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GEOLOGICAL SURVEY OF CANADA.

REPORTS

OF

EXPLORATION AND SURVEYS

1877-8.

To the Right Honorable

Sir John A. Macdonald, P.C., K.C.B.,

Minister of the Interior.

Sir,—I have the honor to transmit herewith the customary annual reports relating to the operations of the Geological Corps. The last annual report, a volume of 531 pages royal 8vo., with numerous maps and illustrations, was dated 1876-77, but was not published, owing to delays in the printing, till May, 1878. It included, besides the field work of 1876, some of that of the summer of 1877, also the results of investigations in the laboratory, which were only completed early in 1878. In like manner the reports now published will include details of portions of the field work of 1877 and 1878, with a brief summary statement of the museum and laboratory work up to the close of the past year. This is considered desirable in order to avoid any unnecessary delay in the publication of results. Each of the reports now submitted is paged separately, with letters added to facilitate reference, and to indicate the order in which they are intended to appear in the volume. Considerable delay has sometimes arisen in the printing the reports, from the fact of their not always being ready for the press in the order in which they had to be paged; this will henceforth be avoided.

I have the honor to be,

Sir,

Your obedient servant,

ALFRED R. C. SELWYN.

Montreal, May, 1879.

GEOLOGICAL SURVEY OF CANADA.

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

REPORT OF PROGRESS

FOR

1877-78.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:

DAWSON BROTHERS.

1879

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I.

SUMMARY REPORT

OF THE

OPERATIONS OF THE GEOLOGICAL CORPS,

TO 31st DECEMBER, 1878,

BY

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

DIRECTOR OF THE GEOLOGICAL AND NATURAL HISTORY SURVEYS OF CANADA.

The Act (35 Vic., cap. 22) establishing the Geological Survey having been passed, in accordance with previous practice, for five years only, expired on the 30th June, 1877, and during the then session of Parliament the continuance of the Survey was provided for by an Act: "To make better provision respecting the Geological and Natural History Survey of Canada, and for the maintenance of the Museum in connection therewith." Act establishing the Survey.

The investigations to be thenceforth undertaken by this branch of the Department of the Interior were more particularly defined, and were made to embrace not only those immediately connected with petrographical geology, palæontology and mineralogy, but likewise other branches of Natural History. While, however, the scope and objects of the Survey have been thus very greatly enlarged, no corresponding increase has as yet been made in the annual appropriation; consequently I have been unable to make the requisite arrangements for effectually carrying out these extended investigations. In the meantime, however, the officers in charge of the several field parties have been instructed to utilize every favorable opportunity for making botanical and zoological observations and collections, and in connection with this work the thanks of the Survey are due particularly to Messrs. Samuel H. Scudder and John L. LeConte, M.D., also to Professor Macoun, of Belleville, Acknowledgements.

and Dr. G. Engelman, of St. Louis, for the examination and naming of zoological and botanical collections.

Paris Exhibition.

From early in August, 1877, much of my own time and attention, as well as much of that of other members of the staff, was devoted to work connected with the preparation of the maps and specimens for the forthcoming Paris Exhibition. Before the close of the year a very fine and varied collection of the economic minerals of Canada, and a stratigraphical collection of rocks and fossils was secured, and the larger portion, contained in 120 packages, shipped to Havre, in December, by the Government steamer "Newfield." The remainder, some sixteen packages, were forwarded *via* New York, early in 1878. This collection was the largest and most complete representation of the geological formations and the mineral resources of British North America ever seen in Europe. To secure its proper arrangement in Paris, I was authorized to proceed there to personally superintend the work, and to attend the meetings of the International Geological Congress to be held in August. Having made all necessary arrangements for the work of the Survey during my absence, I left Montreal on the 5th February, and arrived in Paris on the 25th of the same month. By the 1st of May, the day appointed for the opening of the Exhibition, the whole of the collection was fairly arranged.

Awards to Geological maps and collections.

With the exception of a short absence in the latter part of August and early in September, I was in daily attendance at the Exhibition, or engaged on work connected with it, up to the 27th November, and arrived in Montreal on the 30th December. The highest prizes, viz., diplomas equal to gold medals, were awarded to the Canadian Geological Maps and Collections.

In disposing of the collection at the close of the Exhibition, only those specimens which had been taken from the Survey Museum, and of which there were no duplicates, were sent back to Canada, while a much larger number of which there are duplicates in the museum, or which could easily be replaced, were sent to Kensington for the Colonial Museum, proposed to be established there. The stratigraphical collection of rocks was presented to the École des Mines, and that of fossils to the Museum of the Catholic University, and a large number of smaller collections, representing the economic minerals of Canada, was made up and presented to French and other foreign scientific and educational institutions.

Investigation by Mr. Selwyn of the Quebec group.

In my last Summary Report, 1876-77, I referred pages 3 and 4 to the question of the geological relations of the various members of the Quebec group, and stated that a preliminary examination had been made of a portion of the south shore of the St. Lawrence, but that a good deal more of careful investigation of the stratigraphy would be required before the true structure of the region could be finally determined. During the season of 1877, I devoted a portion of the months of July, August and September, in company with Messrs. Richardson, Webster and Weston, of the Geological Corps, to this work, and a large number of new and important facts were collected, over an area extending north-easterly from the townships of Acton, Roxton, &c., to Montmagny and L'Islet, including the whole of the Island of Orleans and the valleys of the Chaudiere and the Etchemin rivers. The completion of the investigation, however, involves a careful re-examination of the whole region, from the Vermont boundary to Cape Rosier, in Gaspé, including the Shickshock Mountains; and as the interpretation of the geological structure and the sequence of the older palæozoic and archæan formations of the whole of North Eastern America depends on the correct determination of this intricate problem, no pains should, I think, be spared which may be found requisite for its satisfactory solution.

The latest views of Dr. T. Sterry Hunt on the subject, have recently been published in a valuable Report issued by the Second Geological Survey of Pennsylvania, in the prefatory letter to which, by Professor Lesley, the State Geologist, we find the following remarks: Views of Dr. T. Sterry Hunt.

"We owe, therefore, a debt of gratitude to Dr. Hunt for this historical monograph, which will supply a deeply felt deficiency in the literature of our science. It is a treasury of notes and suggestions of the greatest value to the geologists of Pennsylvania and other States, working in such districts as are underlaid at moderate depths by Cambrian and sub-Cambrian formations; although no final demonstration has been accomplished by the author of those problems of superposition, unconformability and identification at which so many geologists are still half despairingly at work." Remarks by Professor Lesley.

The results of the recent labours of myself and colleagues in endeavouring to determine this question, so far as they have progressed, are briefly stated in the present Report A. now submitted, which also contains a few remarks on the investigations of the Survey up to 1878 among the crystalline archæan (Laurentian and Huronian) formations of the Dominion. In these remarks the conclusions arrived at are stated, and I may say respecting them—again quoting Prof. Lesley—that "they will reinforce those of other geologists where they agree, and lead to fruitful discussion where they disagree."

Besides the investigations above-mentioned, explorations and surveys have been made in other portions of the Dominion during the years 1877 and 1878 as follows:— Explorations during 1877 and 1878.

1877.—1. British Columbia.
2. The eastern shores of Hudson's Bay.
3. Quebec: in Ottawa county.
4. New Brunswick: in Albert, Kings and St. John counties.
5. Nova Scotia: in Cumberland and Colchester counties, and in Cape Breton.

1878.—1. British Columbia: in the Queen Charlotte and Vancouver islands.
2. The North-West Territory: the eastern shores of Lake Winnipeg, and the Nelson River and Hayes River routes to Fort York on Hudson's Bay.
3. Quebec: in Ottawa county, the Eastern Townships, the Lower St. Lawrence, and the Shickschock Mountains.
4. New Brunswick: in Albert, Westmoreland, Kings, St. John and Charlotte counties.
5. Nova Scotia: in Cape Breton, Inverness, Richmond and Guysboro' counties.

These explorations and surveys have afforded a large amount of new and valuable information, both of economic and scientific interest. Of the greater part of this work, the detailed reports, with maps and illustrations, are now submitted.

Explorations of Dr. G. M. Dawson in British Columbia.

It will be found that in 1877 Mr. G. M. Dawson devoted particular attention to ascertain the distribution and probable workable area of the bituminous and lignitic coals, as well as that of the economic minerals, on the mainland of British Columbia, chiefly in the Okanagan, Nicola and North Thompson valleys; his observations extended over an area of about 18,000 square miles, and much interesting and valuable information on the geology, topography and natural history of this extensive area will be found in his Report.

In 1878 Dr. G. M. Dawson was occupied the greater part of the season in making a geological and geographical exploration and survey of a part of the Queen Charlotte Islands, with special reference to the deposits of anthracite coal which occur at Skidegate. Attention was also paid to the climate and natural resources of the islands, including the fisheries. It was found necessary to carry a running survey along the eastern and northern coasts. This, when laid down, will form a trustworthy map, on which many harbours and inlets not previously known are represented.

An examination was also made of the coal rocks of Quatsino Sound, on the west coast of Vancouver Island, and also of those extending from Beaver Harbour to the Nimkish River. It would appear that besides these there are several smaller basins of similar rocks on Vancouver

Island, and on the mainland adjacent, which have not yet been examined, but in some of which workable coal seams may yet be found. The detailed report and map of this work will appear with the next annual reports.

Explorations of Dr. R. Bell.

The Report of Dr. Bell, on the examination and partial survey of upwards of 700 miles of the eastern shores of Hudson's Bay, affords a number of interesting and important facts in connection with the climate, zoology, botany and geology of that hitherto wholly unexplored region, tending, for the most part, to shew that it is by no means so inhospitable and barren as has been generally supposed. And there can be no doubt that Hudson's Bay is destined, at no very distant date, to become of very great importance in connection with the development and opening up of the magnificent Territories of the Dominion in the North-West, to which it is the natural and shortest highway from Europe. My views on this subject were submitted to the late Ministers of the Interior and Finance early in 1877, when the exploration, to which the present Report of Dr. Bell relates, was sanctioned, and which it was then proposed should be continued in succeeding seasons, with a view to securing thoroughly reliable and accurate information respecting the climate and natural resources of the shores and waters of this great inland sea and its tributaries, of none of which are there any accurate surveys existing. Accordingly, in 1878, the work was again taken up, and during this season a track survey has been made by Dr. Bell, from Norway House to Fort York, of the routes *via* Oxford and Knee lakes and Hill, Steel and Hayes rivers. Also a similar survey, with numerous soundings, of the mouth of Nelson River, and up it for a distance of about ninety miles, or to the first rapids. An instrumental survey was made of the neighbourhood of Fort York, and the latitude and magnetic variation determined. Returning to Norway House, a survey was carried down the Nelson River from Lake Winnipeg to a point about half-way to the sea—a distance, following the bends of the river, of about 200 miles, leaving a portion of the river, probably about 100 miles in length, unsurveyed.

On Lake Winnipeg, the eastern shore was examined and a track survey made of it from the outlet at the Nelson River to the Dog's Head Narrows, a distance of 170 miles, connecting with the previous examinations from the south made in 1874. From the Narrows, the western shore was followed and similarly examined for a distance of about seventy miles, or to a point some distance south of that reached by the Dominion Lands Survey from Red River. The details of this work, with maps and illustrations, are given in the Report B. B., now submitted.

Exploration in Quebec by Mr. Vennor.

In Quebec Mr. H. G. Vennor's attention has been devoted to carefully tracing out and mapping the distribution of the phosphate-bearing rocks. These have now been followed in a northerly direction to a point nearly ninety-six miles from the Ottawa River, and eastward to the township of Grenville. The area over which workable deposits of phosphate may probably be discovered is thus greatly extended, and the particular belt of country within which such deposits should be sought, can be very closely indicated. Neither its eastern nor western limits have, however, yet been ascertained, but there appear to be good grounds for predicting that the phosphate belt will be found to recur in the region between Lake Nipissing and the Georgian Bay, as well as in portions of the country to the north and north-east of Grenville—and possibly in other localities within the Laurentian area on the north side of the St. Lawrence.

Explorations in New Brunswick and Nova Scotia.

In New Brunswick the surveys have included about 930 miles of measurement of coast-line, roads and streams, and large and interesting collections of rocks and fossils have been made.

In Nova Scotia the topographical survey of Cumberland county was continued by Mr. Scott Barlow. About seventy-five miles of the coast-line on the Bay of Fundy and the Basin of Minas was carefully measured, completing the survey of the south and west shores of Cumberland county, with the exception of about ten miles around Cape Chicgnecto. The principal roads and brooks were likewise measured, about 400 miles in all being thus surveyed. A number of interesting geological specimens, rocks and fossils, were collected, among the latter a fine series of reptilian foot-prints from Spencer Island settlement, Cumberland county, may be mentioned; but the geological structure of the district has, however, yet to be worked out, the topographical survey being an essential preliminary operation.

In Cape Breton Island the combined geographical and topographical survey has been continued by Mr. Fletcher, the work having now embraced nearly the whole of the counties of Cape Breton and Richmond, and a portion of Victoria and Inverness, forming a connected survey from Sydney and Louisburg to the Strait of Canso. The survey was also carried during the past season to the west side of the Strait of Canso, including a tract of country lying north of Chedabucto Bay, eastward of a line from Guysboro harbour to Little Tracadie.

The publication of the map and detailed report of this work will be deferred till next year.

Palæontological investigation.

Palæontological Branch. In this department a large amount of useful and important work has been accomplished by Mr. Whiteaves. The second part of the first volume of Canadian Mesozoic Fossils, referred to on page 5 of my last Summary report, has been completed, and is now in the press. It was hoped that this would have been issued before the close of the year, but its publication has been delayed by the serious illness of Mr. A. H. Foord, before the last two plates were finished. It contains 97 pages of letter-press and ten plates, with 108 figures, being descriptions, identifications and illustrations of the fossils collected from 1872 to 1875, by Mr. Richardson, from the Nanaimo and Comox coal fields of Vancouver and on some of the islands in the Strait of Georgia. The figures have all been drawn and lithographed by Mr. A. H. Foord, the artist to the Survey. The third part, of which a commencement has been made, will complete the volume.

During the early part of September Mr. Whiteaves spent a week in collecting fossils from the limestones of the Levis formation in the vicinity of Bedford, St. Armand and Phillipsburgh. And a large and interesting collection was also made during the summer by Mr. Weston, from the same formation in the Gaspé Peninsula. Valuable additions to the palæontological collections have also been made by the same indefatigable worker, from the Island of Orleans, from Point Levi, and from the valleys of the Chaudiere and the Etchemin.

