Boisdale, incrusting boulders of granite and other rocks which lie in the marshy land where it occurs. A similar deposit, of what appears to be a brown iron ore, forms small spherical concretions, or a cement for a rather coarse grit, in a marsh near the Bourinot road. Bog iron ore is also found in small quantity on Indian Brook, above Hugh McPhee's, and higher still, at Malcolm McMullin's.

Indian Brook.

Pyrolusite.—On Donald McLean's land, three miles from Big Pond, on the L'Ardoise road, blocks of black oxide of manganese or pyrolusite are said to have been found, but nothing further is known respecting them.

Cupriferous conglomerate.

Copper Ore.—Mention has already been made of a number of places in which copper-glance, oxidised on the surface into carbonate, is found impregnating a conglomerate, often at its contact with an overlying bed of limestone. Instances have been observed at Irish Cove, East Bay, Washaback, Middle River and North River. Three assays of samples from the Washaback conglomerate near Crow Point are stated by Professor H. Y. Hind, in a private report on this district, to have yielded to Dr. Hayes:—

1.— 5 dwts. per ton of gold.

2.— $\frac{3}{10}$ per cent. of copper, and, at the rate of 19 dwts. 14 grains of gold per ton.

3.—16 dwts., 8 grains of gold, and 6 dwts., 12 grains of silver.

Although in some cases these deposits may be the remains of plants replaced by metallic ores, as pointed out by Professor Hind, it often happens that the ore forms the matrix of the conglomerate, like calcspar and hematite, and contains no traces of organisms. The specimens assayed were, of course, selected, and it is doubtful whether any of these beds are sufficiently rich to be profitably wrought.

Angus McDonald's.

At Angus Macdonald's (Big Angus), on the Caribou Marsh road, about two miles from Gabarus Bay, copper pyrites is found in blotches in compact felsite; but as it was not seen in place it could not be determined whether it came from the Potsdam rocks of the vicinity or from the lower series, hand specimens of these rocks being frequently indistinguishable.

Eagle Head.

The deposit at Eagle Head was wrought to some extent last summer, and rich ore is said to have been obtained, although the prospects cannot be said to have much improved. Calcspar and a soft, soapy mineral are found among the quartz, and much copper pyrites in the surrounding felsites.

Washaback Mines.

Galena.—Mining operations were undertaken on a small scale about twelve years ago by Mr. Alexander Cameron, of Baddeck, and others, to test the value of the quartz veins of the schistose rocks of Burnt Head and Boulaceet Harbour. At the former place a number of irregular, ferruginous quartz veins, the largest about fifteen inches thick, hold traces of argentiferous galena, copper and iron pyrites. An analysis by Dr. Hayes, of Boston, of specimens from one of these veins, shows it to contain 39 oz. 10 dwts. 12 grains of silver to the ton.* At Boulaceet Harbour another vein, which varies from half-an-inch to four inches in thickness, with small barren feeders, runs nearly at right angles to the strike of the rocks, and dips eastward at an angle of 27°. In this vein a rich pocket of galena, containing gold, sulphide of silver, copper and iron pyrites, produced at the rate of 18 oz. 9 dwts. 3 grs. of gold and 97 oz. 10 dwts. 14 grs. of silver to the ton. Scattered through the hornblendic and quartzose rocks in which the vein is contained are grains of copper pyrites and specular iron ore. As there appeared to be little prospect of the discovery of other rich pockets, and as the rock is hard to work, the mine was abandoned.

Analysis.

Gold and silver.

The hills between St. Annes Harbour and North River, which attain a height of upwards of a thousand feet, furnish some of the grandest scenery on the island. On the west shore of the harbour, after leaving

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*Many of the details respecting the Washaback deposits are from Professor Hind's report.

St. Annes.

the fringe of red Carboniferous rock at the base of the bar, we encounter compact felsite and porphyry, of greenish and other colours, succeeded near McDonald Pond by syenite, which is said also to occupy the tops of these hills. A mile or two from the shore, on the road between McDonald Pond and the upper settlement of North River, a number of small quartz veins occur, abounding in specks of galena, copper pyrites, black and honey-coloured blende and iron pyrites. They seem to have no persistency nor definite direction, but blend with the red syenite. On a small tributary of Barasois Brook, near the road, several of them have been sufficiently developed to prove their worthlessness. In one place, a quartzose belt, three or four feet wide, occurs in a soft, slaty, greenish-black rock.

Veins.

North River mine.

On Donald McDonald's farm, about a mile north of the bridge at the head of tide-water in North River, a much more important deposit has been mined by Messrs. Ingraham, Blackett, Gisborne, Dr. McKay and others, without satisfactory results. The vein is ill-defined, but varies from two or three inches to a foot in thickness, being in one place split by a band of eighteen inches mixed quartz and feldspar. The veinstone is quartz, often brecciated, carrying galena, copper pyrites and black blende in abundance. A parting divides it from the overlying rock, while the lower, and generally the richest part, adheres strongly to the foot-wall. The trend of this vein is about N. 26° W.—in one place N. 6° W.—the dip easterly at an angle of 45°; but both strike and dip are variable. The wall-rock is a greenish, jointed, porphyritic felsite, followed higher in the brook by red and green mottled felsites, like those of Gabarus, Louisburg and Coxheath.

Analysis of ore.

An analysis, made for Mr. Gisborne at the Boston School of Technology, of a sample of 900 pounds of ore from this vein, yielded at the rate of 501 pounds of concentrated ore to the ton, or 155 pounds of ingot lead, and 2·95 oz. of silver.

Molybdenite.—On the Gaspereaux River road, near Rory McKinnon's, molybdenite was seen spotting a syenitic rock; and a red ochre is said to occur in sandstone below the road near the same place.

Gold.—A considerable quantity of gold has been obtained by washing the sands of the brooks which flow from the hills in the vicinity of Middle River, above the Margarie road. This is generally fine, but a nugget, weighing an ounce, is also said to have been found. The only gold found *in situ* is believed to have been taken by Mr. McDougall, of Sydney, from the quartz of McLean Brook.

Middle River.

Gold in the quartz.

In the first large tributary of Middle River, on the left bank, above

Rory McLennan's, is a greenish and reddish, micaceous, glistening felsite or slate, in rather thick beds, made up of coherent laminæ, which wear into thin flat pebbles. White, irregular, barren quartz veins of no great thickness traverse this rock, which has sometimes the aspect of an altered fine grit. Shafts have been sunk in the hope of finding gold in these veins, but hitherto without success. Larger exposures of whitish quartz are also found. At the Garry, a house and farm on the hills at the source of McLean Brook, granitoid and compact felsite is stated to occur with arsenical pyrites; but its relation to the slates is unknown. The nearest allies of these slates in the country already surveyed would seem to be the laminated felsites of Shenacadie and Escasonie, from which, however, they are, in many respects, dissimilar. Sufficient examination was not made to determine their age, although, as the brooks offer every facility for geological research, such determination should not be difficult.

Arsenical pyrites.

Crossing Middle River, near McLean's, and ascending the brook behind the school house to its source, Carboniferous shales, feldspathic sandstone and cupriferous conglomerate were encountered. The lower rocks were not seen, but nearer Margaric the road crosses red syenite, so that the pre-Silurian rocks are probably not far distant, and the structure of this district seems similar to that of the eastern part of Cape Breton.

Coal.—Discoveries of coal are reported to have been made at three localities in the sandstone of Gaspereaux and Salmon Rivers, but at none of them was the exposure actually seen by us, so that the details given concerning thickness and other characters are from hearsay. The first of these, about a quarter of a mile south of the Gaspereaux River road, on the farm of Rory McKinnon, is from fifteen to eighteen inches in thickness, with a clay roof and floor. The coal burns with little flame, and leaves an inconsiderable residue of ash. A second outcrop occurs in a marsh on the edge of a small lake between the Glengarry and L'Ardoise roads. The third, and most important outcrop, was proved in a pit sunk by Mr. Neil Morrison and others, on the left bank of Salmon River, and two miles south of the Morrison road, where two eighteen-inch seams of coal, divided by a parting of sandstone and clay, varying from a few inches to four feet, are said to have been cut. A little further to the deep they bored 110 feet, but failed to strike the coal, which in the shaft dipped N. 26° W. $<$ 20°. It is an ordinary bituminous coal, and burns with a bright flame. Thin, pyritous bands are often present. An analysis made by Dr. Harrington gave:—

Gaspereaux River.

Salmon River.

Hygroscopic water	1·53
Volatile combustible matter	20·16
Fixed carbon	47·49
Ash	30·82
	100·00

Coal in Carboniferous conglomerate.

The coal found on the farm of Donald Gillis derives its interest from its association with the Carboniferous conglomerate. Its thickness can scarcely be defined, as it merges into the shales above and below. An analysis of an average sample, made by Dr. Harrington, gave:—

Volatile combustible matter	17·80
Fixed carbon	29·04
Ash, (reddish-grey)	53·16
	100·00

It bears all the marks of being identical in its origin with the more important coal seams of the millstone grit and coal measures.

Coal at Hunter's Mountain.

About eight miles from Baddeck, at McDonald's mill, Hunter's Mountain, is another outcrop of a black substance, resembling a lustrous coal, and similar in composition and mode of occurrence to that just described. It is of irregular shape, and varies from a few inches to two or three feet, dipping about S. 26° E., at a high variable inclination. Cleavage-planes intersect the coal in every direction, and break it into small pieces, many of which are covered with films of galena. The associated rocks are compact, shaly, feldspathic sandstone, argillaceous shale, and a coarse grit, composed of syenite *debris.* A thin band of this grit sometimes forms the floor of the seam, but a kind of fire-clay often occupies that position. Above the coal, and separated from it by a considerable thickness of sandstone, shale and red marl, including a few feet of grey and greenish compact limestone, is another black band, containing streaks of coaly matter, interlaminated with clay and other rocks; and in the immediate neighbourhood are large exposures of coarse conglomerate. In Harris Brook, near McIver's, there is said to be a seam of clean coal, a foot and a-half thick; but it is possible that this may be of similar character.

Harris Brook.

Gypsum.—Although so much plaster exists on the shores of the Bras d'Or Lakes, offering great facilities for cheap working, comparatively few quarries have been established, and none of them are now in operation except those at Port Bevis, already referred to.* At Big Harbour,

Boulardrie Island.

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* Report for 1875-76, p. 417.

Boulardrie Island, there is an excellent shipping place, but the want of sufficient capital, and the distance from a profitable market, has retarded the development of the quarries there.

Baryte.—It has been already stated that a bed of this mineral occurs in Pine Brook, Loch Lomond. Its thickness and other conditions were not ascertained, but it is hardly likely to prove of much importance.

Limestone.—Limestone, fit for the manufacture of lime, is met with in many places. The principal known outcrops are marked on the accompanying map, as well as those of gypsum. Professor Nichols, of New York, is said to have found at Whykokomagh a bluish limestone suitable for the preparation of artificial building-stone and cement, and attempts are being made to utilise it. The railway which is about to be built from the Broad Cove coal mines to Whykokomagh, will, it is hoped, give an impetus to this and other industries in the neighbourhood.

Cement-stone

Mineral Springs.—On its discovery, about twenty years ago, the remarkable spring at East Bay, believed to supply a water of life and remedy for fevers, rheumatism, consumption, and all the mental and bodily ills that flesh is heir to, was much resorted to by invalids from the Maritime Provinces and the United States, many of whom professed themselves benefitted by its use. Of late years, however, it has been in less repute, and since the great August gale of 1873 the spot has been almost inaccessible from fallen trees which obstruct the road; yet it is still the point to which many footpaths converge, and its situation is further indicated by names cut in the bark of the surrounding trees, by the remains of camp fires, broken earthenware, rags, paper, soda-water bottles, and other marks of a fashionable watering place.

East Bay.

The water issues in small quantity—sometimes accompanied by gas—from the side of a hill of syenitic rock in a piece of marshy land at the fork of the Ben Eoin and Gaspereaux River roads, about four miles from the shore of East Bay, and on the bank of a brook of perfectly fresh water which flows into Gaspereaux River: it is brackish and has a strongly astringent taste. The following are the results of an analysis by Professor How,* calculated for the imperial gallon of 70,000 grains. The water was clear and of neutral reaction. It afforded:—

Analysis by Professor How.

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* Mineralogy of Nova Scotia, page 193.

	Grains in a gallon.
Iron and phosphoric acid................	Traces.
Carbonates of lime and magnesia........	0·60
Sulphate of lime........................	0·94
Chloride of sodium......................	343·11
Chloride of potassium..................	4·55
Chlorde of calcium......................	308·90
Chloride of magnesium..................	4·47
	662·57
Specific gravity at 54° F...........	1007·397

No iodine was detected in the residue left by 1,500 grains of the water.

Professor How compares the East Bay mineral water with the saline waters of St. Catharines, Ancaster, Whitby and Hallowell, in Ontario, analysis of which are given in the Geology of Canada, 1863, pages 531 and 547.

Salt-springs.

Salt springs arise from many of the beds of gypsum in the district. One of these, a strong spring in the neighbourhood of Deadman Point, Washaback, covers with rust the ground in the immediate vicinity, and smells strongly of sulphuretted hydrogen.

Escasonie marble.

Marble.—The crystalline limestone of the French Vale and Escasonie often contains beds, which, being of fine grain and susceptible of a high polish, appear fit for decorative purposes. But a want of uniformity seems to prevail in the texture and distribution of colour of the layers, so that attempts hitherto made to find a marketable marble have proved abortive. On the hills near Bown's an opening was made on a band of whitish, yellow-streaked, finely crystalline, serpentine marble, but afterwards abandoned.

Syenite, *porphyry* and *granite* are among the products of the pre-Silurian rocks. Fine varieties of different colours exist in many places on the shore of the Bras d'Or lakes, but their adaptation to ornamental purposes has not yet been put to the proof.

Fireclay.—An altered felsite, similar to that analysed by Mr. Hoffmann, has been seen at several places in the Coxheath and East Bay Hills; and although the colour is seldom so pure as that found in McIntyre Brook, it is probable that some of it will prove suitable for the manufacture of fire-bricks and pottery. Among other localities may be mentioned the iron mine at Big Pond, Gillis mill-brook, East Bay, and a brook flowing into Forks Lake.

Pottery-clay.

Sandstone.—The shores of Boulardrie Island afford grey sandstone, fit for rough work in building.

GEOLOGICAL SURVEY OF CANADA
Alfred R C Selwyn F R S Director

GEOLOGICAL MAP
of part of
CAPE BRETON, NOVA SCOTIA
by
Hugh Fletcher B A
1876
Scale One Inch to a Mile

The Burland Desbarats Litho Comp^y Montreal.

Salt-

Esca
mar

Potte

ADDITIONS

TO THE

INSECT-FAUNA OF THE TERTIARY BEDS AT QUESNEL, BRITISH COLUMBIA.

BY

SAMUEL H. SCUDDER.

Since my previous paper on this subject Mr. George M. Dawson has sent me a few more specimens for examination, which enables me to add a few details concerning one of the forms described, and to offer notices of five additional species.

Sciara deperdita.—The remains of this species consist of a single perfect wing (No. 44), and the fragments of an eye, whose facets are ·0165 mm. in diameter. The wing is oval, and regularly rounded, with a somewhat abrupt inner angle; the surface covered with microscopic hairs. Judging from Winnertz's descriptions, this insect must be more nearly allied to *Sc. ungulata* Winn., than to any other of the numerous species mentioned in his monograph of the group. The costal and first and second longitudinal veins, together with the cross-veins uniting the two latter, are much heavier and darker than the other veins of the wing; the veins near the centre of the wing, and from there toward the base, are more delicate and fainter than elsewhere, but this, perhaps, is due to their indifferent preservation; the costal vein, which scarcely fails of reaching the tip of the wing, is covered with fine and short spinous hairs. The first longitudinal vein strikes the middle of the costal margin, and the cross-vein below unites it at the middle with the second longitudinal vein; the auxiliary vein is very obscure, though broad, and scarcely extends more than half-way to the cross-vein, in close juxtaposition to the first longitudinal vein; the transverse shoulder vein is equally faint, oblique, uniting the middle of the auxiliary vein with the costal margin. The second longitudinal vein is strongly bowed, and extends nearly to the tip of the costal vein. The basal undivided part of the third longitudinal vein is straight, originates from the second barely beyond the tip of the auxiliary vein, and forks somewhat abruptly at the middle of its course, and just beyond the extremity of the first longitudinal vein; shortly beyond their origin the forks are very nearly straight and quite parallel to the tip, the upper fork striking exactly the tip of the wing; the tips of the two forks and of the second longitudinal vein are equidistant, and the costal vein terminates mid-way between the extremity of the second and of the upper fork of the third longitudinal vein; the tip of the fourth is slightly further from that of the lower fork of the third longitudinal vein than the separation of the two forks. The fourth and fifth longitudinal veins are straight and sub-parallel at base, beginning to diverge where they bend downward, just beyond the middle; the tip of the fourth lying about mid-way between that of the fifth and the lower fork of the third longitudinal vein. The sixth longitudinal vein is rudimentary, and very indistinct, extending less than a quarter way toward the margin. Length of wing, 2·75 mm.; breadth, 1·25 mm.