The Lower Silurian fossils from Manitoba, in the Museum of the Survey, have been mounted, classified and partly studied, as have also a number of Devonian corals, shells, etc., collected by Dr. R. Bell, in 1877, from the neighbourhood of Hudson's Bay.

A series of Lower Cretaceous and Tertiary fossils from various parts of British Columbia have also been examined, and some notes on the species have been prepared for publication in Dr. G. M. Dawson's report on his explorations and surveys in that Province.

A number of smaller collections brought in from the field has also been examined, and a series of characteristic Canadian fossils, consisting of about 160 species, was selected, mounted and labelled for the Paris Exhibition.

In compliance with a request from Mr. Murray, Director of the Geological Survey of Newfoundland, a collection of fossils from the Menevian and Acadian groups of the south-eastern extremity of that island has been examined and reported on, and a short paper on some of the specimens has been contributed to the September number of the American Journal of Science and Arts. As far as possible, duplicates of each of the species have been retained for the Museum, and the rest have been determined, labelled and returned to Mr. Murray. Mr. Whiteaves has also contributed an interesting paper to the *Canadian Naturalist* on the marine invertebrata collected by Mr. Richardson in 1874 and 1875, in the Gulf of Georgia and off the coast of British Columbia.

Laboratory. In the chemical and mineralogical branch of the Survey much important work has been done. In my last summary report I

Chemical and mineralogical work.

stated that the results of Mr. Hoffmann's chemical investigation of Canadian Graphites would "be given in the next Annual Report." The investigation was, however, completed before the printing of last year's report was finished, and the results were therefore included in it. It is hoped that the publication of these may have a beneficial influence in promoting the more general introduction and sale of Canadian plumbago, as they conclusively prove it to be, chemically, in every respect equal to the best Ceylon varieties.

In the early part of 1878 Dr. Harrington was fully occupied in the preparation of a descriptive catalogue of the mineral collections sent to the Paris Exhibition. Besides a list of the minerals exhibited, this includes a series of articles giving a large amount of information relating to the mineral resources of the Dominion. The manuscript was transmitted to me in Paris, where it was translated into French, and afterwards printed in London. Copies are now available for distribution. It has not been printed in English.

The examination and analysis of minerals of scientific interest, and also the analysis or assay of various specimens of gold-bearing quartz, silver, copper and iron ores, coals, etc., has likewise occupied a considerable portion of Dr. Harrington's time during the year. Among the minerals analysed are several from the north Ottawa apatite region, which offers a field of much interest for mineralogical investigation. Collections of minerals have been made from this region by Dr. Harrington, and are now being studied, named and arranged by him in the Museum, and will form a very interesting and instructive series, shewing the various combinations, varieties and modes of occurrence of Canadian apatite and plumbago.

Several minerals of scientific interest have also been analysed, and microscopic examinations have been made of a number of crystalline rocks, the slices having been prepared by Mr. Weston, the scientific lapidary to the Survey.

Since the completion in June, 1878, of the investigation by Mr. Hoffmann, already mentioned, his time has been almost exclusively devoted to a similar analytical investigation of Canadian apatite. This mineral, as is well known, has of late been attracting much attention, and it was deemed very desirable that its true composition should be fully established by a complete series of analyses. The investigation is still in progress, but will, perhaps, be completed soon enough for the results to be published with the reports now submitted. In this connection it will not be amiss to quote the following remarks on Canadian phosphates, which occur in a small pamphlet issued by Messrs. Bernard, Lack & Alger, one of the largest manufacturers of superphosphates in England, in connection with their exhibit of phosphate manures at Paris:

"As a rule, Canadian phosphate does not contain carbonate of lime, and only a little oxyd of iron and alumina; but it always contains variable and generally considerable quantities of fluorine. In dissolving it in sulphuric acid, the irritating fumes of hydrofluoric acid are given off in great quantity; and as these fumes are poisonous, it is necessary to effect the treatment of the pulverised mineral with acid in closed vessels furnished with ventilating tubes, to carry off these noxious vapours. Canadian phosphate, though somewhat hard and difficult to reduce to fine powder, is otherwise very well adapted for the manufacture of concentrated superphosphates." Canadian phosphate.

"The high price of freight from Canada to England in a great measure paralyses the development of the trade in Canadian phosphates, and the result is that very few cargoes have been imported into England during the current year."

Museum. Some further improvements and additions have been made to the Museum during the year. A second table show case thirty-two feet long, and containing thirty drawers and ten glass cases, has been placed in Room No. 4, affording increased accommodation for the stratigraphical and mineralogical collection. The former now numbers upwards of 5,000 specimens from all parts of the Dominion, and when complete and fully arranged will constitute an interesting and instructive representation of the various formations and groups of strata described in the Survey Reports and Maps. A set of maps, shewing the distribution of all the known economic minerals in the Dominion, has been prepared and is now exhibited in the Museum. These maps, when published, will be found a useful and compendious guide to the localities in which the various minerals are already known to exist in workable quantity, as well as to those where further search may result in their development. Museum.

Thirty-nine catalogued and named collections of Canadian minerals, rocks and fossils, containing upwards of 2,000 specimens, have been presented since the date of my last report to various educational institutions, scientific societies and individuals, in the Dominion and in foreign countries. In connection with this work and with that of the preparation of the specimens which were sent to the Paris Exposition, my thanks are due to Mr. Willimott, Museum Assistant, for his industry and efficiency in carrying out my instructions. Distribution of specimens and publications.

A large number of valuable maps, reports and memoirs has been presented, during the year, to the library in exchange for the publications of the Survey, of which 2,805 copies have been distributed from Ottawa, and 1,126 copies from the office of the Survey.

From the 1st May, 1877, to the 31st December, 1878, 3,147 names have been entered in the visitors' register. Number of Visitors.

ADDITIONS TO THE LIBRARY,

FROM 1st MAY, 1877, to 31st DECEMBER, 1878.

BY PRESENTATION.

Royal Society of London:—

Proceedings.......................... Volume XXVI., Numbers 179-187

Royal Society of Edinburgh:—

Proceedings.............................. Volume IX., Session 1875-76
" .... " " " 1876-77

Geological Society of Edinburgh:—

Transactions.................................... Volume XII., Part I

Manchester Geological Society:—

Transactions......................... Volume XIV., Parts VIII.-XXII

Literary and Philosophical Society of Manchester:—

Memoirs.................................. Volume V., Third Series
Proceedings........................... Volume VIII., Session 1868-69
" .... " IX., " 1869-70
" .... " X., " 1870-71
" .... " XI., " 1871-72
" .... " XII., " 1872-73
" .... " XIII., " 1873-74
" .... " XIV., " 1874-75
" .... " XV., " 1875-76

Cincinnati Society of Natural History:—

Proceedings.. Number 1
The Cincinnati Quarterly Journal of Science..... Volume I., Numbers 1-4
" " " ..... " II., " 1-4

American Philosophical Society, Philadelphia:—

Proceedings.............................. Volume XVI., Number 99
" .... " XVII., " 100
List of Surviving Members.................. " " " 101

Boston Society of Natural History:—

Proceedings................................ Volume XIX., Part I.-IV
Memoirs............................. Volume II., Part IV., Number 5
Appendix, Index and Title-page............................. Number 6

American Geographical Society of New York:—

Bulletin............................. Numbers 4-5; Sessions of 1876-77
" .... " 1-2; " of 1878

Royal Society of New South Wales, Sydney:—

Journal and Proceedings .... Volume X., 1875

Climate of New South Wales. By H. C. Russell, B.A., F.R.A. & E.M.G., &c

Rules and List of Members 1877

Department of Mines, New South Wales, Sydney:—

Annual Report for the year 1876.

The Academy of Natural Sciences, Philadelphia:—

Journal .... Volume VIII., Part II.-III

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

Memoirs .... Volume V., Numbers 1-2

Bulletin .... Volume V

" .... " " Plates

" .... " " Numbers 2-7

Annual Report of the Curator of Harvard College for 1877-78.

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

Bulletin of the Minnesota Academy of Natural Sciences for 1875.

" " " of " for 1876.

Essex Institute, Salem, Mass.:—

Bulletin .... Volume VIII., 1876

" .... " IX., 1877

J. W. Powell, Washington:—

Contributions to North American Ethnology .... Volume I

Board of Agriculture, State of Maine.—S. L. Boardman, Secretary:—

Twenty-first Annual Report 1876-77

Institution of Engineers and Ship-builders in Scotland:—

Transactions .... Twenty-first Series, 1877-78

Nova Scotian Institute of Natural Sciences:—

Proceedings and Transactions .... Volume III., Part II

" " .... " IV., " IV

Department of Mines, Nova Scotia:—

Report for the year 1877.

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

Transactions and Proceedings .... Volume IX

Reports of Geological Explorations during 1873-74, with Maps and Sections.

" " " " 1874-76, " " " "

" " " " 1876-77, " " " "

Meteorological Report, 1873, including Returns for 1871-72 and Abstracts for previous years.

Meteorological Report, 1875, including Returns for 1873-74 and Averages for previous years.

Proceedings of New Zealand Institute, 1876.

Twelfth Annual Report on the Colonial Museum and Laboratory.

Transactions and Proceedings of the New Zealand Institute. . Index I. to VIII

Lisbon Academy of Sciences:—

Sobra A Existencia do Terreno Siluriano. By J. F. N. Delgado.

Noticia Acerca Das Grutas Da Cesareda. By " "

Descripçao Do Solo Quaternaris Das Bacies Hydrographicas Do Tejo E Lado. By CARLOS RIBIERO.

Memoria Lobre O Abastegimento De Lisboa. By " "

Alguns Silex E Quartzites Lascados. By " "

Congresso De Anthropologia de Archeologia Prehistorica. By " "

JOAQUIM MANDEL DE MACEDO, Rio De Janeiro:—

Brazilian Biographical Annual .... Volumes I., II., III

Geological Survey of India:—

Palæontologia Indica.................. Volume I.-II., Series X., Part II

" " .... " " " XI., " I

" " .... " " " II., " II.

Memoirs .... Volume XII., Part I.-II

" .... " XIII., " I.-II

Records .... Volume IX., Parts II.-III.-IV

" .... " X., " I.II

United States Geological Survey of the Territories.—Dr. F. V. HAYDEN, U.S. Geologist:—

Report of the United States Geological Survey of the Territories. Volume VI. By F. V. HAYDEN.

Report of the United States Geological Survey of the Territories. Volume XI. By F. V. HAYDEN.

Ninth Annual Report of the United States Geological and Geographical Survey of the Territories, embracing Colorado and parts of adjacent Territories, 1875. By F. V. HAYDEN.

Fur-bearing Animals; a Monograph of North American Mustelidæ. By ELLIOTT COUES.

Ethnography and Philology of the Hidatsa Indians. By WASHINGTON MATTHEWS.

First Annual Report of the United States Entomological Commission for the year 1877, relating to the Rocky Mountain Locust, with Maps and Illustrations.

List of Elevations principally in that portion of the United States west of the Mississippi River. By HENRY GANNETT, M.E.

Descriptive Catalogue of Photographs of North American Indians. By W. H. JACKSON.

Bibliography of North American Invertebrate Palæontology. By C. A. WHITE and H. ALLEYNE NICHOLSON.

Bulletin. Volume III., Number 4.

" " IV., Numbers 1, 2 and 3.

Geological and Geographical Atlas of Colorado and portions of adjacent Territories, 1877. Twenty sheets.

United States Geological Exploration of the Fortieth Parallel.—CLARENCE KING, Geologist, in charge:—

Microscopical Petrography. Volume VI. By FERDINAND ZIRKEL.

Descriptive Geology. Volume II. By ARNOLD HAGUE and S. F. EMMONS.

Ornithology and Palæontology. Volume IV. By MEEK, HALL, WHITFIELD and RIDGWAY.

Geological and Topographical Atlas accompanying the Report of the Geological Explorations of the Fortieth Parallel. By CLARENCE KING.

Geological Survey of New Jersey.—GEORGE H. COOKE, State Geologist:—

Annual Report for the year 1877.

Report on the Clay Deposits of Woodbridge, South Amboy and other places in New Jersey.

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

Report of Progress. In the Counties of York, Adams, Cumberland and Franklin, 1875. By Persifor Frazer, Jr.

Report of Progress. In the Cambria and Somerset District of the Bituminous Coal-Fields of Western Pennsylvania, 1875. By F. and W. G. Platt.

Special Report on the Coke Manufacture of the Youghioghany River Valley in Fayette and Westmoreland Counties, 1875. By Franklin Platt.

Report of Progress. In the Cambria and Somerset District of the Bituminous Coal-Fields of Western Pennsylvania, 1876. By F. and W. G. Platt.

Report of Progress. In the Fayette and Westmoreland District of the Bituminous Coal-Fields of Western Pennsylvania, 1876. By J. J. Stevenson.

Report of Progress. Oil Wells and Levels, 1876-77. By John F. Carll.

Report of Progress. In the Beaver River District of the Bituminous Coal-Fields of Western Pennsylvania, 1875. By J. C. White.

Report of Progress. In the Fayette and Westmoreland District of the Bituminous Coal-Fields of Western Pennsylvania, 1877. By J. J. Stevenson.

Report of Progress. Two Hundred Tables of Elevation above Tide Level in and around Pennsylvania, 1875-76-77. By Charles Allen.

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

Reports upon the Geology and Mineralogy of the State of New Hampshire, 1869-73.

The Geology of New Hampshire. Volumes II. and III.

The Distribution of the Till in New Hampshire and Long Island. By Warren Upham.

Atlas of Maps and Sections, in seventeen sheets; illustrating the Report on the Geology of New Hampshire, 1878.

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

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Atlas of Maps.

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REPORT

OF

OBSERVATIONS ON THE STRATIGRAPHY

OF THE

QUEBEC GROUP,

AND THE

OLDER CRYSTALLINE ROCKS OF CANADA,

BY

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

DIRECTOR OF THE DOMINION GEOLIGICAL AND NATURAL HISTORY SURVEY.

Though the investigation is not yet completed, it seems desirable to record as briefly as possible the conclusions already arrived at from the examinations made in the field during the seasons of 1876 and 1877, which were undertaken for the purpose of satisfying myself, before publishing the geological map of the Eastern Townships, respecting the much-discussed questions of the structure and the age of the rocks in the region on the south-east side of the St. Lawrence, extending from the Vermont, New Hampshire and Maine boundaries north-easterly to Gaspé.

I shall also make some remarks on the results of the work of the Geological Survey in connection with the stratigraphy of the Laurentian rocks on the north side of the St. Lawrence valley, and the conclusions to which they seem to point, and which are closely connected with those relating to the Quebec group.