Sciomyza revelata Scudd.—Two other specimens (Nos. 42, 43) give additional parts of the neuration and fragments of the body. There is nothing characteristic about the body, unless it be that the thorax is elevated and very abruptly rounded in front. No. 42 has both wings twisted about, and overlapping in a perplexing manner. No. 43 has parts of a single wing; and together they furnish the complete outline and neuration of the wing, by which we can supplement the description before given, and feel a stronger confidence in the generic reference made on partial evidence. The wing is a little more than twice as long as broad. The costal vein is setose throughout the anterior margin. The transverse shoulder vein does not run as before described, but is exactly transverse, and lies a little beyond the base of the basal cells. The first longitudinal vein apparently terminates just within the small transverse vein; this lies as far within, as the large transverse vein is beyond the middle of the wing, and is midway between the basal cells and the large transverse vein. The third longitudinal vein strikes the tip of the wing; the fifth is lost just before reaching the margin. The posterior large transverse vein is a little longer than the distance from its lower extremity to the margin, following the course of the fifth longitudinal vein. The second and third longitudinal veins separate just over the extremities of the small basal cells, and their common stalk arises from a cross-vein which unites the first and fourth longitudinal veins before the middle of the small basal cells. The sixth longitudinal vein appears to run half-way to the margin. Length of wing, 4·5 mm.; breadth, 2 mm.

Euschistus antiquus.—(No. 38.)—This is the first of the Pentatomidæ found fossil in America, although they are rather numerous in the European Tertiaries. I have referred it to Euschistus, although the form of the front of the head does not agree with that of the species I have seen; but Dallas, in establishing the genus, allowed some diversity of structure in this respect. It may be more closely allied to Nezara. The specimen is unusually perfect, and appears to be a male. The head is slightly longer than broad, equal beyond the expanding base, broadly rounded and somewhat flattened in front; the slight carinæ marking the borders of the middle lobe are parallel throughout, and extend to the front of the head. The pronotum is so imperfectly preserved as to throw doubt upon the generic affiinities of the insect, but it appears to have been more than twice as broad as long, with a median furrow, and its front margin very slightly concave behind the head; probably, also, it was considerably produced at the hinder lateral angles, and had its lateral margin slightly denticulate anteriorly. The scutellum is large, a little narrower than the breadth of the base of the abdomen, of nearly equal length and breadth, pretty regularly triangular, but with a slight emargination of the sides on their basal half; the tip bluntly pointed and rounded off, extending a little way on to the middle of the strongly advanced fourth abdominal segment. The surface of the head, prothorax and scutellum is covered pretty uniformly and abundantly with distinct round punctures, which are, however, deepest, most sharply defined, and so abundant as nearly to occupy the entire surface, on the front half of the head and next the margins of the prothorax. The corium of the tegmina includes more than half the wing, and is covered with punctures, deeply impressed, and much minuter and more frequent than on the scutellum; there is also a distinct vein passing down the middle, a little to one side, and another separating the clavus from the corium, but distinct on the specimen only apically, where it is continuous with the inner margin of the membrane. The membrane is well rounded, but slightly produced at the outer angle, and the space is occupied by nine nearly longitudinal veins, distributed in three sets of three each; the first set is composed of three obscure veins, pretty close together next the inner edge, originating from the same point, equidistant from one another, the innermost hugging the inner margin. From, apparently, the same point, originates the next cluster, starting in a single vein, which almost immediately forks, and sends its innermost branch parallel to those mentioned; the other branch diverges strongly from it, and again forks, the two branches running parallel to the first; while from opposite the point of origin of the last fork the third cluster takes its rise, starting as a shouldered vein, which forks at its shoulder into two slightly divergent veins which run subparallel to the previous veins; but the innermost of these again forks beyond its middle, crowding the veins together at this point. There is also a short, tenth, independent vein close to the outer extremity of the produced coriaceous field. The outer margin of the wing is delicately wrinkled with a simulation of veinlets.

The abdomen is ovate, somewhat regularly tapering at its outer half; the apex obscure, but apparently regularly rounded; the pleuræ are punctured like the scutellum, while the dorsal surface is minutely and profusely but obscurely punctulate. Such portions of the chitine as remain are of an intense black. The specimen is apparently a male, but whether two small triangular pieces, nearly equiangular, following the posterior edge of the sixth abdominal segment laterally are to be considered the anal cerci, is doubtful.

Directly beside this specimen, and, in fact, partly underlying it, is the abdomen, and part of the sternum of another insect, which, although much smaller, should, doubtless, be regarded as the female of the same species. This abdomen represents an under surface; it is very rounded and ovate; the extremity well rounded; the sixth segment represented by a circular fissured plate. The sides of the abdomen are punctulate, as in the other specimen, but the punctulation dies out before reaching the middle of the abdomen. Little can be said of the other parts of the body, excepting that the rostrum appears to terminate at the front limit of the middle coxæ, and the sternal parts of the thorax are coarsely punctate as above, and more particularly at the margins of the separate pieces.

Length of the *male*, 15 mm.; of head, 2·9 mm.; breadth of same beyond the base, 2·4 mm.; length of thorax, 3·25 mm.; of tegmina, 11 mm.; breadth of same near tip, 4·35 mm.; length of scutellum, 4·2 mm.; breadth of same, 4·5 mm.; greatest breadth of abdomen, 8 mm.; breadth of its dorsal face at tip of scutellum, 6 mm. Length of abdomen of *female*, measured beneath, 4 mm.; breadth of same, 5 mm.; width of fissured plate, 1·25 mm.

Although this insect is pretty plainly a Pentatomid, its generic affinities are uncertain. In no recent insect that I have observed is the extremity of the abdomen constructed as here, and until some closer correspondence is found in several parts, its position must remain doubtful. That it cannot properly be placed in Euschistus is evident from the fact that in the fossil species the mesosternum is much longer than the metasternum, and the coxal cavities of the two hinder pairs of legs are thus brought into contiguity, being separated only by a common paries.

Lachnus Quesneli, (No. 34 a.)—The remains which are preserved of this second fossil species of Lachnus from Quesnel, are a pair of overlapping front wings, with torn edges, but with all the important parts of the neuration; and some of the veins of the hind wings. The body is completely crushed and all other members are absent. The parts which can be studied are thus very similar to those found in *L. petrorum*, described before from the same bed. The present species is, evidently, closely allied to that, but differs from it in some important particulars; and noticeably, in the straightness, as opposed to the sinuosity of the veins. Owing to the absence of the margin the shape of the wing cannot be determined. The costal vein is thick throughout, but broadens apically; the first and second discoidal veins are both perfectly straight, originating scarcely further apart than the width of the costal vein, and diverging considerably. From the position in which the wings are preserved (one front wing almost exactly covering the other, and the two enclosing between them both hind wings, also almost exactly superimposed), the first and second discoidal veins of the two front wings and the two discoidal veins of each hind wing form a medley of almost confluent lines; so that it is a little difficult to determine to which of the four wings and to what part of that wing each of the eight veins belongs; regarding the veins of the hind wings there may, therefore, be some error in the statement to be made, but there can be little doubt of the position and relation of the veins of the front wing which appears to lie uppermost. The third discoidal vein originates at a distance beyond the base of the second, barely greater than the distance at which the latter is placed from the first; it makes an angle with the costal vein of less than forty-five degrees; is nowhere in the least degree sinuous, but is bent very slightly forward at each forking, rather more at its first than at its second; sends off its first branch at slightly less than a millimetre from its base; forms with it an angle of twenty-five degrees, and at an equal distance further on emits its second branchat a similar or slightly smaller angle; both the branches are perfectly straight, and the upper branch of the last fork lies mid-way between the lower branch and the stigmal vein; which is similar to that of *L. petrorum*, but is not so strongly curved; the first branch of the third discoidal vein also divides equally the space between the second discoidal and the lower branch of the last fork of the third discoidal vein. The discoidal veins of the hind wing originate at no greater distance apart than the first and second discoidal veins of the front wings; are a little less divergent than they, and equally straight. Length of fragment of wing, 5 mm.; breadth of same, 1·35 mm.; distance from base of front wing to the origin of the stigmal vein, 4·1 mm.

Bothromicromus.

Nov. gen. Hemerobinarum.

This genus agrees with Micromus in lacking the recurrent vein above the costal vein next the base of the front wing, and differs from it in the very wide expansion of the costal area at this point, and in the possession of numerous sectors. In these respects it agrees with Drepanopteryx, but the wing is not falcate, and notwithstanding the wide expanse of the costal area, the recurrent nervule is wanting, all the veinlets of this area arising next the base, as elsewhere, from the sub-costa. The wing is shaped much as in Megalomus, to which, indeed, it is closely allied, being broad at the base, very gradually increasing in width, apically, the extremity rounded, with no abrupt emargination or falcation, but with the inner angle strongly excised. At the base the costal area is nearly as broad as the remainder of the wing; the costal veinlets are all furcate and apparently connected, much as in Drepanopteryx, by a single line of inosculating veinlets, dividing the area in two nearly equal longitudinal halves. The costa and sub-costa run side by side in the closest proximity, but are apparently separated to the apex. Sectors extremely numerous, with a single complete series of gradate veinlets in the middle of the wing, and another, apparently crossing only the lower half of the wing, more than half way from this to the outer margin; veins and margins very shortly ciliated.

The genus also seems peculiar in the structure of the maxillary palpi, the basal joint of which is half as broad again as long; the second and third joints sub-equal, moniliform; the fourth, apparently, only half as broad as the previous, but of equal length, and the terminal again slenderer, but twice as long, being conical, pointed and unarmed, while the others are furnished on the apical half with scattered setæ. Antennæ sub-moniliform, the joints near the base of equal length and breadth, the basal joint double the width of the others; no hairs can be seen upon the antennal joints.

Bothromicromus Lachlani.—(Nos. 36 and 37.)—One front wing and a part of the head with its appendages are preserved on No. 36, with a pale, brownish tint to the wing, while the reverse, on No. 37, is wholly colourless. The only parts of the head preserved are one eye and a portion of the other, indicated by a broad, black, annular ring; also, a few of the basal joints of the antennæ, and both maxillary palpi, crossing each other and detached from the head. The wing is strongly expanded at the extreme costal base; beyond this the costal border is straight, with a scarcely perceptible emargination nearly to the tip. The inner margin is almost equally straight, but faintly convex. The extreme tip of the wing falls in the middle of the upper half; below it the wing is strongly excised, but well rounded at the tip and lower outer angle. The shape of the wing, therefore, resembles closely that of *Micromus hirtus* of Europe. The cubitals are, if anything, more numerous than the veinlets of the costal area, and beyond the origin of the anterior cubital vein ten originate from the sub-costa itself in the basal half of the wing. The first and second of these fork and subdivide several times before reaching the margin, or even long before reaching the first series of gradate veinlets, while the third to the ninth are simple, either quite or almost as far as the very margin. The tenth again forks close to its origin, and the outer sectors originate from its upper branch, which is connected with the costa by infrequent cross nervules. The wing is of a pale wood-brown colour, the veins margined with a line of dull pale-yellow, and the darker brown of the interspaces broken frequently by a slightly paler tint, so as to give the wing a minutely blotched appearance, only visible under the lens. The two series of gradate veinlets are again accompanied by a slightly darker tint, giving the wing the appearance of being crossed by two oblique dusky lines. All the margins are minutely and sparingly ciliated, and similar black, rather distant hairs are scattered indiscriminately over the wing, both upon the membrane and veins, but showing a certain tendency to follow the course of the latter. At the extreme lower base of the wing they are seen to have their origin from minute papillæ, less than one hundredth of a millimetre in diameter, and averaging a twentieth of a millimetre apart. Length of wing 9·5 mm.; greatest breadth, 4·25 mm.; breadth at base, 3 mm.; diameter of eye, 0·45 mm.; length of joints of antennæ near base, 0·09 mm.; of middle joints of maxillary palpi, 0·075 mm.; length of maxillary palpi, 0·4 mm.

Aranea columbiæ.—Among the stones obtained by Mr. Dawson are several containing the flattened remains of the egg cocoons of Araneidæ. There are no less than eight of them, of different shapes and sizes, occurring by pairs, none of them reverses of others. They occur on stones numbered 38–41. As the form of the egg cocoons in Araneidæ is so various, and the number of specimens found indicates a probability of obtaining at some time the probable constructor of the webs, I have only applied an ancient, broad generic name to these products of the insect, for the sake of indicating the nature of all the fossil remains from Quesnel. It is probable that the spider will be found most nearly allied to Theridium, species of which construct pedunculate egg cocoons not very different from these. The cocoons vary slightly in size, and more in shape, owing no doubt to their varying position when crushed; probably they were globular, or possibly, slightly oval in shape; averaging about 5 mm. in the longer and 4 mm. in the shorter diameter; of a firm structure; testaceous in colour; and hung by a slender thread, less, or much less than quarter the length of the egg cocoon, (averaging, perhaps, 1 mm. in length), to a thickened mass of web, attached to some object or to the insect's web.

That they have been preserved by pairs upon the stones has no significance, and indeed, may be due simply to the way the stones were broken; for they lie at varying distances apart, with no sign of connection, and placed with no definite relations to each other. Two of them show no sign of the pedicel, but this is certainly due to poor preservation; and a single one, the least circular (40 a) not only has no pedicle, but appears to be formed of a lighter, flimsier tissue, and may belong to a different species. The following are the longer and shorter diameter, and length of pedicel of each specimen:—

No. of specimen.	Long diameter.	Short diameter.	Length of Pedicel.
	Millimetres.	Millimetres.	Millimetres.
No. 38 b......	5·0	3·5	1·5
No. 38 c......	6·0	4·0	0.8
No. 39 a......	4·0	3·6	1·2
No. 39 b......	4·0	3·5	...
No. 40 a......	5·5	2·5	...
No. 40 b......	5·2	3·7	1
No. 41 a......	5·0	3·9	Base only of pedicel preserved.
No. 41 b......	4·5	4·2	" " "

NOTES

ON

MISCELLANEOUS ROCKS AND MINERALS.

BY

B. J. HARRINGTON, B.A., PH.D.,

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—I have the honour to submit, in the following pages, the results of the examination of a number of Canadian rocks and minerals, chiefly of economic importance. They will, it is hoped, meet with your approval, and be of some slight service to those who are endeavouring to develop the mineral resources of the Dominion.

COAL AND LIGNITE.

British Columbia.

Coal of Nicola River.

1. *Nicola River.*—In the Report for 1872-73, notes were published with regard to the character of the coals of Vancouver and Queen Charlotte Islands, but little has been written concerning the coals and lignites of the mainland of British Columbia. In the Report for 1871-72, p. 66, Dr. Hunt gives the following proximate analysis of coal, stated to be from Nicola River:—

	Slow coking.
Volatile matter	21·51
Fixed carbon	74·58
Ash (greyish)	3·91
	100·00

It was found to yield a firm dense coke.

Subsequently, two specimens were given to me by Mr. Richardson for examination. They were bright and clean, but rather brittle. The specific gravity of I. was 1·28, that of II., 1·27.

By fast coking the following results were obtained :—

	I.	II.
Volatile matter	36·15	35·98
Fixed carbon	60·98	61·60
Ash (pale-red)	2·87	2·42
	100·00	100·00

In each case a bright and tolerably firm coke was obtained.

Different seams. These specimens, however, are somewhat different in character from coal more recently brought from Nicola River by Mr. G. M. Dawson, and are possibly from other seams.* Mr. Dawson's sample was taken by him from a bed several feet in thickness at the junction of the Nicola and Coldwater Rivers. It was rather brittle, but this may have been due to its being from the surface. On the whole it was bright or somewhat pitchy, but contained occasional dull layers. Fracture subconchoidal. The joints contained a little clayey matter, probably washed into them from the surface. The streak was perfectly black, but the powder communicated a dark-brown colouration to a boiling solution of caustic potash ; the dull portions of the coal giving a much more intense colouration than the bright. Analyses by fast and slow coking gave the following results :—

	Fast coking.	Slow coking.
Hygroscopic water (at 115° C)	4·45	4·45
Volatile combustible matter	33·79	29·68
Fixed Carbon	53·05	57·16
Ash (cream-coloured)	8·71	8·71
	100·00	100·00

No coke was obtained either by rapid or slow heating, only a very few particles of the powder being slightly sintered together. The deportment with caustic potash shows that this is not a true bituminous coal ; and although it contains less water, yet, on the whole, it resembles some of the Saskatchewan coals which are mid-way in characters between bituminous coal and lignite. †

2. *Near "The Indian Reserve," forty-five miles up the North Thompson.*—

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* Mr. Dawson's explorations have, since the above was written, shown that there are several distinct seams.

† See analysis No. 5, Report of Progress, 1873-74, page 64.

Coal from the North Thompson.

Coal is stated to occur here, but the locality has not been visited by any of the members of the Geological Survey. A small specimen of the coal was, however, given to Mr. Dawson by Mr. Barnard, of British Columbia. It consisted of alternate bright and dull layers; the former breaking with a conchoidal fracture. The powder was black, and scarcely communicated any colour to a boiling solution of caustic potash. By fast and slow coking the following results were obtained :—

	Fast coking.	Slow coking.
Hygroscopic water	2·22	2·22
Volatile combustible matter	38·10	32·05
Fixed carbon	46·76	52·81
Ash	12·92	12·92
	100·00	100·00
Coke	59·68	65·73
Ratio of volatile to fixed combustible.	1 : 1·23	1 : 1·65

Fast coking gave a bright and firm coke, which on burning away left a reddish-white ash. By slow coking the powder was agglutinated only at the bottom of the crucible. This coal approaches a true bituminous coal more closely than that from Nicola River last described, but whether it is older geologically I am not aware. Its resemblance in composition to one from Saaquash, on Vancouver Island—which, however, does not coke—is so striking that the analysis of the latter is cited here for comparison :—

	Fast coking	Slow coking.
Water	2·84	2·84
Volatile combustible matter	39·23	33·56
Fixed carbon	46·36	52·03
Ash	11·57	11·57
	100·00	100·00
Ratio of volatile to fixed combustible.	1 : 1·18	1 : 1·55

3. *Upper Nechacco River, South of Fort Fraser.*

Lignite from Nechacco River.

A specimen of lignite, from a four-foot seam occurring at this place, has been given to me for examination by Mr. G. M. Dawson. It is black, and most of it has a distinct woody structure, although portions of it have lost all trace of this structure, becoming highly lustrous and divided up by numerous reticulating cracks, precisely as is the case with some of the Tertiary lignites east of the Rocky Mountains.

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* Report of Progress, 1872-73, page 79.

It also contains occasional specks of mineral resin. Analyses by fast and slow coking gave as follows:—

	Fast coking.	Slow coking.
Hygroscopic water	10·46	10·46
Volatile combustible matter	41·44	35·01
Fixed carbon	43·21	49·64
Ash	4·89	4·89
	100·00	100·00
Ratio of volatile to fixed combustible	1 : 1·04	1 : 1·41

By rapid heating a portion of the powder was sintered together into a friable silvery-grey coke. The ash was of a brick-red colour.

4. *Baynes Sound Mine, V. I.*

Richardson seam, Baynes Sound.

This specimen was from what is known as the "Richardson seam." It was a firm and bright coal, and gave, on examination, the following results:—

	Fast coking.	Slow coking.
Hygroscopic water	1·18	1·18
Volatile combustible matter	34·13	27·57
Fixed carbon	48·51	55·07
Ash (cream-coloured)	16·18	16·18
	100·00	100·00
Coke	64·69	71·25
Ratio of volatile to fixed combustible	1 : 1·42	1 : 1·99

Slow heating gave a friable, and rapid heating a firm, silvery-grey coke. The coal gave a black streak, and the powder communicated no colour to a boiling solution of caustic potash.

NEW BRUNSWICK.

Anthracite of Lepreau.

1. *Little Lepreau, Charlotte County.*—A deposit of impure anthracitic coal occurs at this locality in the Devonian rocks, at the junction of the Cordaite shales and the Dadoxylon sandstone. Much of it has a dull, earthy appearance, but in places it presents smooth lustrous surfaces, looking as if slickensided. The seam is said to be about "ten feet thick," but much of it is probably only a carbonaceous shale, and none of the material which I have seen would be worth mining. A specimen of the brighter kind was found to contain—

	Fast coking.	Slow coking.
Hygroscopic water	1·25	1·25
Volatile combustible matter	5·83	4·38
Fixed carbon	56·04	57·49
Ash	36·88	36·88
	100·00	100·00

CAPE BRETON, NOVA SCOTIA.

1. *Port Hood, Inverness County.*—Among the coals recently examined is one from Port Hood, stated to be from the "lower seam" and from a "new mine." It was sent for examination by Dr. George Murray, of New Glasgow, who states that the seam is from six to seven feet thick, and that the sample was taken at between 150 and 200 feet from the crop on the slope by which the mine is worked. The coal is bright and does not readily soil the fingers. It shows well marked planes of cleat, on which there are often thin films of carbonate of lime. Pyrites, in very considerable quantity, also occurs on the cleat planes, as well as in layers parallel with the bedding, and in irregular veins and masses traversing the coal in all directions. For analysis, ten pounds of the coal were reduced to powder in order to obtain a fair average sample; a portion of this was taken, and yielded, by fast and slow coking, the following results:—

Analyses of Port Hood coal.

	Fast coking.	Slow coking.
Hygroscopic water	4·02	4·02
Volatile combustible matter	38·81	34·86
Fixed carbon (with some sulphur)	49·65	53·60
Ash (purplish-red)	7·52	7·52
	100·00	100·00
Sulphur	6·658	6·61
Coke	57·17	61·12
Ratio of volatile to fixed combustible	1 : 1·28	1 : 1·53

Rapid heating gave a bright and tolerably firm coke of a steel-grey colour, but when the powder was slowly heated, about half of it remained in a pulverulent condition. The coal in fine powder is dark-brown, but does not colour a boiling solution of caustic potash. The determinations of sulphur were made by two different methods, and the proportion found is so very high as greatly to detract from the value of the coal, rendering it not only inferior for gas-making, and injurious to grate bars, as well as unfit for many metallurgical purposes, but making it liable, on exposure, to spontaneous ignition.

2. *McAdam Lake, Bourinot Road.*—A sample of the so-called coal, from this locality, collected by Mr. Hugh Fletcher, proves to be little more than a coaly shale. The fresh fracture is dull and earthy, but the surfaces of what appear to be bedding planes, and also of jointage planes, are often smooth and lustrous. The bed from which the specimen was obtained is said to be about two feet thick, "among red and grey sandstones, shales, and conglomerates of the Carboniferous conglomerate." An analysis, by fast coking, gave the following results:—

Volatile matter	17·80
Fixed carbon	29·04
Ash (reddish-grey)	53·16
	100·00

Coke from coal with 53 per cent. of ash.

Notwithstanding the large amount of ash, the material was found to cake, and a porous coke was obtained.*

TABLES OF ANALYSES OF COALS AND LIGNITES.

The accompanying tables have been compiled in order to show the composition of many of our western coals and lignites, and to facilitate comparison between those of different localities. Under the heading "Remarks," a few statements are given concerning the characters of the different coals, but for fuller details, the original sources must be consulted.

Authorities of analyses.

In Table I., analyses VI., VIII., X., XI. and XIII. to XV. inclusive, and also No. XVII., are by Dr. Hunt, and taken from the Report of Progress for 1871-72, pp. 66 and 99. No. XVI. is by Professor Whitney, and to be found on page 30 of the "Geology of California." No. XXIV. is by Mr. G. M. Dawson, and taken from his "Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel," page 172. The remainder are by myself, and to be found as follows:—I. to V. inclusive, VII. and IX., in the Report of Progress for 1872-73, pp. 76–79; XVIII. to XXI. in the present Report; No. XXII. in the Report for 1873-74, page 99, and No. XXIII. in that for 1875-76, page 6.

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* Since the above was written, an impure coal, brought by Mr. Fletcher from Loch Lomond, in Cape Breton, has been examined, and yielded by fast coking—

Hygroscopic water	1·53
Volatile combustible matter	20·16
Fixed carbon	47·49
Ash (greyish-brown)	30·82
	100·00

The coal showed distinct planes of bedding and cleat, and contained thin films of iron pyrites. It occurs in the Millstone grit formation. The powder showed no disposition to sinter even when rapidly heated.

I.—BITUMINOUS COALS.

LOCALITY.	ANALYSIS BY SLOW COKING.						ANALYSIS BY FAST COKING.					Colour of Ash.	REMARKS.
	Number of Specimen.	Water.	Volatile Combustible matter.	Fixed Carbon.	Ash.	Ratio of Volatile to fixed Combustible.	Water.	Volatile Combustible matter.	Fixed Carbon.	Ash.	Ratio of Volatile to fixed Combustible.		
A. Vancouver Island.													
Brown's River........	I.	0·95	21·57	73·14	4·34	1 : 3·39	0·95	23·85	70·86	4·34	1 : 2·55	Reddish-grey	Surface specimen ; brittle. Coked readily.
Trent River—3ft. 8in. seam......	II.	0·92	28·50	62·76	7·82	1 : 2·20	0·92	32·94	58·32	7·82	1 : 1·77	Reddish-grey	Good firm coal. Cokes readily.
Trent River—Same seam as last..	III.	0·97	25·09	66·42	5·95	1 : 2·65	0·97	29.95	61·58	5·95	1 : 2·05	Pale reddish grey.	Like No. 2 contained thin films of calcite. Cokes easily. Sulphur 1·57 per cent.
Saaquash or Sukwash...........	IV.	2·84	33·56	52·00	11·57	1 : 1·55	2·84	39·23	46·36	11·57	1 : 1·18	....	Does not coke.
Newcastle Island—Upper Seam..	V.	1·57	30·95	58·03	8·63	1 : 1·87	1·57	38·14	50·84	8·63	1 : 1·33	Reddish grey.	Sulphur 0·82 per cent. Scarcely coked even when rapidly heated.
Newcastle Island—Lower Seam..	VI.	35·49		52·57	11·94	......	......	......	......	......	......	Grey........	Scarcely coked.
Comox, Union Mine—Lower Seam.	VII.	1.70	27·17	68·27	2·86	1 : 2·51	1·70	32·36	63·08	2·86	1 : 1·95	Brick red....	Surface specimen, rather brittle ; bright on fresh fracture.
Comox, Union Mine—Earthy portion of Lower Seam..........	VIII.	23·83		54·57	21·60	......	......	......	......	......	......	....	Much weathered.
Comox, Union Mine—4ft. 4in. Seam	IX.	1·34	28·11	67·72	2·83	1 : 2·41	1·34	30·01	65·82	2·83	1 : 2·12	Pale brick-red	Weathered, but bright on fresh fracture ; contained a little mineral charcoal.
Comox, Baynes Sound Mine—Upper Seam................	X.	29·10		57·48	13·42	......	......	......	......	......	......	Grey........	Dense firm shining coke.
Comox, Baynes Sound Mine—Lower Seam................	XI.	29·55		64·70	5·75	......	......	......	......	......	......	Reddish......	Coke firm.
Comox, Baynes Sound Mine—Richardson Seam	XII.	1·18	27·57	55·07	16·18	1 : 1·99	1·18	34·13	48·51	16·18	1 : 1·42	....	A firm bright coal. Cokes readily.
Comox, Beaufort Mine..........	XIII.	29·30		55·75	14·95	......	......	......	......	......	......	Grey........	Bulky soft coke.
Nanaimo, Upper Seam..........	XIV.	38·40		51·45	10·15	......	......	......	......	......	......	Greyish	Coke firm.
Nanaimo, Dunsmuir Seam.......	XV.	34·70		55·50	9·80	......	......	......	......	......	......	Grey........	Scarcely coked.
Nanaimo (?) marked "lower 7ft. seam"	XVI.	27·63		59·29	13·08	......	......	......	......	......	......	Grey........	Coke firm.
Nanaimo	XVII.	2·98	32·16	46·31	18·55	1 : 1·44	......	......	......	....	......	....	This analysis is given here under "slow coking," but Prof. Whitney does not state how it was made.
B. Mainland of British Columbia.													
Nicola River..................	XVIII.	21·51		74·58	3·91	......	......	......	......	......	......	Greyish......	A firm, dense coke.
Nicola River..................	XIX.	......	......	......	......	......	36·15		60·98	2.87	......	Pale red.....	Sp. gr. 1·28. Coke firm.
Nicola River..................	XX.	......	......	......	......	......	35·98		61·60	2·42	......	Pale red.....	Sp. gr. 1·27. Coke firm.
Nicola River..................	XXI.	4·45	29·68	57·16	8·71	1 : 1·93	4·45	33·79	53·05	8·71	1 : 1·57	Cream-colour.	Shows only slightest disposition to coke ; not strictly a bituminous coal.
The Indian Reserve, North Thompson River	XXII.	2·22	32·05	52·81	12·92	1 : 1·65	2·22	38·10	46·76	12·92	1 : 1·23	Reddish-white	A bright, firm coke.
Near Chilliwack River	XXIII.	......	......	......	......	......	35·73		63·86	0·41	......	Dark red	Gives a brittle coke.
Canon of the Mountain of Rocks—Peace River................	XXIV.	2·10	21·54	71·63	4·73	1 : 3·32	2·10	25·09	68·08	4·73	1 : 2·71	....	A firm coke by rapid heating.
C. East of the Rocky Mountains.													
St. Mary River—18in. seam......	XXV.	5·05	25·30	64·65	5·00	1 : 2·55	......	......	......	......	......	Reddish-grey.	Shows traces of horizontal lamination, and more or less mineral charcoal; cleat in two directions, with smooth shining faces. Cokes readily.

Coke from coal with 53 per cent of ash.

Authorities of analyses.

The coal showed distinct planes of bedding and cleat, and contained thin films of iron pyrites. It occurs in the Millstone grit formation. The powder showed no disposition to sinter even when rapidly heated.

In Table II., analyses I. to VII. are the writer's; one being from the present report and the others from that for 1873-74, pp. 63, 64. Nos. VIII. to XI. are by Professor Haanel, of Cobourg, Ontario, and were published in the *Toronto Globe* of March 14th, 1874. Nos. XII. to XXVI. are by Mr. G. M. Dawson, and from the report already mentioned, pp. 169-172. Nos. XXVII. to XXXIV. are by Mr. Christian Hoffmann, and, with the exception of the last, are to be found, with many additional details, in the Report of Progress for 1873-74, pp. 90-93. No. XXXIV. is from the Report for 1875-76, p. 422, and No. XXXV. by Mr. J. W. Spencer, from the Report for 1874-75, p. 69.

Ash in Vancouver coals.

The average percentage of ash in sixteen samples of Vancouver coal is 9·58; that of fixed carbon in the same number being 59·37.

The inferior quality of the lignites east of, say, the 112th meridian, as compared with most of those west of that line, is very evident from table II.; all the samples from No. XII down being from the east, while the preceding ones are from the west of the line. The latter, as a rule, contain considerably over fifty per cent. of fixed carbon, (slow coking), while those to the east generally contain considerably less than fifty per cent.—39·39 per cent. being the average amount, as deduced from twenty-four determinations.*

Mineral Resins.

Occurrence of mineral resins.