In some respects the views I am about to express on these questions are in accordance with those of others, while as regards some points they are, I believe, new. Whether they eventually prove to be correct or not, I can say that they are the result of close personal examinations in the field, and a very careful consideration of all the evidence recently collected by myself and colleagues, as well as of that collected by my predecessor, the late Sir W. E. Logan, who spent almost his last days in working out this very embarrassing and difficult question. Had his later investigations, instead of being confined to the country around Richmond and Danville, been extended to the north-east, I feel persuaded that there would have been no material difference between his views and those which I now submit.

Investigations of Sir W. E. Logan.

In the Preface to the Geology of Canada, 1863, page viii., Sir William writes respecting the region now under consideration: "The country through which the rocks in question extend is still under investigation; and the structure which has been assumed for the purpose of conveniently describing the metalliferous region, which appears to be one of great economic importance, must for the present be considered as in some degree provisional." From that date up to 1869 or '70, when the later investigations I have alluded to were commenced, Sir William does not appear to have made any further personal examinations in relation to the relative ages of the altered and unaltered portions of the Quebec group, and therefore it seemed all the more desirable that the whole question should be re-investigated before the publication of the geological map, and this work I am now endeavouring to carry out.

All who have taken any interest in Canadian Geology are aware that the whole of the region referred to has been described by the Canadian Geological Survey as occupied by only four great formations or groups of strata, which in descending order are:

1. Devonian.
2. Upper and Middle Silurian.
3. Lower Silurian.
4. Laurentian.

No. 3 includes:

a. Hudson River or Lorraine Shales.
b. Utica Slates.
c. Trenton Limestone.
d. Bird's Eye and Black River Limestone.
e. The Quebec group, and its supposed equivalents, Chazy and Calciferous.
f. Potsdam Sandstone.

Subdivision *e*, the Quebec group, is the one about which so much discussion has arisen and so many different opinions have been expressed. Indeed so varied have these been that it is now almost impossible to suggest anything which some one has not already suggested; but most of these opinions have been advanced on palæontological, mineralogical or theoretical grounds, with but little, or only very local, study of the actual stratigraphy in the field. According to the latest determination by the geological corps, under my predecessor, Sir W. E. Logan, the Quebec group is divided into three conformable formations, viz., in descending order:

Subdivisions of the Quebec group.

The Sillery.
The Lauzon.
The Lévis.

These have been supposed to occupy the whole of the region lying south of the St. Lawrence between the great St. Lawrence and Champlain fault and the Upper Silurian overlap, notwithstanding the very diverse mineralogical, palæontological, and physical conditions under which they appear in different parts of the area. The base and the summit of the middle division, which was only introduced in 1866, has been supposed to be characterised by copper ores, crystalline dolomites, limestones and serpentines, and it would really seem that in mapping the structure the presence of any one of these has almost invariably been made to determine the limits of this division, which must I think be abandoned.

I shall now proceed to state my own views of the geological structure of the region under consideration.

First, then, I may say that I recognize in it three distinct groups of strata, which in descending order may be enumerated as:

Proposed new divisions.

1. The Lower Silurian group.
2. The Volcanic group, probably Lower Cambrian.
3. The Crystalline Schist group. (Huronian ?)

Group 1.—This group consists of a great variety of slates or shales (argillites), red, green and black; limestones, in thin bands; limestone conglomerates, often dolomitic; sandstones and quartzites. In every part of their distribution from the Vermont boundary to Gaspé, 500 miles, these strata hold a large number of genera and species of characteristic Lower Silurian fossils, full descriptions of which have been given in the reports of the Geological Survey. This fossiliferous belt occupies a strip of country on the south side of the St. Lawrence, which in its widest part, in the valleys of the Chaudière and the Etchemin, does not exceed twenty-five miles, and in this portion the structure presented is that of a broad crumpled and folded synclinal, with prevailing south-easterly dips on the north-western side, and north-westerly dips on the south-eastern side; the characteristic Point Lévis limestone conglomerates and associated graptolitic shales coming up near the base on both sides. There are doubtless a number of local and unimportant overturn dips, but there seems to be no evidence whatever of a general inversion of the strata.

The St. Lawrence and Champlain fault.

On the north-western side this belt is bounded by the St. Lawrence and Champlain fault, or overlap, which brings the even-bedded shales and limestones of the Hudson River or Lorraine shale group into contact with the crumpled and twisted strata of what have been regarded as the subdivisions of the Quebec group, viz.: the Lévis, Lauzon and Sillery formations. The line of this dislocation or unconformity—whichever it may be—has been supposed to pass in rear of the Quebec citadel. This I hold to be a mistake, and I think it can be distinctly shewn that it passes from the south-west end of the Island of Orleans under the river and between Point Lévis and Quebec; it appears again on the north shore of the St. Lawrence about one mile north of Point Pizeau, passes north of St. Foy, and thence in a direct course to where it again crosses the river south-west of Cap Rouge. The entire absence of characteristic Lévis fossils in the citadel rocks is thus easily explained. I have traced this break carefully from the last-named point on the north shore of the St. Lawrence to the north-east end of the Island of Orleans, where, on the beach, the actual contact of the two formations is well seen, and a short distance inland we find the characteristic Lévis limestone conglomerate.

Palæontological characters.

Salterella and *archæocyathus* have been found in these conglomerates on the island, and the former occurs also at Point Lévis, while the graptolite (*Phylograptus*) shales are interstratified at both places with at least some of the conglomerate beds. *Obolella* occurs also in shales clearly above the Lévis conglomerates and below other shales holding graptolites, while in some beds both occur together. These facts are mentioned because it appears to have been almost entirely on the evidence afforded by a few fossils, some of them doubtfully characteristic, and others occurring in boulders, that a belt of country, formerly—up to 1868—considered to be occupied by the strata belonging to the Quebec group, has since been assigned to the Potsdam formation. *Geological Survey Report*, 1866-69, *p.p.* 119-141. And I would now state that after having carefully examined a considerable portion of these supposed Potsdam rocks, that there is, in my opinion, at present no sufficient evidence, either palæontological, stratigraphical or mineralogical, for separating this belt of rocks from other very large areas of the Quebec group hitherto assigned, the larger part to the Lauzon, but in some places also to the Lévis and Sillery formations. That there are within the area under consideration, the rocks of which I have designated as group 1, strata which may be very much lower in the series than those of Point Lévis, and therefore possibly belonging to the Potsdam period, is quite possible; but, if so, the information we at present have is not sufficient to enable us to define the limits of these subdivisions of the Lower Silurian system in this

Potsdam formation.

region, and therefore it will, I consider, in any geological map now published, be best to include the whole of the rocks of this great fossiliferous belt in one group, notwithstanding the probability that within its limits are included all the recognised subdivisions from the Primordial or Potsdam up to the Hudson River or Lorraine shales.

On the north-west side of the great St. Lawrence and Champlain fault the several subdivisions are easy to recognise, and their respective limits can be defined, whereas on the south-east side of the break the folded, faulted and generally disturbed condition of all the formations renders any such attempt a task of exceeding difficulty and one requiring more time than can at present be devoted to it.

Limits of group 1.

On the south-eastern side, the fossiliferous belt, group 1, is bounded by a line which, commencing on the United States boundary near St. Armand, runs on a course nearly parallel with the St. Lawrence, passing through the townships of Dunham, Brome, Shefford, Stukeley, Melbourne, Cleveland, Chester, Halifax and Leeds to the vicinity of Ste. Marie on the Chaudière. Between Ste. Marie and St. Claire, on the Etchemin River, the strata which I have referred to, group 2, increase greatly in width, cropping out, apparently unconformably, from beneath the fossiliferous belt and separating it from group 3. The boundary we have been tracing of the fossiliferous belt, group 1, is here suddenly deflected to a course nearly north for some sixteen or eighteen miles, viz., from St. Claire to St. Vallier, where it again turns north-east, and beyond this it has not yet been defined with certainty. It may be that this apparent unconformity is really a fault which running transverse to the strike brings the black slates and limestone conglomerates of group 1., into contact with a set of strata which lithologically can not in this part be well distinguished from the typical Sillery sandstones of New Liverpool, Sillery Cove, &c., above Quebec, or from those of Acton, Roxton and Granby, which they still more nearly resemble, and which there are some reasons for supposing may occupy a similar unconformable position beneath the rocks of group 1. The distribution of these sandstones and associated strata, as indicated on the unpublished map of the Eastern Townships, and their apparent relations to the surrounding fossiliferous strata, very forcibly suggests this idea.

Group 2. Lithological characters.

Group 2.—This group embraces a great variety of crystalline, sub-crystalline and altered rocks; coarse, thick bedded, felspathic, chloritic, epidotic and quartzose sandstones, red, grey and greenish siliceous slates and argillites, great masses of dioritic, epidotic and serpentinous breccias and agglomerates, diorites, dolerites and amygdaloids, holding copper ore; serpentines, felsites, and some fine-grained granitic and gneissic rocks, also crystalline dolomites and calcites. Much of the division, especially on the south-eastern side of the axis, is locally made up of altered volcanic products, both intrusive and interstratified, the latter being clearly of contemporaneous origin with the associated sandstones and slates. The greatest development of these volcanic rocks appears to occur, as above stated, on the south-eastern side of the main axis, to which I shall presently refer, and about the summit of division 3, of which they may perhaps be only an upward extension, as we have at present no distinct evidence of any unconformity between these two divisions. The rocks composing this group have, hitherto, for the most part, been included in the Sillery sandstone formation, supposed to be the highest member of the Quebec group; represented by a yellow color on the large geological map of Canada and on the unpublished map already referred to. It appears to me, however, that neither their true stratigraphical position nor their geological characters have been correctly appreciated, and they have, regardless of these, been confounded and incorporated with the true Sillery sandstones, which are only a local development of thick sandstones at several horizons in the Quebec group or fossiliferous Lower Silurian, group 1 of the present report. At Sillery, above Quebec, and at various points thence north-eastward to Gaspé, good exposures of these sandstones may be examined, and it has now been shewn that at Little Metis, at Ste. Anne (the Pillar sandstones of Mr. Murray's report of 1844) and elsewhere, they are characterized by graptolites and other Lévis fossils, whereas in the massive red and green sandstones and slates which in part are associated with contemporaneous volcanic rocks, and which the stratigraphy, as I think, clearly shews to be a lower unconformable formation, no fossils of any description have yet been found, unless the slates near Actonvale, in which certain fucoid markings have been observed, belong to this group. Further examination, which will be undertaken during the ensuing summer, may probably afford other fossils, but if so I should expect them to indicate a lower horizon than the Lévis formation, probably not far removed from that of the St. John group and the Atlantic coast series of Nova Scotia, or Lower Cambrian. In describing the belt of these sandstones and slates which extends north-eastward from St. Claire on the Etchemin river, Sir W. Logan writes: "The area over which these strata occur commences in a point near the Chaudière; it has been traced to the north-eastward across the Seignories of St. Mary and Joliette into St. Gervais, and it probably extends much further. . . . The distance between this area and its equivalent to the south is about ten miles." "The sandstones in the two areas on the opposite sides of the Rivière du Sud are massive; on the northern side they are very often coarse grained, and in general of a green color, while the shales which separate the masses are usually red. Very coarse beds are not so frequent on the

Contemporaneous volcanic rocks.

Prabable age of group 2.

south side, and there the red color is not confined to the shales, but characterizes the sandstones also, which are as often red as green."*

There are two other distinctions not pointed out by Sir W. Logan. The one is that fossils, *obolella* and *graptolites*, characterize the northern area. Another is that the sandstones in the latter frequently present a peculiar schistose structure, not, so far as I know, to be seen, or only very rarely, in the true Sillery sandstones of the Lévis formation, to which the northern of these two sandstone areas clearly belongs.

Group 3.—I shall now pass on to the consideration of group 3, which, however, as I have already stated, may be intimately related to the preceding. The rocks composing it are chiefly slaty and schistose, and embrace various chloritic, micaceous, siliceous and magnesian strata with copper ores, also imperfect gneisses, white and grey crystalline micaceous dolomites and magnesian limestones. They constitute the main anticlinal axis of the region, which axis may be traced from Sutton Mountain, east of Lake Memphremagog, on a gently curving line, north-eastward to the counties of Montmagny and L'Islet—a distance of 150 miles. Between the St. Francis River and the townships of Chester and Wolfestown, a very considerable dislocation crosses the axis transversely; the structure here is exceedingly complicated, and is rendered still more obscure by the overlapping of the Upper Silurian rocks, and by the interposition, in the magnesian belt—by a complication of faulting and unconformable superposition—of a long, narrow band of the black shales and dark earthy limestones of the fossiliferous group. Further north, however, the magnesian belt assumes its normal relation to the overlying divisions 1 and 2. And on page 258 of the Geology of Canada, we find its course thus described: "The general course of the magnesian rocks on the south side of the *synclinal* is, however, pretty well determined by a band of dolomite occasionally passing into serpentine, which has been traced from the 13th lot on the line between Chester and Halifax to the Chaudière, near the line between St. Mary and St. Joseph." The synclinal spoken of is, in my opinion, a purely theoretical one, and if we lay the above described line down on the map, it will be found to cross diagonally not only this Sillery synclinal, but likewise the Lauzon and the Lévis formations, as shewn on the map; while, on the other hand, it runs entirely parallel with the line which, without any previous knowledge of the above quoted description, I had myself carefully traced on the ground, in 1877, as the upper limit of the magnesian belt and division 2, and the unconformably overlying fossiliferous formations.

The gneissic mica schists of Sutton Mountain are probably the deepest

Group 3.

Course of the magnesian belt.

Sutton mountain gneisses.

* Geology of Canada, p. 258.

North-eastern extension of group 3.

exposed portion of this great anticlinal. To the north-east, between the county of l'Islet and the Trois Pistoles River, the rocks of the anticlinal have not been traced. They will, however, doubtless be found to continue till they pass beneath the overlapping Upper Silurian strata which on the Rimouski River are stated to rest directly on the fossiliferous Lower Silurian formation. Rocks which clearly belong to the upper part of the division, with associated traps, emerge from beneath the Upper Silurian along the northern shore of Matapedia Lake, and I think it will be found that they extend thence into the Shickshock Mountains, which on the north are flanked by the fossiliferous Lower Silurian rocks, and on the south by strata of Upper Silurian age. The investigation of the structure of these mountains presents a fine field for any active and enterprising geologist.

Copper ores.