The occurrence of mineral resins in the coals and lignites of the North-West and British Columbia has been noticed by several observers. Bauerman, in his paper "On the Geology of the South-Eastern part of Vancouver Island,"† speaking of the Nanaimo coal, which he calls lignite, says that "a mineral allied to retinite or amber is common in the more earthy portions." I have not observed anything of the kind in the specimens collected by Mr. Richardson, but they were not taken from the earthy portions of the seams. Professor Bell, in describing four seams of lignite, occurring near what he calls the Dirt Hills, says that "all the beds contain specks and small rounded lumps of brittle, yellowish resin or amber." Mr. G. M. Dawson, also, in his report for 1875-76, states that "small spots and drops of amber are abundant in some layers" of the lignite near Quesnel Mouth. In his "Report on the Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel" he also mentions the occurrence of "amber or fossil resin" in lignite from Souris

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* See Mr. Dawson's Report, already cited, page 180.

† Quarterly Journal Geological Society, 1860, Vol. XVI., p. 198.

River and Porcupine Creek, (pp. 171, 172). The lignites further south likewise, in Colorado and New Mexico, frequently contain mineral resins, and one from New Mexico, occurring in lignite of Cretaceous age, has been described and named Wheelerite, after Lieut.-Col. Wheeler.

Resin from North Saskatchewan.

Within the last year or two several specimens of mineral resins have been collected by members of the Canadian Survey, and the results of their examination, though incomplete, may be given here. The first one examined was from the North Saskatchewan, and occurred in litttle drop-like masses in a lignite. It was found to possess the following characters:—Colour amber-yellow to brownish; lustre resinous; transparent to translucent; fracture conchoidal; hardness a little over 2; specific gravity 1·066; electric on friction; begins to soften at about 190° C., gradually getting softer until at about 290° C. it becomes semi-viscid, and, after remaining at this temperature for a short time, darkens, as if undergoing decomposition; dissolves in sulphuric acid, communicating to it a reddish-brown colour, and being re-precipitated in a flocculent state on addition of water; communicates a yellow colour to absolute alcohol, which in a single experiment dissolved 29·30 per cent.

Resin from Peace River.

The second was brought by you from Peace River, and occurred in nodules in a shaly sandstone containing a little black coaly matter. The largest nodule was over a quarter of an inch in diameter, but impure, containing a good deal of black carbonaceous matter. Selected fragments, however, varied in colour from pale yellow to yellowish-brown, ranging from transparent to translucent, and some of the fragments showing slight opalescence; lustre resinous; fracture sub-conchoidal; hardness about 2; strongly electric on friction; begins to soften at about 190° C.; at 320° C. has not melted, but stirred with a wire becomes spongy or granular; dissolves in sulphuric acid, and is re-precipitated on addition of water; absolute alcohol dissolved (a single experiment) only 0·91 per cent. after digestion for several days.

Resin from Nechacco River.

The third specimen was collected by Mr. G. M. Dawson on the Nechacco River, south of Fort Fraser, British Columbia, and occurred in a black lignite,* in little grains, flattened in the direction of the planes of bedding of the lignite. The grains are yellow in the interior, but the exterior portions have evidently been altered, and have assumed a dull, brownish-white colour. One mass, about three-sixteenths of an inch across, was brown in the centre, and surrounded by a brownish-white ring. The unaltered yellow material is transparent, has a vitreo-

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* For analysis of the lignite, see p. 468.

II.—LIGNITES, OR BROWN COALS.

LOCALITY.	Number of Specimen.	ANALYSIS BY SLOW COKING.					ANALYSIS BY FAST COKING.					Colour of Ash.	REMARKS.
		Water.	Volatile Combustible matter.	Fixed Carbon.	Ash.	Ratio of Volatile to fixed Combustible.	Water.	Volatile Combustible matter.	Fixed Carbon.	Ash.	Ratio of Volatile to fixed Combustible.		
A. British Columbia.													
Upper Nechacco River, south of Fort Fraser................	I.	10·46	35·01	49·64	4·89	1 : 1·42	10·46	41·44	43·21	4·89	1 : 1·04	Brick-red....	See page 468.
B. North West Territory.													
Rocky Mountain House, North Saskatchewan—3 ft. seam.....	II.	7·82	31·35	54·97	5·86	1 : 1·75	7·82	38·00	48·25	5·93	1 : 1·27	Brick-red....	Looks like a true Carboniferous coal. Shows a slight tendency to coke.
Rocky Mountain House—Probably same seam as last............	III	7·50	31·46	51·19	9·85	1 : 1·63	7·50	37·06	45·48	9·96	1 : 1·17	Brick-red....	Looks like a true Carboniferous coal. Shows a slight tendency to coke.
North Saskatchewan............	IV.	11·81	32·75	53.36	2·08	1 : 1·63	11·81	36·58	49·40	2·21	1 : 1·35	Brick-red....	Greasy lustre and conchoidal fracture. Does not coke.
North Saskatchewan—18ft. seam.	V.	10·90	28·69	54·96	5·45	1 : 1·91	10·90	36·22	47·84	5·04	1 : 1·32	Brownish grey	Dull black, showing horizontal lamination and containing much mineral charcoal. Does not coke.
North Saskatchewan—18ft. seam.	VI.	12·93	26·80	52·28	7·99	1 : 1·95	12·93	34·12	44·95	8·00	1 : 1·32	Grey........	Similar in appearance to last, but showing a slight tendency to coke.
North Saskatchewan—Probably from same seam as Nos. V. & VI.	VII.	11·09	28·33	53·25	7·33	1 : 1·88	11·09	32·49	49·40	7·02	1 : 1·52	Grey........	Similar in appearance to No. V., but showing a slight tendency to coke.
North Saskatchewan—Near Fort Edmonton	VIII.	6·89	23·57	50·90	8·64	1 : 2·16	......	......	......	......	......	....	Sp. gr. 1·337. This and the three following analyses are given under the heading "slow coking." Prof. Haanel does not state whether the coking was rapid or slow.
North Pembina River—100 miles N. W. of Fort Edmonton	IX.	11·88	28·66	57·25	2·21	1 : 2·00	......	......	......	......	......	Reddish - yellow........	Sp. gr. 1·375 Described as "a bituminous coal of a bright lustre," but evidently a brown coal.
Belly River....................	X.	6·60	23·70	53·25	6·36	1 : 2·25	......	......	......	......	......	....	Sp. gr. 1·34.
Near Belly River...............	XI.	11·41	29·07	56·94	2·58	1 : 1·96	......	......	......	......	.....	Reddish - yellow........	Sp. gr. 1·375. Resembled No. IX. in appearance.
Porcupine Creek—Upper part of 18ft. seam..................	XII.	16·87	37·51	34·82	11·30	1 : 0·91	......	......	24·30	......	......	White.......	Outcrop specimen.
Porcupine Creek—Lower part of 18ft. seam..................	XIII.	12·05	35·12	46·18	6·65	1 : 1·31	......	......	41·03	......	......	Light grey...	Tough and compact; separates into layers; shows woody structure and contains mineral charcoal and "amber."
Great Valley—4ft. seam.........	XIV.	15·51	42·65	37·12	4·72	1 : 0·87	......	......	28·44	......	......	Yellowish-white.....	Outcrop specimen; brownish; fracture almost conchoidal.
Great Valley—Upper lignite.....	XV.	15·20	44·43	34·45	5·92	1 : 0·77	......	......	27·61	......	......	....	Outcrop specimen.
Great Valley—Middle lignite....	XVI.	16·28	33·19	46·25	4·28	1 : 1·39	......	......	29·18	......	......	....	Weathered specimen, largely composed of comminuted charcoal-like fragments.
Great Valley—Lowest lignite....	XVII.	18·74	40·54	35.69	5·03	1 : 0·88	......	......	30·04	......	......	Grey........	Weathered specimen; crumbling.

Resin from
North
Saskatchewan.

Resin from
Peace River.

Resin from
Nechacco River.

II.—LIGNITES OR BROWN COALS—(*continued*)

LOCALITY.	Number of Specimen.	ANALYSIS BY SLOW COKING.					ANALYSIS BY FAST COKING.					Colour of Ash.	REMARKS.
		Water.	Volatile Combustible Matter.	Fixed Carbon.	Ash.	Ratio of Volatile to fixed Combustible.	Water.	Volatile Combustible Matter.	Fixed Carbon.	Ash.	Ratio of Volatile to fixed Combustible.		
N. W. Territory—(*continued*)													
Souris River—62 miles West of Wood End......	XVIII.	13·85	30·95	47·90	7·30	1 : 1·55	......	......	......	......	......	Reddish......	Laminated and breaking along horizontal planes on drying. Contains fossil resin.
Souris Valley—7ft. seam	XIX.	15·11	32·76	47·57	4·56	1 : 1·45	......	......	41·67	......	......	Yellowish white......	Black, hard, and compact. Traces of woody structure.
Souris Valley..................	XX.	14·73	39·99	42·48	2·80	1 : 1·06	......	......	34·07	......	......	Yellow	Black and compact; much woody structure.
Souris Valley—Layer 2..........	XXI.	17·97	44·56	32·86	4·61	1 : 0·74	......	......	30·10	......	......	Greyish white.	Weathered specimen; soft and crumbling.
Souris Valley—Layer 10.........	XXII.	14·90	42·98	36·94	5·18	1 : 0·86	......	......	36·68	......	......	Light yellowish ..	Separates along horizontal planes; lustre dull.
Souris Valley—Layer 17.........	XXIII.	12·67	49·52	31·39	6·42	1 : 0·63	......	......	28·01	......	......	Yellowish ...	Weathered; black, compact, with shining faces.
Souris Valley—Layer 19.........	XXIV.	13·94	35·00	45·27	5·79	1 : 1·29	......	......	38·35	......	......	Yellow brown.	Weathered specimen, separating into horizontal laminæ.
Souris Valley—Lowest lignite, 2ft. 3in. thick..................	XXV.	12·07	39·74	45·44	2·75	1 : 1·14	......	......	38·90	......	......	Reddish white.	Conchoidal fracture, with rather dull surfaces; resembles cannel coal.
Rainy River—Near Fort Francis, E. of Lake of the Woods......	XXVI.	15·45	33·70	43·45	7·40	1 : 1·29	......	......	......	......	......	Yellowish-grey	Compact and showing woody structure.
Dirt Hills, Middle Bluff—Lowest seam	XXVII.	15·50	33·74	47·00	3·76	1 : 1·39	15·50	35·96	44·78	3·76	1 : 1·24	Light yellowish brown..	Black, with shining resinous lustre and sub-conchoidal fracture; an imperfect coke by rapid heating.
Dirt Hills—Quarter way up E. Bluff.......................	XXVIII.	17·53	34·61	40·24	7·62	1 : 1·16	17·53	35·47	39·38	7·62	1 : 1·11	Pale brownish grey	Almost black, and splitting into laminæ; fracture sub-conchoidal; lustre resinous; a slight disposition to coke.
Dirt Hills, Middle Bluff—2nd seam	XXIX.	16·69	36·87	41·18	5·26	1 : 1·12	16·69	37·89	40.16	5·26	1 : 1·06	Pale yellowish grey	Brownish black; shows slight woody structure; sub-conchoidal; resinous.
Dirt Hills, Middle Bluff—4th seam.	XXX.	19·33	33·07	39 96	7·64	1 : 1·21	19·33	33·27	39·76	7·64	1 : 1·19	Pale yellowish brown	Dark brownish-black; friable; fracture uneven; a slight disposition to coke.
Dirt Hills—Bare Hill...........	XXXI.	14·80	34·76	47·20	3·24	1 : 1·36	14·80	36·64	45·32	3·24	1 : 1·24	Pale brownish yellow......	Almost black; slight woody structure, and sub-conchoidal fracture; cokes imperfectly by rapid heating.
Woody Mountain—First Hill, lowest seam..................	XXXII.	12·26	37·60	46·98	3·16	1 : 1·25	12·26	41·51	43·07	3·16	1 : 1·04	Pale greyish yellow......	Distinct woody structure; dark brownish black to black; sub-conchoidal; resinous.
Woody Mountain—First Hill, thickest seam................	XXXIII.	18·61	37·73	38·95	4·71	1 : 1·03	18·61	39·11	37·57	4·71	1 : 0·96	Pale brownish grey......	Brown; shows woody structure; fracture uneven; lustre resinous.
Main Moose River..............	XXXIV.	11·74	39·60	45·82	2·84	1 : 1·16	11·74	41·39	44·03	2·84	1 : 1·06	Light yellowish-grey....	Black, inclining to brown; decided woody structure.
Sander's River—A branch of Swan River	XXXV.	18·83	26·32	50·70	4·15	1 : 1·93	18·83	28·02	49·00	4·15	1 : 1·81	Light buff....	Nearly black, and showing woody structure.

Resin from
North
Saskatchewan.

Resin from
Peace River.

Resin from
Nechacco River.

resinous lustre and conchoidal fracture. It begins to soften at about 143° C., and at 177° C. becomes somewhat viscous and elastic; at 216° C. begins to run, but even at 282° C. runs with difficulty. In the closed tube intumesces, gives off water, and is converted into a yellowish oil.

On account of not having sufficient material, no analyses were made; but it is evident from the characters given that none of these resins can strictly be referred to succinite or amber, although having many points of resemblance to that body. The solubility of the first in alcohol precludes it from being so called, while the deportment of the others on heating is different from that of amber. Nor, so far as I am aware, do they coincide exactly in characters with any of the so-called species of resins heretofore described. They, accordingly, may be simply classed under the general term of mineral resins—bodies, many of which are about as deserving of specific names as would be the different varieties of mineral coal. It will be remembered that Geoppert, many years ago, stated that he knew of no instance of true amber being found in the brown coal beds of Northern Germany, the substance found in those beds being "retinite."

IRON ORES.

Red Hematite.

1. *East Bay, Cape Breton.*—A red hematite, from the north side of East Bay, Cape Breton, half-way between East Bay and Boisdale, and about seventeen miles from Sydney, has recently been examined. The specimens were collected by Mr. Hugh Fletcher, of the Geological Survey, and stated to have been broken from different parts of the bed, in order that the average composition of the ore might be ascertained as nearly as possible. They consisted of hematite, varying in texture from earthy to compact, and in colour from red to steel-grey, here and there also containing minute scales and veins of specular ore. Most of the fragments were calcareous, and one contained numerous scales of talc. Determinations of the more important constituents gave the following results:—

Hematite from Cape Breton.

Peroxide of iron	85·037
Phosphoric acid	0·032
Sulphur	0·075
Silica	5·130
Metallic iron	59·526

According to Mr. Fletcher,[*] the ore occurs as a bed from five to nine

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[*] Report of Progress, 1875-76, p. 414.

feet thick in the George River limestone. If the deposit is as extensive as supposed, and of such quality as the specimens analysed, it will, no doubt, prove of much importance.

Hematite from Flamborough.

2. *Flamborough, Ontario.*—The proportion of iron in a specimen of impure, calcareous and fossiliferous red hematite from the eleventh lot of the first range of Flamborough, was, at your request, determined. The specimen was in the Survey Museum, and collected many years ago by Professor Bell; it contained only 28·50 per cent. of iron, equal to 40·71 per cent. of peroxide, and is no doubt the " red, ferruginous, calcareo-arenaceous rock " or " very earthy hematite " mentioned on page 314 of the Geology of Canada. A specimen from the continuation of the same deposit, near Ancaster, was found by Dr. Hunt to contain 37·80 per cent. of iron.*

TITANIFEROUS IRON ORES.

Titaniferous iron ores.

1. *Shawenegan, Quebec.*—The occurrence of magnetite in the township of Shawenegan has frequently been reported, and during the past winter specimens of the so-called ore, said to occur on lots nineteen, twenty-one and twenty-two of the seventh range, were brought to the Survey laboratory for examination. One of the specimens, which was regarded by the owner as an especially rich iron ore, consisted wholly of a heavy, black pyroxene, while the other was poor in iron and at the same time contained a considerable proportion of titanic acid. Quantitative determinations of iron and titanic acid in this specimen gave :—

Iron	34·64
Titanic acid	10·07

It was readily attracted by the magnet, dark iron-grey in colour, rather fine-grained and associated with a plagioclase feldspar, black hornblende, quartz and a little hypersthene. The owner of the specimens, it is needless to say, was disappointed with the above results, as he had, without having any previous examination of the ore made, spent a considerable sum of money on the property.