The copper ores of the region under consideration, to which too much importance has, I think, been attached, in determining the limits of the divisions of the Quebec group, appear to me to belong to two distinct periods, and to occur under conditions almost, if not quite, as distinct as they do in the Huronian and "Upper Copper-bearing" rocks of Lake Superior. Those of the first period belong to the crystalline, magnesian schist group, and occur both in beds and in lenticular layers parallel with the stratification, and also in veins cutting the strata transversely, but in no case, that I am aware of, accompanied by intrusive crystalline rocks. The Harvey Hill mine, the Viger mine and the Sherbrooke mines are examples of this mode of occurrence. Those of the second period seem to be chiefly confined to the rocks of group 2, but occur also within the limits of the fossiliferous belt. They are in almost every instance more or less closely associated with certain highly crystalline intrusive rocks: diorites, dolerites, amygdaloids and volcanic agglomerates, with bands of white, grey and mottled crystalline dolomites and calcites which have much more the appearance of great lenticular, vein-like, calcareous masses than of beds belonging to the stratification. No traces of organic forms have been found in them, and yet many of them are scarcely more crystalline than certain Devonian and Carboniferous limestones in which fossils are abundant. The Acton mines, and the numerous openings that have been made in searching for copper ore in that vicinity and in the neighbouring townships of Roxton, Milton, Wickham and Wendover, may be cited as instances of this second class. And it certainly appears as if the copper ore in these upper divisions were in some way connected with the intrusion or segregation of the crystalline rocks which everywhere accompany it. In any case, I think, there are very few who would agree with Dr. Hunt in the general proposition that the diorites and serpentines of the Quebec group are of sedimentary origin, and the amygdaloids

Serpentine amygdaloids, &c.

altered argillites; and, unless all contemporaneously interbedded volcanic products are to be considered as of sedimentary origin, the Quebec group might be said to present some of the most marvellous instances on record of "*selective metamorphism.*" But whether this is so or not, there seem to be no good grounds for assigning either an age or an origin to the cupriferous diorites, dolerites, and amygdaloids of the Eastern Townships different from that of the almost identical rocks of Lake Superior, which Dr. Hunt* states have been shewn to overlie *unconformably* the Huronian and Montalban series, but which at Keeweenaw Point are stated by Prof. Pumpelly† to rest *conformably* on the Huronian; Prof. Pumpelly justly remarks that "the question would still seem to be an open one, whether the cupriferous series is not more nearly related to the Huronian than to the Silurian." The same may certainly be said of the lower cupriferous rocks of the Eastern Townships. Brooks does not not, in his paper‡ quoted by Dr. Hunt, give any very conclusive reasons for his change of views since 1872, and writes altogether as if the question of the unconformable superposition of the copper-bearing rocks on the Huronian were still undecided; and so late as 1877, Prof. Roland Irving writes: "the unconformity between the Huronian and the upper copper-bearing rocks *is not certainly proven.*" § Opinions of Messrs. Hunt, Pumpelly and Irving.

A very considerable amount of careful investigation and laborious work in the field is yet required before the divisions I have now indicated can be correctly delineated on the map. The two maps exhibited in the Geological Survey Museum, Room 4, shew, respectively, the supposed distribution of the old divisions of Lévis, Lauzon and Sillery, and that of the new divisions (so far as they have been determined), which it is now proposed to adopt. These latter have at least the advantage of simplicity; they also obviate the necessity of invoking any of the numerous almost impossibilities in physical and dynamical geology and the numberless overturned dips which are required to explain the previous theory of the structure, and they are, moreover, very closely in accord with the views entertained by Prof. Hitchcock as regards the general succession of the formations in the adjoining States of New Hampshire and Vermont. Maps.

Laurentian.—I shall now make some observations on the results of the recent work of the Survey in unravelling the complications of the stratigraphy of the older "*crystallines*" on the north side of the St. Laurentian.

* Second Geological Survey of Pennsylvania; Special Report on Azoic Rocks and Trap Dykes, §158.

† Geological Survey of Michigan, Vol. I., 1873.

‡ *American Journal of Science*, Vol. XI., 1876, pp. 206–207.

§ *American Journal of Science*, Vol. XIII., 1877.

Investigations Mr. H. G. Vennor.

Lawrence Valley. Since 1866, Mr. H. G. Vennor, of the Geological Corps, has been occupied in a careful examination of the stratigraphical relations of the Laurentian rocks. His observations, commencing in Hastings county, north of Lake Ontario, have now extended across the Ottawa River, eastward, to Petite Nation and Grenville, embracing a band of country 200 miles in length, with an average breadth of fifty-five to sixty miles. Throughout this tract of country Mr. Vennor has followed and mapped, in all their windings and convolutions, the great series of Laurentian limestone bands first investigated and described by Sir W. E. Logan in the years from 1853 to 1856, more particularly in the Grenville region, and in 1865, by Mr. Macfarlane, in the Hastings region. The results and conclusions of all these earlier examinations are given in detail in the Geological Survey Reports. And these shew that the classification then adopted by Sir W. E. Logan was regarded by him as provisional. (See Note, p. 93, Geological Survey Report, 1866.)

Thus, at the commencement of Mr. Vennor's investigation in 1866, it was supposed that the limestones and calcareous schists of Tudor and Hastings holding *eozoon*, together with certain associated dioritic, felsitic, micaceous, slaty and conglomerate rocks, were a newer series than those already examined and described by Sir W. E. Logan, and they were accordingly designated, in the report published in 1870, the *Hastings series*, and it was further supposed, from its apparent stratigraphical position and from certain lithological resemblances, that it might be of Huronian age. The gradual progress of the work, however, from west to east has now, I think, conclusively demonstrated that the Hastings group, together with the somewhat more crystalline limestone and gneiss groups above referred to, form one great conformable series, and that this series rests quite unconformably on a massive granitoid, or syenitic, red gneiss—the gneiss 1*a*, in part, of Sir W. E. Logan's Grenville map, published in 1865, in the Atlas to the Geology of Canada. I wish it to be understood that I have not yet been able personally to examine this region, and I am therefore, in what is above stated, expressing the views of Mr. Vennor, from which, however, I have no reason to dissent.

Correlation of the Hastings and Grenville groups.

Of the actual distribution of this lower or "Ottawa" gneiss very little is at present known with certainty, though it probably occupies very extensive areas from the eastern shores of Lake Winnipeg to Labrador. And between these same localities there will doubtless yet be found many large areas of the so-called Norian series. The first suggestion of this unconformable Upper Laurentian series, which, it seems to me, however, is intimately connected with the Hastings and Grenville series, appears to occur in the supplementary chapters to

Norian series.

The Geology of Canada, 1863, pages 838-839; but the evidence there given by no means proves the subsequent assumption of this unconformity; while the careful descriptions by Sir W. E. Logan, both in the supplementary chapter above cited and likewise in Chapter III., shewing the intimate association and interstratification of the orthoclase gneisses, quartzites and crystalline limestones with these supposed unconformable Upper Laurentian anorthosites, much more strongly favor the supposition that they are part and parcel of the great crystalline limestone series.

The exhaustive History of the labradorite rocks by Dr. Hunt, in the volume already cited,* while giving much valuable and interesting historical information, does not advance us a single step beyond the position taken by Sir W. E. Logan, in 1863, as regards their true stratigraphical relations. In not one of the several areas where they are known to occur in Canada, have they yet been mapped in detail, and even their limits, as indicated on the geological map, are more or less conjectural. This appears to be likewise the case as regards the areas where they have been noticed in Essex and adjoining counties in New York State and in New Hampshire, where Prof. Hitchcock shews that they rest unconformably on the upturned edges of the "*Montalban*" gneisses,† leading to the conclusion that the gneisses of the White Mountains are older than the "Norian," whereas Dr. Hunt, solely, I believe, on mineralogical considerations, supposes these same "*Montalban*" gneisses to constitute a series newer than the Huronian. Here then, as in the Hastings region, we find theory and experience at variance. But the question suggests itself, May we not have labradorite rocks belonging to systems younger than Laurentian? Dr. Hunt refers (§ 318) to the valuable chemical and microscopic examination of these rocks in Essex county, New York, by Mr. Albert Leeds, the results of which are given in the *American Chemist*, March, 1877; but Mr. Leeds does not appear to have studied the stratigraphy of the region, and his general conclusions are stated as follows:—

Dr. Hunt on the labradorite rocks.

Investigations of Mr. Leeds.

"That these norites are a stratified rock, but have undergone a metamorphosis so profound as to have caused them to be regarded by Emmons and earlier observers as unstratified. The dolerites, which are formed of the same constituent minerals, and are of the mean specific gravity of these norites, have probably been formed from a portion of these stratified deposits by deeply-seated metamorphic action, and have further modified and greatly tilted the superposed rocks in the course of their extrusion."

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* Second Geological Survey of Pennsylvania; Special Report on Azoic Rocks and Trap Dykes.

† Geology of New Hampshire, Vol. II., pp. 217-218.

Opinions of Professor James Hall.

Prof. James Hall, in 1866,* has stated his conclusions that the limestones of Essex and adjoining counties in New York State "do not belong to the Laurentian system, either lower or upper." The facts on which a part of this conclusion is based, viz., the unconformity of the Laurentian limestone series to the lower orthoclase gneisses, agree with those of Mr. Vennor, and there is, I think, but little doubt that all these crystalline limestone groups—that is, those of Essex and St. Lawrence counties, United States, and Rawdon, Grenville and Hastings, in Canada,—are parts of one great series, and at present I see no evidence for excluding from this series the associated Norian rocks. Whether the series, as a whole, will eventually retain the name Upper Laurentian, or whether it will be found more convenient to designate it Huronian system, does not much signify.

We can, however, confidently state that these crystalline limestones and their associated strata occupy an unconformable position between a massive gneiss formation below and unaltered Potsdam, or Lower Silurian, rocks above; and this may likewise be stated respecting the stratigraphical position of the typical "Huronian series" of the Georgian Bay, which, together with its close proximity to the western-most known exposures of the crystalline limestone series which we now know, extends from Parry Sound to Lake Nippising, and includes some labradorite gneiss, renders it very probable that a connection will eventually be traced out, between even these supposed greatly different formations, similar to that now, as already stated, proved to exist between the Hastings and Grenville series.

Prof. Hall, in his note already referred to, states that the labradorite formation is "associated" with bands of crystalline limestone, and, further on, that the limestones do not belong to either the Upper or Lower Laurentian. He does not, however, say what the Upper Laurentian he alludes to is, though, in another paragraph, we find it stated that the "Lower Laurentians are succeeded by massive beds of labradorite," which, we may infer, are considered Upper Laurentian—in which case there would seem to be in New York State two sets of labradorite rocks, one associated with the limestones, which are "altogether newer than Laurentian," and another massive, and representing Upper Laurentian. There is, however, so far as I am aware, no evidence of this being the case in Canada.

Origin of the *Norian series* or Labradorite rocks.

If it is admitted—which, in view of the usual associations of Labrador felspars, is the most probable supposition—that these anorthosite rocks represent the volcanic and intrusive rocks of the Laurentian period, then also their often massive and irregular, and sometimes bedded character,

* *American Journal of Science*, Vol. XII., p. 298.

and their occasionally interrupting and cutting off some of the limestone bands, as described by Sir W. E. Logan, is readily understood by any one who has studied the stratigraphical relations of contemporaneous volcanic and sedimentary strata of palæozoic, mesozoic, tertiary and recent periods. Chemical and microscopical investigation both seem to point very closely to this as the true explanation of their origin. That they are eruptive rocks, is held by nearly all geologists who have carefully studied their stratigraphical relations. But I am not aware of any one having suggested that they are the products of volcanic action in the Laurentian, or perhaps Lower Huronian epoch ; doubtless, as Mr. Leeds says, "*profoundly metamorphosed*," as of course they would be from having suffered all the physical accidents which have resulted in producing the associated gneisses, quartzites, dolomites, serpentines and schists.

When we recall the names of Dahl. Kerulf and Torrell in Norway, Maculloch and Geike in Scotland, Emmons, Kerr, Hitchcock, Arnold Hague, and others in America, all of whom consider these norites as of eruptive origin, we may well pause before accepting Dr. Hunt's conclusions respecting them, and that they should often appear as " bedded metamorphic rocks" (the opinion expressed respecting those of Skye by Prof. Haughton of Dublin) is quite as probable as that we should find the mineralogically similar dolerites occurring in dykes and bosses and in vast beds interstratified with ordinary sedimentary deposits of clay, sand, &c., as we do over wide areas in Australia and elsewhere.

In conclusion, I may say that I fail to see that any useful purpose is accomplished, in the present stage of our knowledge of the stratigraphical relations of the great groups of rocks which underlie the lowest known Silurian or Cambrian formations, by the introduction of a number of new names such as those proposed by Dr. Hunt for systems or series which are more or less theoretical, in which category we may, in my opinion, include the Norian, Montalban, Taconian and Keeweenian. These, one and all, so far as known, are simply groups of strata which occupy the same geological interval, and present no greater differences in their physical and mineralogical characters than are commonly observed to occur both in formations of the same epoch in widely separated regions and when physical accidents, such as contemporaneous volcanic action or subsequent metamorphism, have locally affected the general character and aspect of the formation within limited areas.

Introduction of new names for pre-Cambrian formations.

No better instances of such differences could be cited than the Mesozoic and Carboniferous formations of British Columbia and those of the same periods in eastern America, and the Silurian and Cambrian formations of Australia, Europe and America.

It seems to me that the well-known and recognized names,

Laurentian,
Huronian,
Cambrian and Silurian

—with the introduction, where found desirable to denote some local break, of the terms upper, middle and lower—meet all present requirements so far as systems are concerned.

Value of mineralogical and palæontological stratigraphy.

Unfortunately in Canadian geology, hitherto, the stratigraphy has been made subordinate to mineralogy and palæontology, and, as the result, we find groups of strata which the labours of the field geologist during the past ten years have now shewn all to occupy a place between Laurentian and Cambrian, assigned to Carboniferous and Upper Silurian in New Brunswick and Nova Scotia, to the peculiar palæontological Lévis group and its subdivisions, Lauzon and Sillery, in the Eastern Townships, and to Lower and Upper Laurentian, Huronian, Lower Silurian and Triassic on the north side of the St. Lawrence valley and around Lake Superior. The same system of mineralogical stratigraphy is now further complicating and confusing the already quite sufficiently intricate problem by the introduction of the new nomenclature I have referred to, and in some cases these names are applied regardless of and in direct opposition to well-ascertained stratigraphical facts. A similar unfortunate instance of palæontological stratigraphy is found in the history of the Quebec group; and especially in the late introduction in it of the belt of supposed Potsdam rocks, about which I have already stated my opinion.

In the reconstruction of the geological map of eastern Canada,—and in this I include the country from Lake Winnipeg to Cape Breton and Labrador—rendered necessary by the present state of our knowledge, I should propose to adopt the following divisions of systems to include the groups enumerated :—

I. Laurentian : To be confined to all those clearly lower unconformable granitoid or syenitic gneisses in which we never find interstratified bands of calcareous, argillaceous, arenaceous and conglomeratic rocks.