2. *Ste. Julienne, Quebec.*—Owing to litigation in connection with the deposit of titanic iron occurring in the Upper Laurentian rocks at Ste. Julienne, in the township of Rawdon,† I have several times been called upon to examine specimens of the ore, by way of establishing its true character. The result has shown very little variation from the composition originally given, viz. :—

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* Geology of Canada, 1863, p. 682.

† See Report of Progress, 1873-74, p. 227.

Iron	38·27
Titanic acid	33·67

A specimen subsequently examined gave:—

Iron	40·71
Titanic acid	33·64

while a third, in which iron was not determined, was found to contain 35·09 per cent. of titanic acid.

MAGNETIC IRON ORE.

Magnetite of Texada Island.

1. *Texada Island, British Columbia.*—A specimen of the magnetic iron ore from this locality, collected by Mr. James Richardson, was of an iron-grey colour, and contained numerous little cavities, holding red or yellow ochre, and sometimes lined with octahedral crystals of magnetite. It was found to contain:—

Metallic iron	68 400
Phosphoric acid	0·006
Insoluble matter	3·446

Other constituents were not determined. The iron, if calculated as magnetic oxide, equals 94·46 per cent. A more complete analysis of this ore has been published by Professor Chapman, of Toronto, and may be cited here, as the deposit appears to be one of importance.* It is as follows:—

Protoxide of iron	28·33	Metallic iron, 69 p.c.
Sesquioxide of iron	67·31	
Oxide of manganese	trace	
Titanic acid	0·11	
Phosphoric acid	0·07	
Sulphuric acid	0·09	
Insoluble siliceous matter	3·97	
	99·88	

In a second trial Professor Chapman obtained 68·94 per cent. of iron, which differs by about only half per cent. from the amount found in Mr. Richardson's specimen. The proportion of phosphoric acid is low in both analyses, though considerably higher in Professor Chapman's than in mine.

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* "Canadian Journal," April, 1877, p. 22.

SPATHIC IRON ORE.

Spathic iron ore.

1. *Indian Point, Boulardrie, Cape Breton.*—A specimen of impure spathic iron ore was brought last season from Boulardrie by Mr. Hugh Fletcher, who states that it occurs in the form of a bed not far below the rocks of the Millstone grit formation. The spathic ore of Sutherland's River, it will be borne in mind, occurs in sandstones referred to the Millstone grit formation, but is a much more highly crystalline ore than the specimens brought from Boulardrie. Mr. Fletcher's specimen from the latter locality was found to contain 32·58 per cent. of metallic iron, or 67·48 per cent. of the carbonate. It was fine-grained or crypto-crystalline, but contained crevices lined with numerous small crystals of siderite. The weathered surfaces were dark-brown, but those obtained by fresh fracture brownish-grey.

MANGANESE.

Manganese.

A specimen of manganese, from the 6th lot of the 14th range of Cleveland, Quebec, has recently been examined, with the view of ascertaining what proportion of peroxide it contained. The manganese was mixed with angular fragments of quartz and greenish slate, and no less than sixty per cent. of the whole material was found to be insoluble in sulphuric acid. By means of a sieve all the larger particles of rock matter were separated and found to amount to fifty per cent. The brownish-black powder, which passed through the sieve was then examined, but gave only 15·15 per cent. of peroxide of manganese.

COPPER ORES.

Copper ore of Polson's Lake.

1. *Polson's Lake, Nova Scotia.*—Two specimens of ore from this locality were examined in December last. The first was taken at a considerable depth from the surface, at a point where the vein is said to be eleven feet thick. It consisted of a mixture of copper pyrites, spathic iron ore and a little iron pyrites, and was found to contain 11·70 per cent. of copper, but no silver. The spathic iron ore is pale brownish-grey in colour, coarsely crystalline, and has a specific gravity of 3·61. It was found to contain 73·68 per cent. of carbonate of iron, or 35·573 per cent. of metallic iron.

The second specimen was from the surface, and consisted of copper pyrites, pale iron pyrites, hydrated peroxide of iron, and some rock matter. It was found to contain 5·67 per cent. of copper.

GOLD AND SILVER.

British Columbia.

Gold and silver assays.

All the specimens from British Columbia of which assays are given below were, with the exception of No. 12, collected by Mr. G. M. Dawson in 1876. They were nearly all large, and selected in such a way as to be as far as possible average samples.

1. Wright's Mine, opposite Barkerville and Richfield.

Translucent white quartz, with small scales of silvery-white mica, and a little iron pyrites in small cubical crystals.

Gold	0·176 oz. to the ton.
Silver	none.

2. Pyritous belt, south side of Stedman ledge, Richfield.

White and bluish, translucent quartz, with massive iron pyrites.

Gold	0·058 oz. to the ton.
Silver	1·312 " " "

3. North side of the Stedman ledge, Richfield.

Milky white quartz with spathic iron ore, and a little slaty matter, iron pyrites and hydrated peroxide of iron.

Gold	trace.
Silver	1·312 oz. to the ton.

4. Lowhee Creek vein.

About a dozen specimens, selected from a heap of 7,000 lbs., and consisting of white and rusty quartz, with a little galena and iron pyrites.

Gold	trace.
Silver	1·56 oz. to the ton.

5. South Casing, Big Bonanza, between Williams and Lowhee Creeks.

Fragments of rusty quartz and slate.

Gold	0·064 oz. to the ton.
Silver	0·023 " " "

6. Upper or North Casing, Big Bonanza, between Williams and Lowhee Creeks.

Rusty quartz and slaty matter, from which iron pyrites has apparently been removed by weathering.

Gold	trace.
Silver	none.

7. Big Bonanza, between Williams and Lowhee Creek.

So-called "blue quartz," consisting of white quartz mixed with dark bluish-grey slaty matter.[*]

Gold	trace.
Silver	none.

8. Sadoux Ledge, Mosquito Creek.

Rusty quartz and mica slate.

Gold	0·175 oz. to the ton.
Silver	0·802 " " "

9. Sadoux Ledge, Mosquito Creek.

Milky white quartz, coated with hydrated peroxide of iron, and containing numerous cavities, which have probably at one time been filled with cubical crystals of iron pyrites.

Gold	0·058 oz. to the ton.
Silver	0·233 " "

10. Five-foot cross-vein, Stout's Gulch.

White quartz with iron pyrites, occasionally in cubical crystals.

Gold	0·335 oz. to the ton.
Silver	0·131 " " "

11. Ledge at the forks of the Slaughter House Road, Barkerville.

White quartz with iron pyrites and a little slaty matter.

Gold	0·117 oz. to the ton.
Silver	1·123 " "

12. Eureka Mine, Fort Hope.

A yellowish decomposed veinstone, resembling that mentioned in the Report for 1873-74, page 7. The specimen was broken from a mass obtained by Mr. Richardson for the Philadelphia Exhibition. It contained—

Silver	221·666 oz. to the ton.

Possibly other lodes in the Cariboo region will be found to contain larger proportions of the precious metals than those of which assays

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[*] Since these assays were made, other specimens from the Big Bonanza lode have been received. (February, 1878) One of them, consisting of white quartz, with much iron pyrites and black carbonaceous matter, contained—

Gold	0·554 oz. to the ton (value $11.45)

It was reported to contain $90 to the ton. Another, consisting of quartz, with a little iron pyrites and some carbonaceous matter, gave—

Gold	0·0729 oz. to the ton
Silver	0·3354 " "

are given above. But it is not necessary to suppose that the lodes are the only source from whence the alluvial gold is derived; for, as in Colorado, it may in some cases be found to be in some of the volcanic rocks bordering the gold field.

Gold in volcanic rocks.

On referring to a recent report of Prof. J. J. Stevenson, of New York University, on the Geology of a portion of Colorado, I find, under the heading "Economic Geology of the Eruptive Rocks," the following, which may be of interest in this connection. Professor Stevenson says: "The older and more compact trachytes forming the dikes in the main divide between South Park and Blue River, have been found by Mr. Alfred Dubois to be auriferous in every case where analyzed. The proportion is too small to admit of working, as it is usually little more than a trace. The same is true of the quartzites, both Silurian and Carboniferous in the same vicinity; but the volcanic rocks are the richer. These rocks are the source of the free gold in several very extensive 'flats' where gulch-mining has been carried on. On Tarryall Creek, in South Park, this is most markedly the case, for in the Hamilton Pass, from which the stream flows, the only rocks present are the quartzites and trachytes, the latter predominating. In former times this was one of the most important gulch mines, and even now, after having been rudely washed out by the old methods of hand-washing, yields to the hydraulic miner an average of $4 a day for each man employed. On the Blue River side of the divide, the placers are still rich, and are worked very extensively by strong companies."*

Lake Superior, Lake Huron, &c.

1. Cameron's Location, Bachewana Bay, Lake Superior.

Coarse and fine granular galena associated with quartz and iron pyrites. Assays of the coarse-grained portion gave—

Silver	15·069 oz. to the ton.

The specimen was obtained from Mr. Charles Robb.

2. Jackfish Bay, north shore of Lake Superior. "From the principal known gold-bearing vein of Victoria Cape."

The specimen was collected by Professor Bell, and consisted of pale iron pyrites with white translucent quartz. It contained—

Gold	0·198 oz. to the ton.
Silver	5·400 " " "

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* Report on the Geology of a portion of Colorado, examined in 1873, p. 423.

3. Near Partridge Lake.

The specimen consisted chiefly of white quartz with small quantities of iron and copper pyrites. It was obtained from a lode said to be from five to seven feet thick. Assays which were made of it several years ago gave—

Gold	1·336 oz. to the ton.
Silver	none.

4. Little Whale River, on the east side of Hudson's Bay. From a vein which is said to have been worked by the Hudson's Bay Company.

Coarsely crystalline galena, rather pale in colour, associated with brownish-grey, fine-grained dolomite. The specimen was obtained from Professor Bell, and assays by scorification gave—

Silver	5·104 oz. to the ton.

5. Victoria Mine, eight miles north of the mouth of Garden River (near Sault Ste. Marie).

Coarsely crystalline galena, with curved faces, associated with zinc blende, copper pyrites and quartz. The galena, after careful separation from the other minerals, was found to contain—

Silver	168·437 oz. to the ton.

This specimen was obtained by Mr. Frank Adams, who accompanied Professor Bell in his exploration of 1876. The yield of silver is far in excess of anything which I have obtained in other specimens from the same locality, as will be seen from the following assays:—

Victoria Mine, Garden River. (Same locality as No. 5.)

A surface specimen, taken at the west shaft, and consisting of fine granular galena, with quartz, feldspar and a little copper and iron pyrites. It contained—

Silver	2·187 oz. to the ton.

This and the two following specimens were collected by Professor Bell.

7. Victoria Mine, Garden River (same locality as Nos. 5 and 6, adjoining the foot-wall on the east side of the main shaft.

Fine and coarse granular galena, associated with iron pyrites and quartz.

Silver	12·396 oz. to the ton.

8. Specimen marked "Colin Campbell's mine, E.N.E. of Sault Ste. Marie, and twelve miles west of Echo Lake;" probably the same locality as Nos. 5, 6 and 7.

Fine granular galena mixed with iron pyrites.

Silver	7·291 oz. to the ton.

Quebec and Nova Scotia.

Gold and silver assays—Quebec and Nova Scotia.

1. Hatley Township, Quebec, Lot 14, Range 6.

Ferruginous quartz and chlorite, containing—

Gold	trace
Silver	2·19 oz. to the ton.

2. Imperfectly roasted copper ore from the Suffield Mine, near Sherbrooke.

This material was examined several years ago, but the results not published. The figures, however, are so often asked for, that they are given here. Although the ore had been roasted, it contained numerous lumps of undecomposed zinc blende. Determinations of copper and silver gave—

Copper	2·31 per cent.
Silver	10·28 oz. to the ton.

Samples of somewhat similar material, from the same place, since examined by Mr. Hoffmann, contained only about half this amount of silver, or 5,104 oz. to the ton.*

3. Portland Township, Quebec. (?)

Although thus marked, it is not likely that this specimen ever came from Portland Township at all, but rather from Lake Superior. It was, in accordance with your instructions, examined for Mr. Holland, of Ottawa, and found to consist of silver glance, native silver, fine granular galena, colourless quartz, and pinkish-white dolomite. The proportion of silver amounted to no less than 4,388·406 oz. to the ton of 2,000 lbs.

4. Joggins Coal Mine, Nova Scotia.

Coarsely crystalline galena, very pale in colour, and mixed with white calcite and black coaly matter. The specimen was from Mr. A. J. Hill, C.E., who found it in the underclay of the Cumberland seam at the Joggins. The galena is stated to fill

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* Report of Progress, 1875-76, p. 431.

fissures conformable to the line of a "trouble," and to come into contact with the coal. It was assayed for silver, but contained only the merest traces.

5. Cape Breton.

This specimen was examined for W. Macdonald, Esq., M.P., of Cape Breton, but was not labelled when received, so that the exact locality is not known. It consisted of a mixture of galena and calcite, with small quantities of copper and iron pyrites, but contained no silver. Two other specimens were also examined for Mr. Macdonald in 1875, the localities of which are not known. The first consisted of galena, with calcite and copper and iron pyrites. It contained 62·25 per cent. of lead, but only the merest trace of silver. The second specimen was somewhat similar in appearance, but contained more gangue and no copper pyrites. On assay it yielded 49·25 per cent. of lead and a mere trace of silver

IRON PYRITES.

Iron pyrites from St. Jerome.

St. Jerome, Quebec.—Under this heading may be noticed a deposit which has been reported to be "rich in silver and copper," and which occurs on the farm of Charles Lafontaisie, on lot 163 of the cadastral plan of the parish of St. Jerome. It appears to be a vein at or near the junction of a band of glassy quartzite with a thin band of mica-schist, and consists chiefly of hornblende or pyroxene and feldspar, with strings, bunches and occasional crystals of iron pyrites—the whole having an exceedingly *lean* appearance. A large specimen was ground up and the heavier metals separated as far as possible by washing, and then assayed for gold and silver, with the following results:—

Gold	trace.
Silver	0·0875 oz. to the ton.

A carefully picked sample of the pyrites was also examined for copper, cobalt and nickel, and found to contain—

Copper	0·05	per cent.
Cobalt	0·22	"
Nickel	0·10	"

The pyrites, it may be mentioned, constitutes only a small proportion of the supposed vein, which cannot be regarded as of economic importance. The specimens examined were taken at about nine feet from the surface.

SERPENTINE, RENSSELÆRITE, LIMESTONE AND DOLOMITE.

Serpentine.

Pigeon Lake.—The occurrence of serpentine at Pigeon Lake, on Montreal River (Ottawa Valley), is described by Professor Bell, in his report for 1875-76. He says :—" Pigeon Lake is upwards of five miles long. On its north-east shore, at one mile up, a fine-grained, greyish-red syenite occurs. About a mile further up the same side of the lake, there is a bluff of light greenish-grey, finely-crystalline diorite, with disseminated grains of iron pyrites. A small island, in the middle of the lake, opposite this point, is composed of very dark green serpentine, with strings of calcspar and chrysotile. Fresh fractures have a somewhat mottled appearance, and occasionally present surfaces of a striated or finely columnar shining aspect. The natural surface has a rough or 'lumpy' character, and weathers to a rusty colour. * * * In the next half-mile are two more islets in the middle of the lake. The rocks of these, and of the south-west shore opposite, consist of similar and lighter green serpentine, largely mixed with calcspar, constituting, in fact, a sort of limestone in the third islet. In some parts the serpentine is divided into separate pieces by thickly reticulating strings and veins of crystalline and granular light-grey calcspar, leaving the latter scattered as angular fragments through the mass."

The characters given by Professor Bell, it may be observed, might be applied almost word for word to some of the serpentines of the Eastern Townships, which are known to contain varying admixtures of carbonates, passing here and there into limestones or dolomites, and in some instances to have a brecciated structure like the last variety described in the above extract. The Pigeon Lake serpentine also resembles those of the Townships in containing chromium and nickel. A specimen of the rock from the island first mentioned gave, on analysis, the following results :—

Analysis of serpentine from Pigeon Lake.