II. Huronian : To include—1. The typical or original Huronian of Lake Superior and the conformably—or unconformably, as the case may be—overlying upper copper-bearing rocks.

2. The Hastings, Templeton, Buckingham, Grenville and Rawdon crystalline limestone series.
3. The supposed Upper Laurention or Norian.
4. The altered Quebec group, as shewn on the map now exhibited, and certain areas not yet defined

between Lake Matapedia and Cape Maquereau in Gaspé.

5. The Cape Breton, Nova Scotia and New Brunswick pre-Primordial sub-crystalline and gneissoid groups.

III. Cambrian : In many of the areas, especially the western ones, the base of this is well-defined by unconformity, but in the Eastern Townships and in some parts of Nova Scotia it has yet to be determined. The limit between it and Lower Silurian is debatable ground, upon which we need not enter.

The apparent great unconformity of the Nipigon group to the Huronian around Lake Nipigon, as described by Dr. Bell, may perhaps be explained by our having here the deep-seated parts of an ancient volcanic crateriform vent, greatly denuded, and the crater now occupied by the waters of the lake. The eruptions from this crater may have commenced in the Huronian epoch, and been continued at intervals even up to the Triassic period ; but, in the meantime, we have no distinct evidence of any of the eruptions in this region being newer than Lower Cambrian. The Nipigon group.

* The investigations of Dr. Bell of the Geological Corps in 1877, around the eastern shores of Hudson Bay shew that we have there an enormous development of but slightly disturbed strata, lithologically resembling those around Lake Nipigon, everywhere conformably overlain by a thick sheet of doleritic lava forming the uppermost stratum of the series. It is doubtless in this region that the true relations and ages of this formation will have to be worked out. All that can at present be said of it is that it is apparently destitute of fossils, and that it rests unconformably on highly disturbed and crystalline strata of Laurentian and perhaps Huronian age.

One point I wish particularly to insist on is, that great local unconformities and lithological differences may exist without indicating any important difference in age, especially in regions of mixed volcanic and sedimentary strata, and that the fact of crystalline rocks (greenstones, diorites, dolerites, felsites, norites, &c.,) appearing as stratified masses and passing into schistose rocks, is no proof of their not being of eruptive or volcanic origin—their present metamorphic or altered character is, as the name implies, a secondary phase of their existence, and is unconnected with their origin or original formation at the surface, but is due partly to original differences of composition and partly to the varying physical accidents to which they have, since their formation, respectively been subjected.

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* Geological Survey of Canada Reports 1877-78 D.

GEOLOGICAL SURVEY OF CANADA.

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

PRELIMINARY REPORT

ON THE

PHYSICAL AND GEOLOGICAL FEATURES

OF THE

SOUTHERN PORTION OF THE INTERIOR

OF

BRITISH COLUMBIA,

1877

BY

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

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:
DAWSON BROTHERS.

1879

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

Director of the Geological Survey of Canada.

SIR,—I have the honour to submit herewith a report of my work in British Columbia during the season of 1877, being a preliminary report on the Physical and Geological features of the Southern part of the interior of that Province.

I have the honour to be,

Sir,

Your obedient servant,

GEORGE M. DAWSON.

MONTREAL, December, 1878.

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ON

THE PHYSICAL AND GEOLOGICAL FEATURES OF THE SOUTHERN PORTION OF THE INTERIOR OF

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During the summers of 1875 and 1876 a preliminary examination of a considerable portion of the northern part of the interior of British Columbia was made. The exploration of these two summers, lying in contiguous areas, together covers a region extending from the Chilcotin River and Tatlayoco Lake on the south, to François Lake on the north, and bounded to the east and west by the Fraser River and Coast Range respectively. The work was carried on in more or less intimate connexion with that of the surveys for the Canadian Pacific Railway, and much assistance derived from the depôts established by the railway parties, and trails cut by them, without which the geological examination of this hitherto almost unknown region would have been a very difficult matter. The season of 1877 has been devoted to the southern part of the interior of the Province, a region less encumbered with forest, and though in many places rough and mountainous, much more easy of access, and already dotted with settlements. This region is probably the best suited of any in the interior to the elucidation of the general geological structure of the country, and has yielded during the past season many facts of interest in this connexion, though a more detailed investigation of some parts of it is much to be desired. Work of the Geological Survey in British Columbia.

This report, like those previously published for 1875 and 1876, is intended to be a preliminary account of the geological and general features of the district embraced by the explorations of the summer, but is more complete and detailed than those before mentioned, owing to the greater accessibility of the country, which was traversed systematically on a number of lines, chosen as the best suited for geological purposes, and not merely adopted as being the only practicable routes through Character of this Report.

the district. To complete the preliminary geological exploration of the Province on the same basis, the following districts remain to be examined. 1. Region north of Kamloops and east of the Fraser, including the Cariboo district. 2. A large triangular area east of the 119th meridian, including the upper part of the Columbia, and Kootenay district. 3. Region west of the Fraser and south of the Chilcotin Rivers. To each of these a summer's work would have to be devoted. The Queen Charlotte Islands it is intended to examine next summer, but a large part of Vancouver Island and the coast remains unexplored, and in some places where the coal-bearing rocks exist, more detailed work than that at present necessary in the above-mentioned districts would be required. North of the 54th parallel, a vast area including the head waters of the Stuart, Skeena and Peace Rivers, with the Omineca gold mining district, would require for its traverse on one or two lines, at least one complete season's work; while into the immense northern part of the Province, extending to the 60th parallel, and including the Cassiar gold mining district, it will probably not be necessary to extend the work of the Survey till it is more advanced in the southern portion.

Regions remaining unexplored.

On arriving at Kamloops, on the 23rd of May, I availed myself of Mr. Sandford Fleming's generous offer of assistance in the matter of transport, and with the aid of Mr. W. B. Ross, in charge of the Canadian Pacific Railway office and stores at Kamloops, was enabled in a short time to obtain the necessary pack- and riding-animals, and a small party consisting of a Mexican packer, Lillooet Indian, as packer's assistant and cook, and D. McFarlane as general assistant. Temporary additions were made to the party from time to time during the summer of Indians acting as guides, canoe-men, and in other capacities.

Survey party.

On the 28th of May I left Kamloops, and from this date to the 19th of October, was continuously occupied in field-work, scarcely two consecutive days being spent in the same camp. The district embraced by the surveys of the season, extends in longitude from 119° to 121° 30′. In latitude from the 49th parallel to 51° 20′. Explorations were however carried eastward beyond the first mentioned line at Cherry Creek, while it was not approached nearer than about twenty miles, in the south-eastern corner of the area. The second meridian above given nearly coincides with the course of the Fraser River, which practically formed the limit of work to the west. The northern bounding line was only approached in three places, while from the mountainous nature of the country to the south, it was impossible in most places to attain the vicinity of the 49th parallel.

Limits of region examined.

The best general representation of the district is found on the map of British Columbia, compiled under the direction of the Hon. J. W.

Map.

Trutch in 1871, but this is far from being sufficiently accurate for the purposes of even a geological reconnaissance. It was therefore necessary to keep a careful running survey during the entire summer, in which bearings from point to point, or approximate average bearings were taken, and the distances generally estimated by the time occupied in travel. Where circumstances appeared to warrant the additional expenditure of time, these were replaced by paced surveys. The whole being arranged so as to form a loose net-work of lines over the region under examination, and being tied in at known points, or fixed in latitude, from time to time, by sextant observations. Having been unable to secure the services of a suitable scientific assistant, the whole of this work devolved upon myself, and though a necessary part of the survey of the region, employed much time which might have been devoted to strictly geological work. The geographical and topographical results obtained, add much to our knowledge of the country, and are embodied in the accompanying map in as much detail as its scale allows.

Character of surveys.

Measured from point to point of the more prominent angles of the traverse lines, the area of the district included is about 18,000 square miles. Rock specimens, and wherever they could be found, fossils, were collected from all parts of the area. Sixty-five photographs representing points of geological or picturesque interest were taken, but owing to defects in the prepared dry plates employed, and other causes, only a portion of these were found satisfactory on development. A collection of such plants, as appeared to be of special interest, was formed, and has since been submitted to Prof. Macoun, of Belleville, who has furnished a list of species. Meteorological observations were carried on with as much regularity as circumstances admitted, and barometric readings taken at a great number of stations for the purpose of fixing approximately the elevation of all parts of the region.

Collections and observations made.

In this report the subjects are treated in the following order:—A brief sketch of the general characteristics of the region forms the preface to a more detailed description of these, and the general geology. In this the routes travelled over are followed. A short discussion of the economic value of the surface of the country in relation to farming, stock-raising, etc., follows, with statements in regard to the extent and value of water communication. While the general geological features of any particular portion of the region are mentioned in this part of the report and are defined on the map, it is judged best to classify the rocks as far as possible according to age in the more purely geological division of the report, and to deal first, and at greater length, with those localities where large and good sections have been found.

Arrangement of Report.

In doing so the following sub-divisions are used as a basis of arrangement: *Older rocks, Palæozoic and Triassic, Later Mesozoic rocks, Tertiary rocks; Superficial deposits; Traces of glacial action.* In conclusion, a discussion of the general geological relations of the rocks met with is given, with a review of the geological features of economic importance, including the coals, limestone, and metalliferous rocks of the district.

Previous geological work in the district.

Previous to the extension of the work of the Geological Survey of Canada to British Columbia, the geology of the district now in question had remained almost altogether unknown. Mr. G. Gibbs traversed the region in the vicinity of the 49th parellel in connection with the American division of the Internationial Commission employed in fixing the boundary-line, and has published some notes on the rocks met with, together with other matter, in the Journal of the American Geographical Society, Vol. IV., 1874. The article is entitled, "Physical Geography of the North Western Boundary of the United States." Mr. H. Bauerman, who accompanied the British division of this Commission as geologist, examined the rocks of the same region, but his report has not been published.

In 1871, the Director of the Geological Survey, with Mr. Richardson, travelled from Yale on the Fraser River to Kamloops, from which point Mr. Selwyn ascended by North Thompson River to Moose Lake, in the Leather Pass, returning by the same route. Mr. Richardson meanwhile carried on an examination of the rocks near the main waggon road, between Yale and Cariboo, and made continuous paced measurements along it, within the limits of the region now in question, amounting to over 150 miles. On the explorations of this year the preliminary classification of the rocks of the province was based.* The measurements and geological observations have been utilized in the construction of the accompany map. Late in the autumn of 1876, while on my return from the northern part of the province, I made a hurried examination of the route from Kamloops to Nicola Lake, a portion of the results of which are embodied in Appendix R. of the Report on the Canadian Pacific Railway (1877), with these exceptions the whole of the geology represented on the map, and embodied in this report, are the result of explorations in 1877.

GENERAL CHARACTERS OF THE REGION.

Mountain systems.

The greater part of the district included in this report, is best designated as the southern portion of the Interior Plateau of British Columbia. Three systems of mountains, running in general north-

* Report of Progress, 1871-72, p. 54.

westerly and south-easterly bearings, here intervene between the Pacific coast and western margin of the Great Plains. Between the Rocky Mountain Ranges, forming the first, and Selkirk and Gold Ranges, which here represent the second great mountain system, no wide plateau intervenes. They appear indeed almost to inosculate in places, though their respective limits may be considered as defined by the remakably persistent straight valley which carries the upper waters of the Kootenay, Columbia and other rivers. Between the second mountain system and the Coast Ranges, the region above referred to lies. It has an average breadth of one hundred miles, and though best described as a plateau, this term must be taken as representing a generalized idea of its primitive character. Viewed broadly, it differs in no respect from the wide mountainous regions of the Coast, Gold, and other ranges, except in inferiority of general altitude due to the less complete flexure and consequent swelling of the stratified masses. As a result of the closer folding of those regions generally known as mountain ranges, the valleys are there more nearly parallel and closer together; and being formed in masses of greater thickness, and—owing to greater atmospheric precipitation, exposure to frost, and other causes—more rapidly, they are deeper and more rugged than those traversing the plateau. Neither in the Gold Ranges nor those of the coast, are peaked and shattered mountain summits a prominent feature. Frequently from the higher points, the eye appears to travel over an undulating or hilly country, dotted with groves of the hardier species of trees, with banks of hard snow in the shady hollows even in midsummer, and in close proximity to slopes of the greenest grass, dotted with flowers. Far below, however, and seaming the surface in all directions, the rivers, in narrow V-shaped valleys or rocky cañons are forcing their way to the coast. There is thus no limit which can be defined as forming the boundary of the plateau region, nor any distinct line such as exists in many places on the eastern border of the Rocky Mountain Range. Toward the outer margin of the wide system of Coast Ranges, however, this character is in great degree lost. Denudation acting more energetically, has frequently reduced the area of the high intervening regions till they have become sharpened into peaks, and saw-like ridges.

Interior Plateau.

Character of the mountain ranges.

Over very considerable areas a much greater degree of definiteness than it would otherwise have had, is given to the Interior Plateau by deposits due to the Tertiary periods, by which it has been levelled up. These consist of sandstones, clays and shaly rocks holding lignites, which indicate the existence of a wide-spread system of great lakes, and are capped by volcanic accumulations of great thickness, which are not infrequently still nearly horizontal. The normal elevation of the Interior Plateau in its southern part may be stated as 3,500 feet, and a plane at this elevation would most closely coincide with the greatest extent of nearly level land. The hills which rise above this level would probably not more than compensate for the valleys which have been excavated below it. These valleys divide the surface of the plateau into a number of rather irregular polygonal areas, and water standing at an elevation of 3000 feet would flood most of them, converting the plateau into a system of islands with comparatively narrow intervening channels. Some of the valleys may date from a time anterior to the Tertiary deposits, but most of them are evidently subsequent to this and may be assigned to the latest period of the Tertiary, during which there is reason to believe that this portion of the Pacific coast stood considerably higher above the sea level than at present, though with all its main orographic outlines as they now are. All the larger valleys are without doubt pre-glacial. To the north of the area now in question the valleys of the plateau widen, and its general elevation is considerably lowered. Southward, in the vicinity of the 49th parallel, it is higher and more mountainous, though traversed by one wide and deep valley, that of the Okanagan.

Elevation of the plateau.

Valleys.

Almost all the rivers and streams in the district are very rapid, though seldom showing high falls.

Climate of the region.

The climate of the southern portion of the Interior Plateau is in temperature one of extremes, with a very light rainfall, rendering irrigation necessary where farming is carried on. The following table, kindly supplied by Prof. Kingston, indicates these peculiarities, and shows the difference which obtains between Spence's Bridge—the only regular observation station maintained in this part of the province—and Esquimalt, on the coast:

	Mean temperature.	Mean summer temperature	Mean winter temperature, Dec., Jan., Feb.	Mean winter temperature, Jan., Feb., Mar.	Clouded sky.	Total annual precipitation.	Mean highest temperature.	Mean lowest temperature.	Absolutely highest.	Absolutely lowest.	Mean annual range.
	°	°	°	°	p.e.	inch's	°	°	°	°	°
Esquimalt	48.42	57.98	39.46	39.17	53	28.41	80.1	17.2	85.0	8.0	62.9
Spence's Bridge.	47.79	68.41	26.01	29.84	46	10.10	98.8	-9.4	105.0	-29.0	108.2

Spence's Bridge probably fairly represents the lower valleys of the plateau region, but great local diversity is found, owing to difference in elevation, proximity to higher mountain regions, and other causes which are not always easily explicable. The extreme upward limit of agriculture may be stated at 3000 feet, and it will be observed that the greatest area of comparatively level plateau country lies above this elevation, and is subject to more or less severe summer frosts. Farming is in consequence practically confined to the trough-like valley-bottoms, or slopes adjacent to them, and in most cases to those portions of these on which water may be brought for irrigation. It is beginning to be found, however, that fall wheat may be grown on many of the higher benches on which water cannot be obtained, the moisture left by the winter's snow being sufficient for its development in an average season. The soil is almost everywhere very rich, and yields crops excellent both as to quantity and quality. Little demand at present exists for cereals, however, owing to the isolation of the district, but if stiumulated by a good market, a considerable annual export could be made.

Limit of Agriculture

The greater part of the plateau, up to, and in some cases above 3000 feet, is either almost destitute of timber, or only lightly wooded, and over great areas offers excellent pasturage. Stock-raising is thus at the present time much more important than agriculture in the district, and must continue to be so. Above the open or lightly timbered country, forests of Douglas fir prevail, and these with the groves of yellow pine of the lower slopes, afford abundant and excellent supplies of timber, though the trees in no case attain a size so great as those of the coast.

Timber.

The cause of the dry character of the climate of the interior is to be found in the wide and high Coast Ranges, which intercept the moisture of the prevalent westerly winds. It may be raining almost continuously for days over the western portion of the Coast Range, while not a shower falls on the eastern margin only fifty miles distant. The clouds flying eastward appear incapable of precipitating a drop of moisture, though obscuring the sky. A second zone of precipitation, however, commences on the south-westward slopes of the Selkirk and Gold Ranges, and a great rainfall and heavy snowfall in winter must occur on their higher parts as evidenced by the character of the vegetation, and existence of large masses of perennial snow and of glaciers among their summits.

Zones of great and deficient rainfall.

The Fraser and Thompson River Valleys.

The lower portion of the valley of the Fraser River, described both as to its general topographical and geological features, by Mr. Selwyn in the report already referred to,* need not again be treated at length

* Report of Progress, 1871-72, pp. 21 to 24, 60 and 62 to 64.

here. This river is not singular in cutting its way from the region of the high interior plateau of British Columbia through the Coast Range to the sea. It merely repeats, on a larger scale, what has been accomplished by other streams throughout the whole length of the Coast Range in the Province. The Fraser, however, flowing nearly due south from beyond the 54th parallel, traverses obliquely a great part of the length of the central plateau, drains a vast area, and leaves to the other rivers flowing to the coast, basins comparatively very small.

Character of the Fraser Valley.

Though speaking of the Fraser and other rivers as cutting through the Coast Range, this statement, if unmodified, might lead to a wrong conception of the fact. Though the Coast Range, in its general north-westward and south-eastward course, is traversed, more or less, nearly at right angles by these streams, it is found on closer inspection that the smaller mountain systems composing the range, are not by any means parallel to it in their longer axes. These minor systems, at least in the southern portion of the range, are perhaps most generally found in north and south bearings. The valleys defining these minor ranges, have no doubt been formed by the ordinary processes of subaërial waste and erosion by small streams, before the glacial period, and when the drainage system of the country may have been altogether different from the present. Of these valleys the lowest were afterwards adopted by the rivers, and deepened and modified by them. The rivers consequently do not cut across the Coast Range with straight-sided cañons disregarding its structure. The Fraser, owing to its greater size, has succeeded in cutting down its bed to an almost uniform grade from its sources to the sea, and in doing so may be supposed to have modified more profoundly than any other of the streams in question, the valley by which it originally found its way to the coast. Its wide delta, nearly at the present sea level, indicates, as has elsewhere been pointed out * that the present relative positions of sea and land have been maintained for a long time. From the sea to Hope, however, the stream is almost continuously bordered by banks of drift deposits and river wash, and in most places the flat land intervening between the river and the mountains bounding the valley is of some breadth. The current is also comparatively gentle, and the river in this portion of its course is not now excavating its bed to any appreciable extent. It may encroach from time to time on the banks, but the addition of width to the stream on one side, leads but to the formation of wider gravel banks on the other. The history of this part of the Fraser Valley would in fact appear to be the same with that of the other

Uniform grade.

* Canadian Naturalist New Series, vol. viii., p. 241.

fiords and sounds of this coast. Excavated chiefly during later Tertiary time, with the land at a level considerably higher than the present, it became on subsequent depression a wide inlet, which, owing to the great quantity of *débris* brought down by a large river like the Fraser, has long since been completely filled. To the north, we find in the inlets with smaller rivers, a limited area only of level delta-land where the rivers debouch.

Canons of the Fraser.

Above Hope the current of the Fraser becomes much more rapid, but it is on reaching Yale that the stream is found to be bordered on either bank by rocky mountain-sides. From this place to Boston Bar (26 miles by the road), the valley is confined and narrow, with steep, precipitous mountain-slopes of granite, gneiss, diorite and other crystalline rocks, to which little soil clings, the river flowing in a contracted rocky channel, in a succession of heavy rapids and "riffles." The rocks met with are those of the Cascade Crystalline series of the report already referred to,* the age and character of which receive attention on another page. At Boston Bar, the valley suddenly expands to a somewhat greater width, the softer rocks of the Anderson river, or Boston Bar group,† at the same time appearing in its axis. The mountains, though now withdrawing a little from the immediate banks of the river, do not appear to lose much in altitude. The views of the ranges obtained from the waggon road, however, do not give a just idea of the character of the Fraser Valley, or the mountains in its vicinity; for, on ascending to some height on any of those in sight (as for instance, those rising immediately behind Boston Bar), the immediate valley of the river is seen to be a comparatively narrow depression in the centre of a wide, trough-like, though irregular hollow—one of the great structural valleys of the Coast Range. It is not improbable that the actual valley of the Fraser may be due chiefly to its own action of *corrasion*, while the predisposing hollow depends on the original flexures of the rocks and other causes before alluded to. From many points overlooking the river, views may also be obtained of groups of high and snow-capped peaks, which, in clusters here and there, dominate the average altitude of the lower summits. Some of these are probably over 8,000 feet in height.

Mountains of the Coast Range.

Mesozoic Rocks.

Ten miles beyond Boston Bar, or near the 36-Mile Post, the rocks called by Mr. Selwyn,‡ the Jackass Mountain conglomerates, are found, forming a cliff and rock-slide to the right of the road, while the Boston Bar series continue on the left, a few hundred feet distant. The section here displayed is described on a following page. The beds of the Jackass Mountain series were found during the past summer to extend

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* Report of Progress, 1871-72, p. 63. † Ibid, p. 62. ‡ Ibid, p. 60.

southward to the Anderson River, east of the Fraser Valley. Northward they stretch on the same general strike nearly to Lytton, forming south of that place the rough cliff overhanging the river, known as the Jackass Mountain. Here, and also at the 36-Mile Post, fossils were found, and the rocks proved to represent a portion of the Shasta group of California.

Fraser Valley between Lytton and Lillooet.

From Lytton to Lillooet, the Fraser Valley runs a few degrees west of north, following the direction of the inner ranges of the coast mountains, which here have this bearing. The mountains press close on the river in this part of its course, and rise in an almost continuous wall on either side, probably exceeding 5,000 feet in altitude in many places. The river is extremely rapid, but grain is nevertheless carried down it in boats from Lillooet to Lytton, the boats being afterwards tracked up by Indians with great labor. Between the steep slopes of the mountains and the river, there is generally a certain width of land with more gentle inclination and nearly free from timber. This is too rugged, however, for cultivation, which is limited to the gently sloping apron-like areas of certain "fans" * which have been formed at the entrance points of streams, and are abruptly terminated in the axis of the valley by the trench-like excavation which the river has made for itself in the most recent period. All the patches of land suitable for farming appear to be already taken up, and the stock ranges in the vicinity of the river are quite limited in area. In the bottom of the valley the bunch-grass has almost disappeared, owing to the number of Indian horses engaged in packing, on the trail. About twenty-two miles above Lytton, near Forster's Bar, the main valley turns a little to the west, while that of a small stream continues nearly in the general direction ot the lower reach. This is followed by one trail, while the second follows the bank of the Fraser. In travelling by the first mentioned, the valley is found to run directly through to Fountain, where it again joins that of the Fraser. A watershed occurs mid-way, with an elevation of 2,600 feet, beyond which the water flows to the Fraser by Fountain Creek.

"Fans."

At Fountain the Fraser makes a sharp bend, running nearly east and west, for a short distance. Above this point the valley again resumes its north-north-westerly bearing, which it maintains apparently with considerable regularity to the mouth of the Chilcotin.

Old route to the interior.

A good waggon road extends from the east bank of the Fraser, opposite Lillooet, to Clinton, a distance of forty-seven miles. Lillooet was a place of considerable importance some years ago, before the trunk

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* See F. Drew, F.G.S., on Alluvial and Lacustrine deposits and Glacial Records of the Upper Indus Basin, Quart. Journ. Geol. Soc., 1873, p. 441. This term is adopted as a convenient one to designate deltas of a certain class, abundant in this region.

road by the Fraser and Thompson Valleys, between Yale and Clinton, was constructed. At that time all communication with the interior of the Province was maintained by a route following the Harrison, Lillooet, Anderson and Seton lakes, with intervening portages. On crossing the Fraser at Lillooet this system of broken carriage came to an end, and goods were consigned to trains of pack animals for transport to Cariboo. Lillooet is at present the centre of some farming industry. It is said to be at an elevation of 862 feet only above the sea, and beans—which form an important article of diet—are grown here for the supply of the greater part of the interior. No serious frosts interfere with agriculture on this part of the Fraser; melons, tomatoes, and other tender vegetables come to maturity, and grapes have been successfully cultivated. Farming.

At Lytton the Thompson River unites with the Fraser, and while the valley of the latter continues northward, nearly following the general direction of strike of both the Boston Bar and Jackass Mountain series, the former coming from the east nearly at right angles, cuts across a great thickness of greyish granitic, gneissic and dioritic rocks, of the Cascade Crystalline series of the preliminary classification. A few miles further up the Thompson, volcanic rocks of Tertiary age, forming an extension of those of the Nicola Valley and surrounding regions, which are more fully described on a following page, appear on the east side of the waggon road. The river valley soon again assumes a nearly north and south direction, and volcanic rocks continue to characterize its eastern bank, and also to appear in small outlying areas on the opposite side, in contact with the granite rocks, till Spence's Bridge, or Cook's Ferry, at the mouth of the Nicola, is reached. Thompson River.

A few miles above this place, on the road, limestones of the Cache Creek series appear, and with their associate quartzites and other rocks, occupy the greater part of the valley to Cache Creek. An area of Mesozic rocks, probably of Cretaceous age, but the limits of which are not precisely known, occurs, however, near Cornwall's, midway between the two places. This portion of the Thompson Valley is wide, with some considerable areas suitable for cultivation, and though the hills appear to rise very steeply on each side, they afford extensive grazing priviliges. In the lower parts of the valley the bunch-grass has been for the most part destroyed by over-feeding.

The main waggon road between Cache Creek and Clinton follows the right bank of the Bonaparte for some miles, and then leaving the river continues north-westward in a wide valley which has been called Glen Hart, in which are several small lakes and pools. The lower part of the Bonaparte Valley is so wide as almost to be comparable with that of the Thompson, but above the point at which the road leaves it, it Bonaparte River.

narrows pretty rapidly, and holds very little land suited to agriculture, or even fit to produce hay. The slopes are, however, open and afford some good pasturage. The stream itself is small, and can be forded easily at low water wherever the bottom is hard.

Pavillion Mountain.

South of Clinton, and between Glen Hart and the Fraser River, is a high region, penetrated on several sides by deep valleys, but without conspicuous rugged peaks. This is known as Pavillion Mountain, and is crossed by the road before mentioned which runs from Clinton to Lillooet. The road on leaving Clinton follows a wide valley south-westward to Kelley's Lake, which discharges to the Fraser. It then ascends from the valley, and passes over the summit to the western entrance to Marble Cañon. From Kelley's Lake, a branch road, which in 1877 was unfinished, leads north-westward, toward Canoe Creek on the Fraser. It follows another wide valley, which appears to coincide with the strike of a belt of slaty rocks, and is bordered to the north-east by a range of rugged limestone mountains, reaching an elevation of about 6000 feet. Little soil or vegetation appears on the upper slopes of this range, which in this respect, and the white color of the component rock, resembles that bordering the north-eastern side of Stuart Lake.

Causes of lakes.

Kelly's Lake is small but deep, with the usual shallow margin extending a few yards from the steep shores. It appears to be held in by a steep fan which has blocked the valley. The little lakes or pools in Glen Hart above noticed, are in some cases evidently formed in the same way, by the inwash of the hills stopping the natural drainage of the valley. One or two of them, however, can scarcely be accounted for thus, but have probably been hollows left between terraces which have spread from the bases of surrounding mountains when the great valleys were filled with water at a high level.

Marble Canon and Hat Creek.

Marble Cañon and the lower part of the valley of Hat Creek form together a valley nearly transverse to the general structure of the country, and running between the Fraser and Bonaparte, south of the so-called Pavillion Mountain. Marble Cañon lies in a bearing nearly north-west and south-east. It is about ten miles in length, and does not appear to depend on any evident structural fact of the rocks in its vicinity. It may not improbably owe its existence to some fracture or system of fractures, which has led to the erosion of the massive and contorted beds of marble and limestone which form its sides. It is not an absolutely perpendicular-sided chasm, but a straight valley from half a mile to quarter of a mile wide, shut in on either side by cliffs and rugged mountain-slopes, which rise at least 2000 feet above it. The drainage of the valley has originally been to the south-westward, as is evidenced by the higher level of the south-eastern end near the

PLATE I.—LOOKING UP THE NORTH THOMPSON VALLEY FROM NEAR KAMLOOPS.

bend of Hat Creek, and the fact that the valley is here much contracted, and can be shown to have a true rocky floor almost at the present level of the surface. Two narrow lakes, deep, and of the most beautiful blue color, lie in the bottom of the cañon. The first of these is caused by a broad fan, pushed across the valley by a stream flowing from Pavillion Mountain, and is four miles in length. The second, lying higher up the valley, is separated from this by about three-quarters of a mile of meadow and open woodland, based on an irregularly sloping surface formed of material from the bases of the hills, which has apparently been spread out at a former period below water. It is a mile in length, and on the southern side a thread-like cascade falls into it from a cliff of great height.