Silica	34·591
Alumina	2·391
Chromic oxide	0·382
Ferrous oxide	8·660
Manganous oxide (with a little nickel and cobalt)	0·244
Lime	3·625
Magnesia	32·253
Grains of chromic iron	0·280
Water and carbonic acid, by loss	17·574
	100·000

The colour was blackish-green, mottled with olive green, the fresh fracture splintery and mostly dull, but here and there presenting shining surfaces. In places the rock is traversed by minute veins, consisting of carbonates of lime, magnesia and iron. In the above analysis the carbonates were not separated, but another fragment of the rock yielded to acetic acid in the cold 21·378 per cent., the proportions of which, calculated for a hundred parts, were as follows :—

Carbonate of lime	37·90
Carbonate of magnesia	51·95
Carbonate of iron	10·15
	100·00

The carbonate of magnesia is considerably in excess of what would be required to form dolomite with the carbonate of lime, so that there must be some magnesite present, and the rock is either a *dolomitic* or a *magnesitic ophiolite.*

RENSSELÆRITE.

Rensselærite from Portage du Fort.

Portage du Fort.—A bed of rensselærite or pyrallolite has recently been found by Mr. Vennor in the Laurentian rocks of Portage du Fort. A specimen obtained from him for analysis was whitish to pale greenish-grey in colour, compact or crypto-crystalline, slightly waxy and translucent on the edges. It was mostly free from admixed minerals ; but in places contained crystals of a white mineral, which is probably tremolite. One of the surfaces of the specimen was worn by the action of water into curious grooves and pits, and had assumed in places a brownish-red colour from the peroxidation of the iron. A portion of the mass, apparently free from tremolite, was selected for analysis. Its hardness was 2·5, specific gravity 2·743, and composition as follows :—

Silica	61·33
Ferrous oxide	0·67
Magnesia	31·78
Lime	trace.
Water (ign)	5·85
	99·63

If we regard it as a product of the alteration of hornblende or pyroxene, its similarity in composition to that from other localities is most striking, as will be seen by a comparison with the following analyses by Dr. Hunt of specimens from Grenville (I.) and Charleston Lake (II.):—*

	I.	II.
Silica	61·60	61·90
Ferrous oxide	1·53	1·45
Magnesia	31·06	30·42
Water	5·60	6·54
	99·79	100·31

LIMESTONES AND DOLOMITES.

The following analyses were in part made, in order to ascertain whether certain rocks, most of which are employed for structural purposes, were true limestones or dolomites. Specimens of most of them were exhibited at Philadelphia among the building stones.

Limestones from Peace River.

1. *Peace River.*—A limestone described in your report for 1875-76, page 75, as an impure carbonaceous limestone, and containing fossils, referred by Mr. Whiteaves to *Monotis subcircularis* Gabb. The specimen examined was rather earthy, blackish-grey in colour, and contained numerous fragments of *Monotis*. Its specific gravity was found to be 2·67, and an analysis gave:—

Carbonate of lime	48·47
Carbonate of magnesia	5·85
Carbonate of iron	0·85
Insoluble matter	42·26
Carbonaceous matter, water and loss	2·57
	100·00

Another specimen from Peace River was lighter in colour than the last, being less carbonaceous, but also very impure, more than half its weight consisting of insoluble matter. The results of its analysis are as follows:—

Carbonate of lime	38·98
Carbonate of magnesia	7·59
Carbonate of iron	1·14
Insoluble matter	51·13
Carbonaceous matter, water and loss	1·16
	100·00

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* Geology of Canada, 1863, p. 471.

Whether this is from the same bed as the last I am not aware. It does not, however, differ from it essentially in composition.

Limestone from Pembroke.

2. *Pembroke, O., Lot* 12, *Range* 1.—The Chazy formation at this locality affords good limestone for building purposes, in beds from three to eighteen inches thick. An analysis of a specimen gave:—

Carbonate of lime	83·96
Carbonate of Magnesia	9·29
Carbonate of iron	0·69
Insoluble	6·06
	100·00

The stone is light brownish-grey in colour, compact, and breaks with a conchoidal fracture.

Limestone and dolomite from McNab.

3. *McNab, Ontario.*—The Calciferous formation in many localities affords material which answers for building purposes, and appears to be very durable, though often difficult to dress. In some cases the rock is limestone, but it seems to pass by insensible gradations into dolomite, the prevailing rock of the formation. A specimen of the limestone from near Arnprior, on the 11th lot of the third range of McNab, was found to contain,

Carbonate of lime	81·78
Carbonate of magnesia	13·68

It is compact and dark brownish-grey when fractured, although when tool-dressed it has rather a bluish-grey tint. When polished it shows sections of fossils and presents a mottled surface of dark-grey, with patches of light-grey and yellowish-brown.

Another specimen from the same set of beds, but considerably lower down in the formation, was light brownish-grey in colour, and dotted with occasional crystals of white calcite. When polished it presented a mottled appearance like the limestone just described, the colours, however, being much paler. As shown by the following determinations it is a dolomite:—

Carbonate of lime	53·00
Carbonate of magnesia	43·88

The specimen came from an old quarry on the 9th lot of the 14th range of McNab.

Dolomite from Grimsby.

4. *Grimsby, Ontario.*—In the Niagara formation at Grimsby there are beds of dolomite, one to three feet thick, from which stone has been obtained for building purposes. The rock is crystalline, brownish-grey

in colour, and holds a few fossils. Some of it when dressed with a plane surface has a pitted appearance. Analysis of a specimen gave :—

Carbonate of lime	68·92
Carbonate of magnesia	29·48
Carbonate of iron	1·10
Insoluble matter	0·50
	100·00

Dolomite from Dundas.

5. *Dundas, Ontario.*—At this locality the Niagara formation also affords a dolomite, a specimen of which proved, on analysis, to contain much more carbonate of magnesia than was found in the specimen from the same formation at Grimsby. The analysis gave—

Carbonate of lime	51·85
Carbonate of magnesia	41·65
Carbonate of iron	0·62
Insoluble matter	5·88
	100·00

The specimen was brownish-grey, compact and rather earthy.

Dolomite from Little Metis.

6. *Little Metis, Quebec.*—Interstratified in that great series of shales and sandstones which stretches along the south shore of the Gulf of St. Lawrence, there are numerous thin beds of limestone and dolomite, the latter rock, however, appearing to be the more common. They are well seen along the coast at Little Metis, and a specimen taken from directly behind the house of Mr. Turiff was found to contain—

Carbonate of lime	35·46
Carbonate of magnesia	26·40
Carbonate of iron	4·67
Insoluble matter	35·46
	98·72

It is very fine-grained and breaks with a conchoidal fracture. Much of it is traversed by minute veins of white calcite. Colour of the dolomite, light brownish-grey. In the same series of shales there are often thin bands of quartzite, which look very like the more compact dolomites, being of very much the same colour. They have, however, a more glistening appearance, and are, of course, much harder.

A little below the church, at the village of Sandy Bay, the black shales often contain bands, generally from half-an-inch to an inch thick, of a curious columnar limestone, with the columns at right angles to the bedding. It has not been analyzed, but judging from its action with acids, does not appear to be dolomitic. A similar limestone is found at many points further down the gulf.

Limestone from Fort Pelly.

7. *Fort Pelly.*—A specimen from the calcareous band, which was reached at a depth of 259 feet in the boring on Swan River, near Fort Pelly, has been examined by Mr. F. Adams in the laboratory of McGill College, and found to contain no less than 90·53 per cent. of carbonate of lime.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

BY

CHRISTIAN HOFFMANN,

ADDRESSED TO

ALFRED R. C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

ON CANADIAN GRAPHITE.

Object of the investigation.

Sir,—I have the honour of herewith submitting to you the results of an investigation into Canadian graphite, undertaken with the object of determining, as far as possible, experimentally the relative value of Canadian graphite, as compared with that from Ceylon, for the manufacture of black-lead crucibles.

The first four analyses here given appeared in my last report; as, however, they are intimately connected with some contained in the present one, it has been thought desirable to incorporate them in this latter.

Brief Outline of some of the Methods Employed in the Prosecution of this Investigation.

Methods employed in the investigation.

1. *Determination of the Specific Gravity.*—Sufficient water having been introduced into the specific gravity bottle to thoroughly immerse the specimen of graphite therein contained, the whole was placed under the receiver of an air-pump, and exhaustion gradually proceeded with. The pumping was repeated at intervals, and until bubbles ceased to escape on further exhaustion. The bottle was then removed, and the necessary adjustments having been made, weighed; after which, a portion of the

Methods employed in the investigation.

water having been withdrawn, it was again placed under the receiver of the air-pump, etc. etc.

2. *Determination of the Volatile Matter.*—This was effected at a full red-heat, with careful exclusion of atmospheric air.

3. *Determination of the Ash.*—The incineration of the graphite was effected in a platinum boat, inserted in a platinum tube; the latter being heated in a gas combustion furnace; a gentle current of pure, dry oxygen gas being passed through the tube during the operation.

4. *Preparation of the Ash for analysis.*—This was conducted in the same manner as in the preceding determination, with the exception that a much larger boat was employed, and the platinum tube was replaced by one of porcelain.

5. *Determination of the Relative Combustibility of the Graphites.*—The methods employed for determining this depended upon the difference in loss sustained by the specimen under trial as compared with that of the specimen of Ceylon graphite employed as the standard, when ignited under precisely identical conditions.

In the selection of the various graphites it was sought to bring them into the nearest possible accordance as regarded the percentage of ash, for which reason the purest obtainable specimens were in all cases chosen. The percentage of ash in the graphites employed in these experiments was determined after ignition, and the necessary corrections were made for the same in calculating the results. The samples were all ignited previous to use, in order to expel volatile matter, thereby insuring that loss from this source should not be attributed to loss by carbon. The graphite was, in all instances, reduced to the same state of mechanical division. Equal weights of the standard, and the sample under trial, were, in all cases, taken, and due care was observed that the two presented equal surfaces, whether employed in the form of a powder or compressed to that of a cylinder. Although the temperature, as also the strength of the current of oxygen, was very uniformly maintained throughout the course of the experiments, still, no dependence was placed upon this, for which reason the sample under trial was invariably accompanied by a specimen of the graphite employed as the standard.

A. *The Apparatus.*—This consisted of a platinum boat, divided longitudinally into two equal compartments by a strip of platinum foil soldered up the centre. The contour of the boat coincided exactly with that of the interior of the porcelain tube in which it was placed, so that a uniform and tolerably close contact of the sides and bottom of the boat with the tube was ensured. The porcelain tube was heated in a gas combustion furnace.

Methods employed in the investigation.

B. *Preparation of the Graphite.*—All the samples of graphite were reduced to the same degree of fineness. In order to ensure the greatest practicable uniformity in this respect, they were sized by being placed first upon a sieve of sixty holes to the linear inch, that which passed through being afterwards placed upon a sieve of sixty-six holes to the linear inch, the portion remaining on the latter constituting the material employed in the following experiments.

C. *Manner of Conducting the Experiments.*—Method I. The graphite was in the form of powder; all the samples were strongly ignited previous to their employment. Having taken the weight of the platinum boat, a portion of the graphite employed as the standard was introduced into the left compartment and the boat weighed, after which an equal quantity of the graphite under trial was weighed off into the right compartment. The samples having been carefully adjusted so as to present, as near as possible, equal surfaces, the boat was introduced into the strongly-headed porcelain tube, through which a gentle current of pure, dry oxygen gas was now passed. At the expiration of such time as sufficed for the burning off of about half of either of the specimens, the boat was withdrawn and weighed. This weight, substracted from the weight of the boat prior to insertion, gave the total loss. The residual graphite in the right compartment having been carefully removed, the weight of the boat was again noted; this weight subtracted from the weight of the boat, after inserting the graphite in the left compartment, gave the loss upon the sample therein contained, which loss, subtracted from the total loss, gave, by difference, the loss sustained by the sample contained in the right compartment. In making the control experiment, the position of the samples was reversed; that is to say, the graphite employed as the standard was, on this occasion, introduced into the right compartment, whilst the graphite under trial now occupied the left. By this arrangement, also, the loss by difference fell alternately upon the specimen employed as standard, and the one under trial

Method II. The graphite was in the form of cylinders. The various samples having been strongly ignited, were compressed in a steel mould into a compact cylindrical form. In preparing the cylinders it was sought to employ, as near as possible, the same pressure in all cases. As, however, there was a possibility of a slight variation occurring in this respect, the further precaution was taken of weighing out equal quantities of the various graphites, and compressing them into cylinders of equal length. The cylinders, which weighed, as near as possible, two grammes each, were twenty-six millimetres in length and seven millimetres in diameter. They had a beautifully smooth glassy surface, and were perfectly firm. The experiment was conducted in a precisely similar manner to that described under method 1. A cylinder of the standard graphite invariably accompanied a cylinder of the specimen under trial, being laid abreast of each other—one in either compartment.

Canadian Graphite—Disseminated Graphite.

1. *Disseminated Graphite.*

From the twenty-eighth lot of the sixth range of Buckingham. The property of the Montreal Plumbago Mining Company. An exceedingly important deposit. The specimen examined was regarded as a fair average of one of the largest and most extensively worked beds of disseminated graphite in this whole section. The bed averages eight feet, and runs across the whole of this lot and into lot twenty-seven in the seventh range, (the property of the Buckingham Mining Company),—authority, Mr. H. G. Vennor.

Analysis of "Disseminated graphite" from Buckingham.

The graphite, which occurs in scales, is so closely and evenly distributed through the rock as almost entirely to mask its nature. The mineral contains some calcite; the presence of a small quantity of pyrrhotite or magnetic pyrites, was also established. The powdered rock is attacked by hydrochloric acid; this acid, with the aid of heat, dissolved out 17·539 per cent.; the solution was found to contain:

Silica	very small quantity.	Lime	large quantity.
Alumina	very large "	Magnesia	small "
Iron	rather large "	Cobalt	trace.
Manganese	small "	Alkalies	not sought for.

The rock contains:

Graphite	27·518
Rock matter, soluble in hydrochloric acid	17·539
Rock matter, insoluble in hydrochloric acid	54·899
Hygroscopic water	0·044
	100·000

2. *Disseminated Graphite.*

Analyses of "Disseminated graphite" from Buckingham.

From the twenty-second lot of the sixth range of Buckingham. The property of the Buckingham Mining Company. Several important beds of disseminated graphite occur towards the front of this lot. They have as yet only been uncovered. The specimen examined was considered a fair average of one of the most important beds.—Authority, Mr. H. G. Vennor.

The graphite, which occurs in scales, is evenly distributed through the rock; the latter was very much decomposed, and coloured brownish-yellow to reddish-brown from the presence of ferric hydrate. The rock contained no calcite; a small quantity of pyrrhotite was, however, shown to be present. Hydrochloric acid, with the aid of heat, dissolved out from the powdered rock 19·467 per cent.; the solution was found to contain:

Silica	very small quantity.	Lime	large quantity.
Alumina	large "	Magnesia	" "
Iron	" "	Cobalt	trace.
Manganese	small "	Alkalies	not sought for.

The rock contains:

Graphite	22·385
Rock matter, soluble in hydrochloric acid	19·467
Rock matter, insoluble in hydrochloric acid	56·408
Hygroscopic water	1·740
	100·000

3. *Disseminated Graphite.*

From the twentieth lot of the eighth range of Buckingham. The property of the Dominion of Canada Plumbago Company. From a large bed of disseminated graphite, probably of considerable extent. The specimen examined was considered a fair average.—Authority, Mr. H. G. Vennor.

The graphite is pretty evenly disseminated in scales throughout the rock. The latter contains some calcite, as also small quantities of pyrrhotite. The powdered mineral is freely attacked by hydrochloric acid, which, with the aid of heat, dissolved out 21·285 per cent.; the solution was found to contain:

Analyses of "Disseminated graphite" from Buckingham.

Silica	very small quantity.	Lime	large quantity.
Alumina	very large "	Magnesia	moderate quantity.
Iron	large "	Cobalt	trace,
Manganese	small "	Alkalies	not sought for.

The rock contains:

Graphite	23·798
Rock matter, soluble in hydrochloric acid	21·285
Rock matter, insoluble in hydrochloric acid	53·741
Hygroscopic water	1·176
	100·000

4. *Disseminated Graphite.*

From the twenty-third lot of the sixth range of Buckingham. The property of the Buckingham Mining Company.