Sources of Hat Creek.

The upper part of the valley of Hat Creek lies nearly north and south, in a wide valley based on Tertiary deposits. To the northward it becomes a rolling hilly region, and is bounded in this direction and to the west by still higher rocky mountains. The whole region is in great part open, covered with bunch grass, and constitutes a fine stock range. At the eastern entrance to Marble Cañon, Hat Creek adopts an east-north-easterly general course, and flows to the Bonaparte. The lower part of the valley becomes contracted; and is hemmed in by steep mountain-slopes of Tertiary sandstones and conglomerates.

Road from Cache Creek to Kamloops.

Near Cache Creek the Thompson Valley again turns abruptly eastward, the Bonaparte, from the north-west, joining it at the angle. The main waggon road to Cariboo follows the latter in a general way for some distance, while a branch road, to Kamloops, etc., goes eastward by the Thompson Valley. At Cache Creek the peculiar quartzites and other rocks of the Cache Creek formation of the preliminary classification are well shown, but on proceeding eastward on the road toward Kamloops, these are found to be almost immediately covered by Tertiary igneous rocks. For about eight miles, the road follows a wide hollow, which runs from the Bonaparte, at Cache Creek, across the angle formed by the junction of that river with the Thompson. This hollow has all the appearance of having been at one time the course of a river, but whether the Thompson may have flowed through it to the Bonaparte, or the latter to join the Thompson, it is impossible to determine. It is now separated from the Thompson River, which runs at a level considerably lower, by a little range of rounded hills, rising to a height of probably 200 to 400 feet above the road, while to the north, hills of Tertiary igneous rocks rise in the first instance to from 600 to 800 feet, and then continue in an irregular ascent till the general level of the plateau above is reached. Several good farms, with an abundant supply of water for irrigation, are situated in this hollow.

The so-called Eight-mile Creek flows into the Thompson from the north, near the junction of the valley of the latter with the hollow above described. This stream, in October, 1877, was estimated to have an average width of about six feet, with a depth of six inches, and rapid current. From this point the main Thompson Valley continues nearly due eastward, the distance to the lower end of Kamloops Lake, at Savona's Ferry, being about eleven miles.

Character of valley from Cache Creek to Savona's.

The valley is a wide trough, which would appear at first sight to be bounded on both sides by mountains, but is in reality, like that of most of the rivers of this part of the interior, excavated in an irregular plateau, and is far below the general level of the country. It is about a mile and a half in width from the bases of the rocky hills on either side, and though these run into points constricting it somewhat in places, its average width is well maintained. It is floored throughout with detrital deposits, chiefly gravel and sands, which are generally more or less distinctly terraced, but seldom show any great breadth of flat land at any one level. The river itself follows in this wide valley a tortuous course, making broad curves, which touch several times upon the rocky sides of the southern margin of the trough, but elsewhere show only moved material. The rocky bottom of the valley must be at a depth considerably greater than that at which the river now flows. Two miles from Savona's Ferry, a stream called Defeant River on Trutch's map but generally known as Deadman's Creek, joins the Thompson. It is large and rapid, and to it must be attributed a great part of the debris forming terraces in this part of the Thompson Valley, and very probably also the blocking of the valley which has been the immediate cause of Kamloops Lake. The valley of Deadman's Creek can be seen running up into the plateau to the north, with well sustained depth, for about ten miles; its general course being N. 1° W*. No streams of any importance join the Thompson River from the south, in this part of its course.

Slopes of the plateau.

The broken rocky hills which immediately bound the valley, are continued upward in irregular slopes to the higher portions of the plateau on each side, steep rocky declivities and cliffs frequently appearing. In following the trail which runs from Three-mile Creek and Savona's Ferry to strike the Thompson again below its great bend, nearly opposite Cornwall's, one travels for some distance along the southern margin of this part of the valley, the general relations of which are then more clearly seen than when in the hollow itself. The sloping margin of the plateau above the edge of the abrupt sides of the

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* This with other bearings throughout the Report are with reference to the true meridian.

trough, with an elevation of about 3000 feet, is seamed with small streams and water courses—many of them dry in summer. To the south, it rises gradually to higher ground, which has the appearance of a range of hills, but in reality stands little above the general level of the higher parts of the plateau, which must here average 4500 feet in elevation above the sea. From certain points good views are obtained of the region north of the valley, and it is only when thus seen from a height that the apparent irregularity of the hills as viewed from below is lost in a comparatively level sky line. In examining the Tertiary igneous rocks in the valley beneath, there appears to be some complexity in their arrangement, due to small local disturbances. In viewing them at once, however, from the opposite side of the valley, a general grand uniformity becomes apparent. Thus seen, these rocks, which are in great thickness, seem as a rule to dip at low angles away from the valleys. Thus, in the angle between the Thompson and Deadman's Creek, on the west side, they dip north-westward, in that between the same river and the Bonaparte, north-eastward, and in the intermediate region, there is very little noticeable dip, or if any a general inclination northward. In the centre of the block thus enclosed by river valleys are the higher regions of the plateau.

Tertiary rocks in shallow synclinals.

The arrangement of saucer-shaped synclinals in the higher country between the rivers, was suspected in several other localities examined last summer, but here most clearly seen. These general dips are very low, and can be detected only where the comparatively undisturbed rocks of the Tertiary are found, and then, as a rule, not unless broad general views of their arrangement, in regions not too thickly masked with trees or soil, can be obtained. Superimposed on the sharp and irregular flexures of the older rocks, it would be impossible to discover them, though they may have been potent in giving form and direction to the modern river valleys, many of which are otherwise very difficult to account for. If such a general *buckling up*, or gentle flexure of the surface occurred, even in many localities where the Tertiary igneous rocks are still apparently horizontal, it must have been in post-Miocene times, when the older rocks were already fully metamorphosed, and the Tertiary volcanic rocks probably at least completely hardened. It must have been a bending in the cold of strata already solidified, and consequently accompanied by extensive cracking along anticlinals. Among other important deductions which would flow from this theory if it can be shown to have any wide applicability, is that the Miocene and pre-Miocene rivers may have had courses entirely different from the modern, and if such exist search should be made for them in the auriferous districts.

Influence of structure on position of valleys.

The igneous rocks of Tertiary age, already several times referred to, are those characterizing this valley. Older rocks also occur, the area of which, as near as I have been able to define it, is shown on the accompanying map. These and the overlying Tertiary rocks are also more fully described in a following part of this report, devoted to the systematic treatment of the rock formations.

Vegetation.

This part of the Thompson Valley has been somewhat fully described, as it serves in some respects as a type of many others, some containing large rivers, and others not much inferior in size holding small brooks only, with which the plateau country of this part of the interior is seamed. The valley itself, though wide, does not afford much arable land, from the broken character of the benches and fans of detritus filling it, their frequently stony character, and the impossibility of bringing water for purposes of irrigation upon many of them at a moderate cost. In the valley trees are scarce, and represented only by the yellow pine *(Pinus ponderosa)*, which grows in clumps here and there. Bunch-grass and the small sage *(Artemisia frigida)* are the characteristic plants of this and other similarly situated dry valleys of the interior. Both of these plants are valuable as food for cattle and horses, but here, as in many other localities, the former has already been almost entirely destroyed in the lower parts of the valley, by the careless herding of the large bands of cattle now owned in the country. The broken and declining edges of the plateaux on all sides still maintain, however, a luxuriant growth of bunch-grass. They are in some places dotted here and there with trees, in others lightly timbered with yellow pine, while thickets of poplar and a denser growth of Douglas fir are found only on the borders of streams, or other damp spots. It is country of this sort which forms the valuable cattle ranges of the southern interior of the Province. The higher parts of the plateaux more remote from the rivers often become densely wooded.

Lakes and pools on the plateau.

Lakes and pools are everywhere found on the high lands above the river valleys. They are frequently without outlet, and in consequence saline, and often serve as the breeding and feeding places of vast multitudes of water-fowl. On ascending to the plateau immediately south of Savona's Ferry, numerous small lakelets and pools are found scattered over the rough surface, through which solid rock protrudes in places. These do not seem to be related to leading valleys, and are at different levels, and generally show rather bold banks, with occasional small rounded islands in their midst. The impression conveyed by the mode of their occurrence here is, that they occupy depressions in drift deposits, which have been irregularly piled on a rough rocky surface. In following the trail above mentioned westward, other lakelets are found, some of them larger than those just described, with flat land surrounding them, others arranged in series in little valleys, and evidently resulting from interruption of drainage in these by wash from the sides.

Kamloops Lake, from its outlet at Savona's Ferry, to its head, occupies seventeen and three-quarter miles of the continuation of the trough-like valley which has been described. Its western end, for a length of five miles, has a course of N. 70° E. From this point it turns abruptly to a bearing of S. 65° E., and continues thus to its upper or eastern end, a distance of twelve and three-quarter miles. Its average width is about one and three-quarter miles. In the general parallelism of its sides, and its length, much in excess of the width, Kamloops Lake resembles most of the larger lakes of British Columbia, which must have much in common in regard to their origin. Both sides of the lake may be said to be mountainous. The north bank rises pretty abruptly from the water's edge, in all parts of its length, with the exception only of two or three small steeply-inclined deltas, or fans, caused by brooks, and the large flat at the mouth of the Tranquille River. The mountains are rough, rocky, and afford comparatively small grazing areas. On the south side, while the land eventually reaches, in the higher parts of the plateau, a level not much inferior to that on the north, it slopes more gradually, forming a wide, undulating belt of bunch-grass country, through which rocky hills project in many places. Near the east end of the lake are two bold cliffs, the fronts of which plunge at once into deep water. That on the north shore is known as Battle Bluff, that on the south as Cherry Bluff. The former derives its name from an Indian legend, and on a surface of smooth, glacier-polished rock on its front, a few feet in area, traces of red paint are still to be found, and said to have been renewed from time to time in memory of a conflict.

Kamloops Lake.

Shores of the lake.

The only streams of any importance falling in on the north side are,—Copper Creek, four and three-quarter miles from Savona's Ferry, and Tranquille River, two miles from the east end of the lake. On the south side,—Three-mile Creek, two and a-half miles from Savona's, and Cherry Bluff Creek, six and a-half from the east end of the lake. The only cultivated land bordering on the lake is that of the delta-flat of the Tranquille.

Tributary streams.

The geological structure of the lake is more fully described elsewhere, but may be briefly explained here. It is much complicated by disturbance. The rocks about the east end of the lake are chiefly of old volcanic materials, characteristically developed in the hills south of Savona's Ferry. These are in some places volcanic breccias, but are overlain irregularly by newer breccias and conglomerates formed chiefly of their material, and of Tertiary age. Tertiary igneous rocks, with some grey and blackish well-bedded tufaceous and argillaceous rocks of the same age, characterize the whole eastern part of the lake. Cherry and Battle Bluffs are somewhat peculiar in their character, and probably

General Geological features

represent the shattered and highly altered rocks forming in Tertiary times the sub-structure of the accumulation about a volcanic vent, from which most of the Tertiary igneous rocks of the neighborhood may have been derived. In the highly altered rocks of Cherry Bluff deposits of magnetic iron ore, elsewhere described, occur.

Depth of the Lake.

The lake itself is very deep, and pretty uniformly so. In most places the shores are bold. but where shoals occur, as at the mouths of some of the entering streams, they extend only for a limited distance, and then slope down steeply into deep water. When not affected by local circumstances, the average depth of the lake may be said to be three hundred feet. The deepest spot found, in fifteen soundings, made in different places from end to end of the lake, was nearly abreast of Battle Bluff, about equidistant from the north and south shores. Here the depth was four hundred and fifty feet. There is no evidence to show that the lake is a rock basin, on the contrary, as we have already seen, detrital deposits only occur in the bottom of the wide valley of the Thompson, below it, and the immediate cause of the damming up of the waters of the lake is probably to be found in the mass of material brought down by Deadman's Creek. This appears, however, for the most part, to have been distributed as it is now found at a time when the whole valley was filled with water at a higher level. Three-mile Creek has already, by projecting a long delta, or fan into the lake, much constricted it near the lower end, and in course of time must cut off this portion altogether, making of it a smaller separate lake. If the banks formed at the mouth of the Thompson where it enters the lake at its east end, do not extend so rapidly as to coalesce with the Tranquille delta before it touches the south shore, the same process of division must also occur here in the future.

Its cause.

Town of Kamloops.