This deposit has been traced through into the seventh range. It would appear to be a bed whose position is conformable to the stratification of the beds of disseminated graphite, and connecting with the true fissure veins which cross these beds. The rock consists of quartz and a feldspar, and is traversed by more or less disconnected lenticular layers of a twisted, fibrous graphite. These layers, which vary greatly in thickness, may, perhaps, justly be regarded as interstratified veins. As yet the ground has only been uncovered, but it is considered probable that the rocks for a transverse measurement of some fifteen to twenty feet would yield largely. The specimen examined was considered a pretty fair average.—Authority, Mr. H. G. Vennor.

The rock contained no calcite; the presence of a small quantity of pyrrhotite was, however, established The powdered mineral was very little acted upon by hydrochloric acid; this acid, by the aid of heat, dissolved out only 2·475 per cent.; the solution was found to contain:

Silica	trace.	Lime	small quantity.
Alumina	small quantity.	Magnesia	" "
Iron	" "	Cobalt	trace.
Manganese	very small quantity.	Alkalies	not sought for.

The rock contains:

Graphite	30·516
Rock matter, soluble in hydrochloric acid	2·475
Rock matter, insoluble in hydrochloric acid	66·874
Hygroscopic water	0·135
	100·000

Mode of extracting the graphite from the "Disseminated graphite."

The following is a brief outline of the method hitherto employed in the separation of the graphite from the material in which it is disseminated. It is the one which was adopted at the Lochaber Plumbago Company's works, and more recently, at the Canada Plumbago Company's works. The little information that could be obtained on this subject differs but in few particulars from the description of the process given by Sir W. E. Logan.* It will be seen that the dressing is based entirely upon mechanical principles.

The works include a stamping mill, round buddles, slime pits, etc., etc. The crude ore is stamped fine in water and then put through the buddles, by which the graphite and the rock matter associated with it are separated from one another according to their specific gravities. The former, being the lighest, gradually reaches the outer ring; while the latter, being heavier, remains in the centre. The graphite is, subsequently, charged into a reverberatory furnace and ultimately passed through the bolter; the gauze of which is of various degrees of fineness, according to the size required in each special grade.

CANADIAN GRAPHITE—DRESSED GRAPHITE.

The following seven examples of "dressed graphite" were received from the works of the Dominion of Canada Plumbago Company for the special purpose of examination. The material from which they were prepared was taken from a bed of "disseminated graphite," occurring on the twentieth lot of the eighth range of Buckingham. The results of the analysis of what was regarded as a fair average sample of this bed will be found given under analysis 3. The "A 0" grade was in the form of an impalpable powder, and from this they uniformly increased in size of flake up to "A 6" grade, which was the coarsest.

5. *Dressed Graphite.*

Analyses of "Dressed graphite.'

Grade known as "A 0."—Designed employment: electrotyping, pencils. After drying at 100° C. this specimen was found to contain:

Ash per cent.. 17·682.

Colour of the ash light-brownish-red; a portion placed upon moist turmeric paper manifested an alkaline reaction.

Hydrochloric acid dissolved out of this graphite a considerable quantity of iron, alumina, lime and magnesia, especially of the first named; no other constituents were sought for. This graphite contains some calcite.

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* Reports of the Geological Survey, 1863–66.

6. *Dressed Graphite.*

Analyses of "Dressed graphite."

Grade known as "A 1."—Designed employment: lubricating, pencils, pianos.

After drying at 100° C. this specimen was found to contain:

Ash per cent.................................... 5·143.

Colour of the ash reddish-brown; a portion placed on moist turmeric paper manifested an alkaline reaction. The ash contained a little mica.

Hydrochloric acid dissolved out of this graphite a considerable quantity of iron, alumina, lime and magnesia, especially of the first named; no other constituents were sought for. This graphite contains some calcite.

7. *Dressed Graphite.*

Grade known as "A 2."—Designed employment: lubricating, pencils, paints, powder, shot.

After drying at 100° C. this specimen was found to contain:

Ash per cent.................................... 10·737

Colour of the ash reddish-brown; a portion placed on moist turmeric paper manifested an alkaline reaction. The ash contained a little mica.

Hydrochloric acid dissolved out of this graphite a considerable quantity of iron, alumina, lime and magnesia, especially of the first named; no other constituents were sought for. This graphite contained some calcite.

8. *Dressed Graphite.*

Grade known as "A 3."—Designed employment: crucibles, lubricating.

After drying at 100° C. this specimen was found to contain:

Ash per cent.................................... 7·645

Colour of the ash reddish-brown; a portion placed on moist turmeric paper manifested an alkaline reaction. The ash contained mica.

Hydrochloric acid dissolved out of this graphite a considerable quantity of iron, alumina, lime and magnesia, especially of the first named; no other constituents were sought for. This graphite contained some calcite.

9. *Dressed Graphite.*

Grade known as "A 4."—Designed employment: crucibles, lubricating.

After drying at 100° C. this specimen was found to contain:

Ash per cent.................................... 5·696

Analyses of "Dressed graphite."

Colour of the ash reddish-brown; a portion placed on moist turmeric paper manifested an alkaline reaction. The ash contained mica.

Hydrochloric acid dissolved out of this graphite a considerable quantity of iron, alumina, lime and magnesia, especially of the first named; no other constituents were sought for. This graphite contained some calcite.

10. *Dressed Graphite*

Grade known as "A 5."—Designed employment: crucibles, lubricating.

After drying at 100° C. this specimen was found to contain:

Ash per cent.................................... 4·407

Colour of the ash reddish-brown; a portion placed on moist turmeric paper manifested an alkaline reaction. The ash contained mica.

Hydrochloric acid dissolved out of this graphite a considerable quantity of iron, alumina, lime and magnesia, especially of the first named; no other constituents were sought for. This graphite contained some calcite.

11. *Dressed Graphite.*

Grade known as "A 6." Designed employment: crucibles, lubricating.

After drying at 100° C., this specimen was found to contain:

Ash per cent.................................... 3·638

Colour of the ash, reddish-brown. A portion placed on moist turmeric paper manifested an alkaline reaction. The ash contained mica.

Hydrochloric acid dissolved out of this graphite a considerable quantity of iron, alumina, lime and magnesia, especially of the first named. No other constituents were sought for. This graphite contained some calcite.

12. *Dressed Graphite.*

This sample was also received from the works of the Dominion of Canada Plumbago Company.

The grade was not specified. It was prepared from material from the same bed of "disseminated graphite" as the preceding samples. The results of its analysis are given, not with the object of showing its degree of purity, but as illustrative of the beneficial results attendant upon the employment of hydrochloric acid in the final stage of preparation of these "dressed graphites."

After drying at 100° C., this specimen was found to contain:

Ash per cent.................. .... 13·152

Analyses of "Dressed graphite."

Colour of the ash, light reddish-brown. A portion placed upon moist turmeric paper manifested an alkaline reaction. The ash contained mica.

A portion of this graphite was digested with hydrochloric acid, which removed a considerable quantity of iron, alumina, lime and magnesia, a little silica, and traces of manganese. No other constituents were sought for.

The residual graphite having been carefully washed and dried at 100° C., was found to contain:

Ash per cent	6·690

Colour of the ash, white, with a faint reddish tinge. It contained some mica.

An analysis of this ash gave 79·972 per cent. silica. The constituents of the remaining portion, the principal of which appeared to be alumina, lime and magnesia, were not estimated.

On the further purification of "Dressed graphite."

All the foregoing samples of "dressed graphite" contained more or less carbonate of lime and oxide of iron, the presence of which in any graphite, intended for the manufacture of crucibles, is very objectionable. Now, not only are these readily removed by digestion of the graphite with hydrochloric acid, but, as will be seen, so also were other constituents of the foreign mineral matter, so that—taking this particular instance—the graphite, which before treatment contained 13·15 per cent. ash, after treatment was found to contain only 6.69 per cent., a difference of 6·46 per cent. And furthermore, the nature of the ash of the graphite, which had undergone the hydrochloric acid treatment, consisting, as it did, for the greater part, of silica—that is to say, of the 6·69 per cent. ash 5·35 consisted of silica, the balance of 1·34 being composed of alumina, lime, magnesia, etc.,—was such as to warrant the assumption that it would in no wise be prejudicial to the application of the purified graphite for the manufacture of crucibles.

The two following samples of "dressed graphite" were prepared by the Canada Plumbago Company, at present the Montreal Plumbago Mining Company. The material operated on was taken from the bed of "disseminated graphite" occurring on the twenty-eighth lot of the sixth range of Buckingham. The results of the analysis of what was regarded as a very fair average sample of this bed, will be found given under analysis 1.

Analyses of "Dressed graphite."

13. *Dressed Graphite.*

Sample 1. In the form of an almost impalpable powder. Designed employment: electrotyping, pencils.

After drying at 100° C. this specimen was found to contain:

Ash per cent.................................. 5·374

Colour of the ash reddish-brown, almost brick-red; a portion placed upon moist turmeric paper manifested an alkaline reaction.

A portion of this graphite was digested with hydrochloric acid, which dissolved out a considerable quantity of iron, alumina and lime, and a little magnesia; no other constituents were sought for. This graphite contained some calcite.

The residual graphite having been carefully washed and dried at 100° C, was found to contain:

Ash per cent.................................. 2·542.

Colour of the ash white, with a faint reddish tinge.

14. *Dressed Graphite.*

Sample 2. In the form of fine scales. The grade was not specified.

After drying at 100° C. this specimen was found to contain:

Ash per cent.................................. 10·304.

Colour of the ash light-reddish-brown; a portion placed upon moist turmeric paper manifested a slight alkaline reaction. The ash contained mica.

A portion of the graphite was digested with hydrochloric acid; which removed a considerable quantity of iron and alumina, small quantities of lime and magnesia, a small quantity of silica and a trace of manganese; no other constituents were sought for. This graphite contained a small quantity of calcite.

The residual graphite having been carefully washed and dried at 100° C. was found to contain:

Ash per cent .... 5·958.

This ash, which was white, with a very faint reddish tinge, and contained some mica, gave an analysis 74·007 per cent. silica; the alumina, lime and magnesia, and which appeared to be the most predominant constituents of the balance of the ash, were not estimated.

The results of this analysis are given solely for the purpose of further illustrating the advantages resulting from an hydrochloric acid treatment of these "dressed graphites," as already exemplified by analyses twelve and thirteen. The remarks made in the concluding paragraph under the former of these analyses will—apart from the precise figures—apply with equal force, not only here, and where the figures to be substituted for those there occuring are given, but to all dressed graphites obtained according to the present process from either of the two beds of "disseminated graphite" from which the foregoing samples were prepared.

CANADIAN GRAPHITE--VEIN GRAPHITE.

15. *Vein Graphite, var. Foliated.*

Analyses of vein graphite from Buckingham.

From a vein running through lots twenty-one and twenty-two of the seventh range of Buckingham.

The structure of this graphite was massive, dense, made up of broad and thick laminæ. Colour dark steel-grey. Lustre metallic. Specific gravity 2·2689, (containing 0·147 per cent. ash.) Heated in the closed tube it gave off a little water, but not more than sufficient to form a film.

The specimen contained, here and there, thin seams of foreign mineral matter; apart from this it appeared to be very free from such admixture. The mean percentage of ash, in an average sample of a specimen weighing nearly one kilogramme (rejecting such portions as contained the seams of foreign mineral matter) was found to be 0·195 per cent.

The material employed for analysis was carefully selected; its composition was found to be as follows:—

Carbon	99·675
Ash	0·147
Volatile matter	0·178
	100·000

Colour of the ash, light reddish-brown.

COMPOSITION OF ASH PER CENT.

Silica	56·080
Alumina	11·120
Sesquioxide of iron	13·270
Sesquioxide of manganese	0·352
Lime	6·800
Magnesia	6·739
Potash	2·197
Soda	2·827
Protoxide of copper	0·660
Protoxide of nickel	0·483
Protosesquioxide of cobalt	0·326
	100·854

Analyses of vein graphite from Buckingham.

As explanatory of the presence of nickel and cobalt in the ash of this graphite, it may be mentioned that the pyrite from veins in the Laurentian rocks has been found, by Dr. T. S. Hunt, to occasionally contain cobalt and nickel, sometimes in large proportions; in the present instance, however, it is more probable that their presence may be referred to pyrrhotite, also, a nickeliferous and cobaltiferous mineral, and which has been shown to be present in the beds of disseminated graphite (analyses 1, 2, 3 and 4) occurring in the same locality. With reference to the presence of copper, Mr. H. G. Vennor informs me that he has, in more than one instance, observed small scales and grains of chalcopyrite in the quartzo-feldspathic gangue of the veins of graphite.

16. *Vein Graphite, var., Columnar.*

From the twenty-seventh lot of the sixth range of Buckingham.

This specimen is stated to have occurred towards the centre of the vein: it had a lenticular shape and contained a core of corresponding form, consisting of orthoclase and calcite, with very small quantities of quartz; the composition of the feldspar will be found given under analysis twenty-five.

Structure of the graphite, compact, columnar; the columnar structure is usually erect, and at right angles to the surface upon which it occurs; in some instances, however, it is curved, as though from pressure. The graphite breaks readily in the direction of the structure into more or less angular aggregates, each aggregate being made up of thin, narrow foliæ of very uniform width. The length of the columns varied in different specimens from about one and a-half to eight centimetres. In this specimen the foreign mineral matter was very evenly distributed through the structure of, and as a film upon the graphite, so that on incineration the residual ash formed a tolerably perfect cast of the fragment employed. Colour of untarnished foliæ, dark steel-grey. Lustre metallic. Specific gravity 2·2679 (containing 1·780 per cent. ash.) Heated in the closed tube gave off a little water, but not more than sufficient to form a film.

The material employed for analysis was carefully selected; its composition was found to be as follows:—

Carbon ..	97·626
Ash	1·780
Volatile matter	0·594
	100·000

Analyses of vein graphite from Buckingham.

Colour of the ash, light yellowish-grey; a portion placed upon moist turmeric paper manifested a strong alkaline reaction.

A portion of the foreign mineral matter in this graphite consisted of calcite; it may, therefore, be inferred, considering the small amount of water indicated on heating in the closed tube, that the "volatile matter" consisted largely of carbonic acid.

COMPOSITION OF ASH PER CENT.

Silica	45·729
Alumina	10·824
Sesquioxide of iron	1·230
Sesquioxide of manganese	0·467
Lime	34·744
Magnesia	0·952
Potash	0·522
Soda	5·403
	99·871

17. *Vein Graphite, var. Foliated.*

Analyses of vein graphite from Grenville.

From the north-half of the third lot of the second range of the Augmentation of Grenville. An exposure here was at one time mined to a small extent. At the opening of the excavation it showed a thickness of about ten inches, but the pure graphite was found to form a lenticular mass, which appeared to be separated from other masses of the same character by intervals, in which the graphite became intermixed with the limestone. The foregoing from information supplied by Mr. Charles Robb.

The specimen weighed about eight kilogrammes, and was one of great purity. The exposed faces of laminæ had become tarnished with a reddish-brown coloured film; but, apart from this, and the contents of an occasional small fissure, it apparently contained very little foreign matter.

Structure massive, dense, made up of broad and thick laminæ, closely interlocking each other at diverging angles, thus presenting a radiated arrangement, the sides of the vein forming the basal line. Colour, dark steel-grey. Lustre metallic. Specific gravity 2·2714 (containing 0·076 per cent. ash.) Heated in the closed tube this graphite gave off a little water, but not more than sufficient to form a mere film.

The material employed for analysis was carefully selected, and contained no visible foreign matter. Its composition was found to be as follows:—

Analyses of vein graphite from Grenville.

Carbon	99·815
Ash	0·076
Volatile matter	0·109
	100·000

Colour of the ash, light reddish-brown.

COMPOSITION OF ASH PER CENT.

Silica	55·080
Alumina	8·500
Sesquioxide of iron	18·310
Sesquioxide of manganese	0·309
Lime	7·700
Magnesia	2·018
Potash	4·779
Soda	2·969
Protoxide of copper	1·160
Oxides of nickel and cobalt	0·120
	100·945

With regard to the presence of copper, nickel and cobalt in the ash of this graphite, see in this connection remarks made under analysis 15.

18. *Vein Graphite, var. Columnar.*

From lot one of the sixth range of the Augmentation of Grenville. Structure massive, dense, made up of stout, narrow laminæ, interlocking each other at such an angle as to present an almost columnar appearance. In parts, viz., those in closest proximity to the vein rock, this structure was so fine as to appear coarsely fibrous. Colour, dark steel-grey. Lustre metallic. Specific gravity 2·2659 (containing 0·135 per cent. ash.) Heated in the closed tube this graphite gave off a little water, but only sufficient to form a filmy deposition.

This was a very pure specimen of graphite and contained no readily perceptible foreign matter. An analysis showed it to contain :—

Carbon	99·757
Ash	0·135
Volatile matter	0·108
	100·000

Colour of the ash, light reddish-brown.

COMPOSITION OF ASH PER CENT.

Analyses of vein graphite from Grenville.

Silica	60·800
Alumina	10·040
Sesquioxide of iron	16·721
Sesquioxide of manganese	0·869
Lime	4·400
Magnesia	3·877
Potash	1·025
Soda	1·049
Protoxide of copper	1·940
Protoxide of nickel	trace.
Protosesquioxide of cobalt	0·299
	101·020

With regard to the presence of copper, nickel and cobalt in the ash of this graphite, see in this connection remarks made under analysis 15.

The samples of Ceylon and Ticonderoga graphite, the analyses of which here follow, were employed for comparison with the preceding specimens of Canadian graphite, with regard to relative combustibility. For the four samples of the first named, I have much pleasure in acknowledging my obligation to the Messrs. Morgan Brothers, of London, England, the extensive manufacturers of black-lead crucibles.

Ceylon Graphite—Vein Graphite.

19. *Vein Graphite, var. Columnar.*

From Ceylon.

Analyses of vein graphite from Ceylon.

Structure massive, dense, made up of minute laminæ, arranged in such wise as to present a finely fibrous or columnar aspect. Colour dark steel-grey. Lustre of freshly fractured surface sub-metallic, that of worn surfaces bright metallic. Tough. Fracture hackly. When fractured across the structure, a fine granular surface is presented, dull, and blackish-grey in colour. Specific gravity 2·2671 (containing 0·050 per cent. ash.) Heated in the closed tube gave off a little water, but only sufficient to form a film.

This graphite was remarkably free from foreign mineral matter. The following are the results of the analysis of a fair average of a specimen weighing three hundred and eighty-five grammes.

Carbon	99·792
Ash	0·050
Volatile matter	0·158
	100·000

Colour of the ash, very light yellowish-brown.

Analyses of vein graphite from Ceylon.

20. *Vein Graphite, var. Foliated.*

From Ceylon.

Structure massive, dense, made up of thick closely interlocking laminæ. Colour dark steel-grey. Lustre metallic. Specific gravity 2·2664 (containing 0·213 per cent. ash.) Heated in the closed tube gave off a little water, but only sufficient to form a film. The visibly present foreign matter in this graphite occurred as an occasional filmy deposit on the face of laminæ. The material employed for analysis was carefully selected. The analysis gave,

Carbon	99·679
Ash	0·213
Volatile matter	0·108
	100·000

Colour of the ash, light reddish-brown.

21. *Vein Graphite, var. Columnar.*

From Ceylon.

Structure massive, compact, columnar. Colour dark steel-grey. Lustre metallic. Specific gravity 2·2546 (containing 0·283 per cent. ash.) Heated in the closed tube gave off water sufficient to form a beady deposition: the vapour changed the colour of moistened blue litmus paper to red. The foreign mineral matter was very evenly distributed through the structure of this graphite, the composition of which was found to be as follows:—

Carbon	98·817
Ash	0·283
Volatile matter	0·900
	100·000

Colour of the ash, brownish-red: a portion placed on moist turmeric paper manifested an alkaline reaction.

The foreign matter contained in this graphite consisted in part of calcite, as a consequence, the "volatile matter" was composed in part of carbonic acid.

22. *Vein Graphite, var. Foliated.*

From Ceylon.

Structure lamellar, the laminæ being of considerable size. Colour dark-steel grey. Lustre metallic. Specific gravity 2·2484 (containing 0·415 per cent. ash.) Heated in the closed tube gave off a little water, but only sufficient to form a film. At a first glance this appeared to be

Analyses of vein graphite from Ceylon.

a very pure specimen of graphite, but on raising the foliæ it was found to contain, here and there, thin plates of foreign mineral matter.

Its composition was found to be as follows :—

Carbon	99·284
Ash	0·415
Volatile matter	0·301
	100·000

Colour of the ash, light-grey

UNITED STATES GRAPHITE—VEIN GRAPHITE.

23. *Vein Graphite, var. Foliated.*

Analyses of vein graphite from Ticonderoga.

From Ticonderoga, State of New York.

Structure massive, dense, lamellar. Colour dark steel-grey. Lustre metallic. Specific gravity 2·2599 (containing 2·153 per cent. ash). Heated in the closed tube gave off a little water, but not more than sufficient to form a film. The material employed for analysis was carefully selected ; its composition was found to be as follows :—

Carbon	96·656
Ash	2·153
Volatile matter	1·191
	100·000

Colour of the ash, ash-grey ; a portion placed upon moist turmeric paper manifested an alkaline reaction.

The foreign mineral matter contained in this graphite consisted in part of calcite; it may, therefore be inferred, considering the small amount of water indicated on heating in the closed tube, that the "volatile matter" consisted mainly of carbonic acid.

24. *Vein Graphite, var. Foliated.*

From Ticonderoga, State of New York.

Structure massive, compact, made up of narrow laminæ, interlocking each other at such an angle as to present an almost columnar appearance. Colour dark steel-grey. Lustre metallic. Specific gravity 2·2647 (containing 1·760 per cent. ash.) Heated in the closed tube gave off water sufficient to form a beady deposition.

The material employed for analysis was carefully selected ; its composition was found to be as follows :—

Carbon	97·422
Ash	1·760
Volatile matter	0·818
	100·000

Colour of the ash, brownish-red; a portion placed upon moist turmeric paper manifested an alkaline reaction.

The foreign mineral matter contained in this graphite consisted in part of calcite.

Table showing composition of graphites.

In the first of the two following tables the results of the foregoing analyses of vein graphites are given in a tabular form. The composition of the ash of the Canadian graphites 15, 16, 17 and 18, has, however, been omitted; for this information the readers attention is directed to the respective analysis of these graphites. In Table II. are embodied the results of the experiments on the relative combustibility of the graphites.

TABLE I.—SHOWING THE COMPOSITION OF CANADIAN, CEYLON AND UNITED STATES GRAPHITE

Number.	Locality.	Specific Gravity.	Per Cent.		
			Volatile matter.	Carbon.	Ash.
15	CANADA, BUCKINGHAM. *Vein graphite, var. Foliated....*	2·2689	0·178	99·675	0·147
16	CANADA, BUCKINGHAM. *Vein graphite, var. Columnar ..*	2·2679	0·594	97·626	1·780
17	CANADA, GRENVILLE. *Vein graphite, var. Foliated....*	2·2714	0·109	99·815	0·076
18	CANADA, GRENVILLE. *Vein graphite, var. Columnar ..*	2·2659	0·108	99·757	0·135
19	CEYLON. *Vein graphite, var. Columnar ...*	2·2671	0·158	99·792	0·050
20	CEYLON. *Vein graphite, var. Foliated....*	2·2664	0·108	99·679	0·213
21	CEYLON. *Vein graphite, var. Columnar ..*	2·2546	0·900	98·817	0·283
22	CEYLON. *Vein graphite, var. Foliated....*	2·2484	0·301	99·284	0·415
23	U. S., TICONDEROGA, N. Y. *Vein graphite, var. Foliated....*	2·2599	1·191	96·656	2·153
24	U. S., TICONDEROGA, N. Y. *Vein graphite, var. Foliated....*	2·2647	0·818	97·422	1·760

Remarks on the foregoing Table—The numbers in the column preceding that of the locality, correspond with those of the analyses of the various graphites : under these will be found a description of the graphite, and, in some instances, the composition of its ash.

Of Canadian vein graphites the foliated variety possesses the greatest freedom from foreign mineral matter, and is not unfrequently of very great purity : the specimen of which 17 is an analysis may be taken in illustration of this. In selecting the material for analysis, a trifling quantity of foreign mineral matter was separated; the amount, however, was so small that even had it not been excluded, it is questionable if the percentage of ash would have been thereby raised a tenth of a per cent., and this is inferred from the fact that a specimen taken from the same piece, and without any discrimination, gave only 0·098 per cent. ash. Analysis 15 will serve to show the purity not unfrequently attainable by a simple rough hand dressing. By rejection of such portions as contained the more prominent impurities, the ash in this sample was reduced to 0·195 per cent., whilst in the yet more carefully selected portion employed for analysis, it amounted to only 0·147 per cent. The true columnar variety is rarely so pure as the foliated; its structure being generally more or less permeated by earthy impurities. The specimen of which 16 is an analysis, and which was chosen from one of many as being apparently the purest, contained, as will be seen, even after having been very carefully selected, 1·78 per cent. ash.

Of the Ceylon graphites, 19 and 21 may be said to represent the composition of fair averages of the respective samples as received; whereas in the case of 20 and 22, although still very pure specimens, some slight discrimination was exercised in the selection of the material employed for analysis.

The specimens of Ticonderoga graphite both contained a good deal of foreign mineral matter, and the material employed in these experiments, and of which 23 and 24 are analysis, was very carefully selected.

Table showing relative combustibility of graphite.

TABLE II.—SHOWING THE RELATIVE COMBUSTIBILITY OF CANADIAN AND UNITED STATES GRAPHITE AS COMPARED WITH THAT OF CEYLON.

Number.	Locality.	Relative Combustibility.		
		Method I.	Method II.	Mean.
20	CEYLON. *Vein graphite, var. Foliated........*	1·00	1·00	1·00
21	CEYLON *Vein graphite, var. Columnar ......*	1·02	1·00	1·01
22	CEYLON. *Vein graphite, var. Foliated........*	0·98	1·01	0·99
19	CEYLON. *Vein graphite, var Columnar.......*	1·25	1·25	1·25
1	CANADA, BUCKINGHAM. *Disseminated—Scaly ....*	....	1·02	1·02
3	CANADA, BUCKINGHAM. *Disseminated—Scaly.............*	1·01	1·02	1·01
15	CANADA, BUCKINGHAM. *Vein graphite, var. Foliated........*	0·99	1·01	1·00
16	CANADA, BUCKINGHAM. *Vein graphite, var. Columnar ......*	1·00	1·02	1·01
17	CANADA, GRENVILLE. *Vein graphite, var. Foliated........*	1·01	1·03	1·02
18	CANADA, GRENVILLE. *Vein graphite, var. Columnar ......*	1·12	1·12	1·12
23	U. S., TICONDEROGA, N. Y. *Vein graphite, var. Foliated........*	1·02	1·00	1·01
24	U. S., TICONDEROGA, N. Y. *Vein graphite, var. Foliated........*	1·01	1·00	1·00

Remarks on the foregoing Table—The manner in which these experiments were conducted has been described at the commencement of this report, under " methods" at 5. The numbers in the column preceding that of the locality, and which agree with those in the corresponding column of Table I., accord with those of the analyses of the various graphites. Nos. 1 and 3 which do not there appear, here refer to the analyses of the " Disseminated graphite" from which the " dressed graphites," analyses 14 and 11, were prepared, portions of which latter were specially purified for these experiments, in order to bring them into some accordance with the other graphites, as regarded percentage of ash. In selecting the standard, the choice lay between 20 and 22, for the reason however, that the latter was understood to be the most expensive, it was concluded that it would be scarcely likely to meet with such an extensive application in the manufacture of crucibles as the former, to which, in consequence, the preference was given. The figures given under method I. and II. are in both instances the mean of two closely concordant determinations; they represent the amounts of graphite burnt off as compared with 1·00 of that of the graphite employed as standard (Ceylon 20) when ignited under precisely identical conditions. In appearance the Ceylon graphites were, with one exception, undistinguishable from the Canadian, the exception being 19, the structure of which entirely differed from that of any of the Canadian specimens, the only one of the latter at all approaching it in this respect being 18, and this only in parts, the remainder of the structure being much coarser. As will be seen, these two specimens were the most combustible of the Ceylon and Canadian graphites. A specimen of Canadian graphite from Grenville, and closely resembling the Ceylon variety 22 in appearance, was unfortunately omitted from the experiments. There appeared to be some, if indeed it may not be said, a close connection between the combustibility of the graphite, and its resistance to mechanical division (pulverisation); those most difficult to pulverise being the least combustible.

Relative value of Canadian graphite as compared with that of Ceylon for the manufacture of black-lead crucibles.

From these experiments it will be seen that in respect to incombustibility the Canadian graphite may claim perfect equality with that of Ceylon; and that consequently—apart from any consideration of the proportion and nature of the associated foreign matter—it is in no wise inferior to the latter as a material for the manufacture of crucibles.

Prepared according to the present process, the "dressed graphite" (analyses 5 to 14 inc.,) obtained from the beds of the disseminated mineral (analyses 1 and 3) is apt to contain more or less carbonate of lime and oxide of iron; it has however been pointed out, experimentally, (analyses 12 and 14,) how readily these admit of removal by a very simple and inexpensive chemical treatment, leaving the graphite with a very small amount of ash, and that of a nature in no wise prejudicial to its application for the purpose here under consideration. That the graphite from this source, in itself compares favourably with that of Ceylon, will be seen from the above table, 1 and 3.

25. *Orthoclase.*

Analyses of orthoclase from Buckingham.

From the twenty-seventh lot of the sixth range of Buckingham.

The mode of occurrence of this felspar has been referred to under analysis 16. It was intimately associated with calcite and small quantities of an almost colourless translucent quartz.

Hardness 6. Specific gravity 2·5364. Colour white. Lustre vitreous. Translucent. Two distinct cleavage planes meeting at the angle 90°. Fracture uneven. Before the blowpipe in fine splinters it fuses (at about 5) on the edges to a semi-transparent vesicular glass.

The material employed for analysis was very carefully selected; after drying at 100° C. its composition was found to be as follows:—

Silica	64·140
Alumina	18·620
Sesquioxide of iron	0·374
Protoxide of manganese	trace
Lime	0·740
Magnesia	0·065
Potash	14·868
Soda	1·766
Loss by ignition	0·406
	100·979

Oxygen ratio of $R O : R_2 O_3 : S i O_2 = 1 : 2·73 : 10·63$.

26. *Orthoclase.*

From the twenty-second lot of the seventh range of Buckingham.

It is the principal gangue of the greater number of the true veins of graphite in the Townships of Buckingham and Templeton. Authority, Mr. H. G. Vennor. The felspar was associated with a very small quantity of colourless translucent quartz.

Hardness slightly above 6. Specific gravity 2·5796. Colour pearl-grey. Lustre vitreous. Sub-transparent. Two distinct cleavage planes meeting at the angle 90°. Fracture uneven. Before the blowpipe in fine splinters it fuses (at about 5) on the edges to a semi-transparent vesicular glass.

The material employed for analysis was carefully selected; after drying at 100° C., it was found to contain:—

Analyses of orthoclase from Buckingham.

Silica	63·690

* * * * * *

Potash	12·752
Soda	3·106

27. *Orthoclase.*

This felspar is the predominating constituent of the granitoid quartzo-felspathic rock occurring in connection with the vein of graphite on the twenty-seventh lot of the sixth range of Buckingham.

The rock is composed of orthoclase, small quantities of colourless, translucent quartz and dark olive-green pyroxene, with a little clove-brown, subtranslucent sphene and an occasional crystal of pale wine-red, subtranslucent zircon.

This feldspar has a hardness a little above 6. Specific gravity 2·5780. Colour pale violet-grey. Lustre vitreous. Subtransparent. Two distinct cleavage planes meeting at the angle 90°. Fracture uneven. Before the blowpipe in fine splinters it fuses (at about 5) on the edges to a semi-transparent vesicular glass. Carefully selected material dried at 100° C., gave:—

Silica	63·460
Alumina	18·780
Sesquioxide of iron	0·394
Protoxide of manganese	trace.
Lime	1·280
Magnesia	0·216
Potash	13·923
Soda	2·173
Loss by ignition	0·466
	100·692

Oxygen ratio of $RO : R_2O_3 : SiO_2 = 1 : 2{\cdot}62 : 10{\cdot}02$.

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