The town of Kamloops is situated at the junction of the North and South Thompson Rivers, seven miles above the head of the lake. From its position in the centre of the stock-raising region of the Province, and the extensive system of navigable lakes and rivers which bring it within easy reach of considerable areas of fertile farming land, it appears destined to become a place of some importance; though it is possible that if a railway be constructed to the coast by the valley of the Fraser, some place near Savona's Ferry, at the lower or western extremity of the system of water communication, may eventually supercede it. In the angle formed by the junction of the two rivers is the Indian Reserve flat, behind which rises a steep and rocky summit, generally known as Mount St. Paul. This has a height of 2,430 feet above the rivers, or 3,570 feet above the sea. It is nearly isolated from the neighbouring hills, a deep valley lying north of it, from which comes the stream which has formed the gently sloping fan, or delta, of the

Mount St. Paul

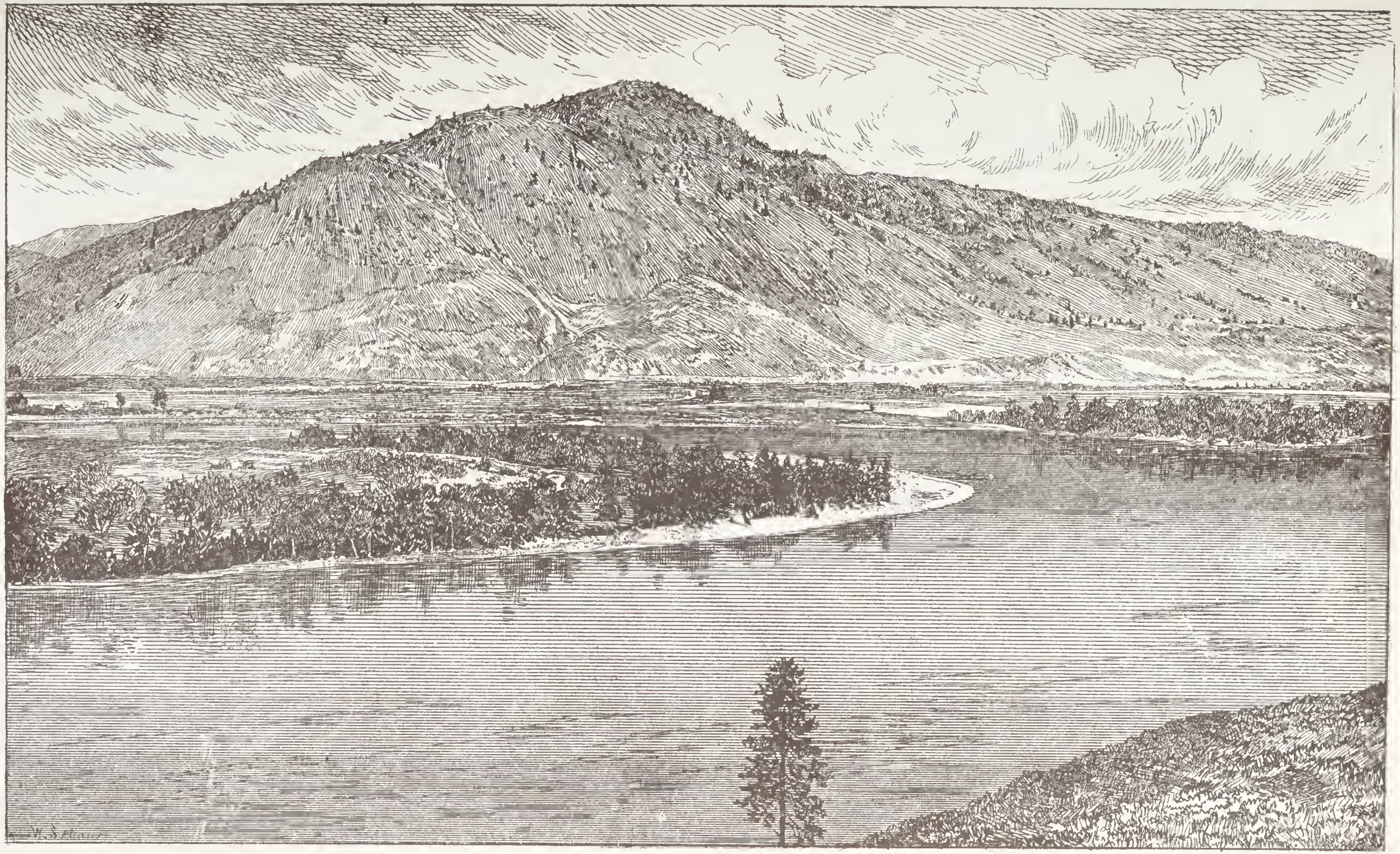

PLATE II.—MOUNT ST: PAUL, NEAR KAMLOOPS.

Indian Reserve, and from it on a clear day a very extensive view of the surrounding country may be gained. From this elevation the summits around are seen to be nearly equal in height, and coalesce to form an almost unbroken horizon-line. This is especially the case to the north-westward. The great extent of open, or partly wooded and well grassed land visible on all sides is a striking feature, and explains at once the ease with which large numbers of cattle and horses are raised in the district. (See Plates I and II.)

Great extent of grass country.

The wide and straight valley, carrying first the waters of the South Thompson, and eventually, below Kamloops, the waters of both this and the North River, is joined nearly at right angles by a similar wide trough-like depression, carrying the latter stream. From this point of view it is apparent that Kamloops Lake is merely, as it were, a minor incident in the topography of the great valley, which differs in no marked respect in this part of its length from its general aspect. It may also be noticed, how a rise in the level of the water of the lake, small in comparison with the depth of the valley, would cause it to extend very far both up the North and South Rivers. That it has done so at some former period is clearly shown by the numerous and well-formed terraces with which the valleys are fringed. Another feature, pretty well shown here and frequently observed elsewhere, is the existence of a second shelf, or minor plateau, between the flat land of the valley-bottoms and average elevation of the uplands. This is in some cases accentuated by the addition of terraces of drift material, but is not entirely caused by this, but impressed besides in the rocky substratum of the country. About Kamloops the average level of this lower plateau may be taken at 1,100 feet above the rivers, or 2,240 feet above the sea. It is, of course, much complicated, when viewed on the ground, by the minor elevations of its surface, and the valleys of streams, but a plane at about this height would more nearly than any other coincide with the greatest area of surface near one level.

Valley of Kamloops Lake.

Minor plateau.

The North Thompson Valley, described at some length by Mr. Selwyn in a former report,* need only be noticed here in general terms. There are already several settlers in the lower part of the valley, and a small saw-mill, supplying Kamloops with lumber, has also been erected. The valley is probably a mile in average width between the bases of the hills, which appear to rise from 1,500 to 2,000 feet above the river in its lower portion, becoming somewhat higher northward. The farming land consists of benches or terrace-flats, which border the river generally on both sides, and are never wanting either on one side or the other, as far up as the mouth of the Clearwater. Only those on which a

North Thompson Valley.

* Report of Progress, 1871-72, page 25.

supply of water for purposes of irrigation can easily be brought have been utilized. If required, a great part of this valley from Kamloops up to Victoria Point, at the mouth of the Clearwater,—67 miles—and even beyond this point, could be brought under cultivation, by leading water from more distant sources, or raising it from the river itself by means of wind-mills. Before reaching the Clearwater, however, irrigation would, probably, from the greater rainfall occurring there, cease to be necessary. The areas suited for stock ranges in the hills above, though extensive, are not so limitless as further south. To the west, an undulating and partly open plateau stretches towards the sources of the Bonaparte, with an elevation of about 3800 feet above the sea. Much of this resembles the "Green Timber" plateau, crossed by the waggon road north of Clinton, and like it, is based on basaltic rocks. Two streams of some importance join the North river from the east, below the mouth of the Clearwater. The first of these is known as Louis creek, twenty-eight and a-half miles above Kamloops, the second, three miles further on, as the Barrière river. The latter, as its name imports, is sometimes crossed with difficulty in the spring.

Timber of the North Thompson.

The lower part of the North Thompson Valley is thinly timbered, chiefly with yellow or pitch pine (*P. ponderosa*), but about thirty miles above Kamloops, with evidence of increasing rainfall, the timber becomes notably thicker, and is quite dense before the Clearwater is reached. The yellow pine continues to appear on dry slopes favorable to it, for some fifty miles up. The cedar (*Thuja gigantea*) found for the first time at about the same place, becomes quite abundant at the mouth of the Clearwater.

Rocks.

The occurrence of coal on the Indian Reserve, forty-three and a-half miles up the river, was the cause of my visit to it. The rocks on the left or east bank, are chiefly old and much altered volcanic products, with limestones and quartzites. Those on the right bank are in the main referable to the Tertiary volcanic period. The river, however, does not strictly follow the dividing line between the two classes of rocks.

South Thompson River.

The wide valley of the South Thompson continues nearly due eastward from Kamloops for about twenty miles, when it bends rather abruptly to a course of north-east, and in sixteen miles is found flowing out from the west end of Little Shuswap Lake. This lake with the Great Shuswap Lake is separately described on a following page. The south Thompson is clear, and in summer warm, the water having deposited all its sediment, and been exposed to the sun and air for a considerable time in the great system of lakes at its head. In these respects it forms a marked contrast to the North River, the water of which is cold, even in the height of summer, and always very turbid, with a fine white sediment, in which minute spangles of mica may often be detected. This in part no doubt comes from glacier sources in the mountains, but is also added to by the constant cutting away and re-arrangement of banks of white silt, occurring in some places on its margin.

Valley of the South Thompson.

In most respects the South Thompson Valley much resembles the lower part of that of the North Thonpson, though the hills bounding it are neither so uniform in their height nor so even in their contours; this difference implying that the plateau is here less regularly maintained. The area of cultivated land on the South River is also less than on the North, owing to the very general absence of the flat benches, above described. The benches or terraces on the south Thompson are at a higher level, and instead of consisting in great part of river-washed material, are older, and formed of hard, fine, white silts, which have been deposited in the bottom of a lake formerly filling the valley. These, though affording a very fertile soil, have under the prolonged action of denudation, been cut up in many places into innumerable little ravines and gullies, which, with the natural inclination of the remaining portions of their original snrface toward the axis of the valley, renders them difficult to irrigate. With the exception of three streams on the south side—Campbell's Creek, twelve miles from Kamloops; Duck and Pringle's Creek, seventeen miles from the same place; and Chase's Creek, at the outlet of Little Shuswap Lake—very little water falls into the valley. This arises partly no doubt from the great aridity of the climate, but also indicates that the sources of other streams can not be far from the banks of this trough to the south and north. There are, however, some very pretty farms on the south Thompson, and spots yet unoccupied, which, though covered with "rye grass" (*Elymus condensatus*), and in places whitened with saline efflorescence, could be turned into fertile fields by irrigation. An extensive flat, standing at a height of about twenty feet above the river, is found at the lower end of Little Shuswap Lake. Its area may be nearly two square miles. Three farmers are settled here, and these are the furthest up in this direction.

Farms.

The Shuswap Lakes.

Shuswap Lakes

These lakes now form the upper part of the South Thompson Valley, though there is reason to believe that the greater part of the region of which they at present receive the drainage, at one time discharged southward into Okanagan Lake by the Spallumsheen* Valley. They occupy deep and comparatively narrow valleys in a mountainous region on the western border of the Gold Range, which here, with a considerable width of high summits, separates the head-waters of the Thompson and

* Also written Speylumacheen, Spillamsheen, etc.

Okanagan from the Columbia River, and with other lakes to the north and south, which bear the same relation to the Gold Range, represent, and are probably homologous with the deep fiords which penetrate the Coast Range of the Province.

Outline of the lake.

The Great Shuswap Lake,with its various arms, and the Little Shuswap Lake, have together an aggregate coast line of about 210 miles, without measuring into any bays less than a mile in width. Great Shuswap Lake may be said to consist broadly of two rudely parallel portions, which are connected by transverse reaches. The actual area of these, however, represents only a portion of the valleys in which they lie, the latter being in all cases continuous beyond the ends of the lake and carrying a river or large stream. Little Shuswap Lake is separated from the lower end of the main division of the great lake by a stretch of low ground, lightly wooded and probably fertile, which occupies the valley, with an area of about three square miles. This is a fan, or delta, produced by Adams' Creek, a large stream which here enters from the north; the length of river now connecting the two lakes being pressed against the southern margin of the valley by its accumulations. The main division of the Great Shuswap Lake may be described as consisting of two reaches, the first, or that nearest the little lake, being called the South-west Arm, and stretching for about twenty-five miles in an east-north-east direction. The second reach may be called the Seymour arm, from the name applied to a little settlement which was established at its head, as a point of departure for the gold mines on the Great Bend of the Columbia. This has a general north-north-easterly course, with a length of twenty miles. The settlement of Seymour is now entirely abandoned, not a single building remaining intact. A line drawn across the angle formed by these reaches of the lake, between its two extremities, has a length of forty-three and a-half miles. A large stream from the Gold Range enters the head of the lake at Seymour.

Arms of the Lake.

The second division of the lake is connected with the first at the angle made by the two reaches just described, by an opening about half a mile in width, known as Cinnemousun Narrows. This division has a total length, following its general course, of about forty miles, running south-westward to form the Salmon Arm, and in the opposite direction, the North-east arm. The former receives the Salmon River, and a smaller stream from White Lake, a sheet of water lying in the country between the two divisions of Shuswap Lake, just referred to, but which was not visited. The North-east arm is continued northward toward Seymour by a low valley in which lies a small lake; north-eastward by a valley penetrating the Gold Range. The third, or south-eastern division of the lake, discharges into the Salmon arm by the Schickmouse Narrows, a constriction caused by the delta of Eagle Creek, a large stream which enters from the north-east. It may be called the Spallumsheen arm, and receives the Shuswap or Spallumsheen River at its southern extremity. It lies north-north-east and south-south-west, is about nine miles in length, and narrower than other parts of the lake.

The elevation of Shuswap Lake is about 1,160 feet. Elevation.

The country bordering the lake is almost everywhere mountainous, frequently rising at once from the shore to an elevation of 3,000 feet, while beyond the heads of the Seymour and North-east Arms, mountains holding much snow, and with glaciers in their intervening valleys, appear. These are those of the axial portions of the range, and probably have in many cases a height above the sea level of considerably over 7,000 feet. Portions of the south-east arm are, however, bordered by low land, especially on its northern shore, where Scotch Creek has formed a delta of considerable size, which will doubtless eventually stretch across the valley and divide the lake, as that of Adam's Creek has already done. About Seymour a similar flat area is found, and low country, as already described, runs southward to the head of the North-east Arm. The delta and flat land of the lower part of the valley of Eagle Creek constitutes still another exception to the generally mountainous character of the region. The wide flat-bottomed valleys of the Spallumsheen and Salmon River in southward continuation of those occupied by the arms of the lake have before been alluded to. There is also about the extremity of the Salmon Arm, in addition to what may be considered as the immediate delta of Salmon River, several square miles of flat or gently undulating country standing less than three hundred feet above the lake. This is continued north-westward by a transverse valley to Blind Bay, on the south-west arm. Country bordering the lakes.

To a mass of high land opposite Cinnemousun narrows, the name of Angle Mountain was applied. It is plateau-like when viewed from a distance, and has an elevation of about 4,900 feet above the lake. Granite Peak, west of the extremity of Salmon arm has an elevation of 5,463 feet. Mount Ida, south of the same place, and prominent as standing in the midst of a low country, 4,160 feet. The north and south Queest Mountains, standing east of the north-east arm, are 5,522 and 5,921 feet respectively above the lake. To the numerous summits less conspicuous than these, which by their comparative isolation are remarkable, no distinctive names have been applied. Conspicuous Mountains.

On the farms situated on the Thompson, immediately below Little Shuswap Lake, irrigation is found necessary, but in approaching the Gold Range there is every evidence of increased rain-fall, these mountains evidently constituting a second zone of precipitation, like that which the westerly winds first encounter in the Coast Vegetation.

Range. *Pinus ponderosa*, the characteristic tree of the dry country, occurs along the northern side of the South-west Arm to Scotch Creek, where it disappears. Near the south-western extremity of the Salmon Arm it is again found, though not very abundantly. The remainder of the region bordering this system of lakes, whether mountainous or flat land, is densely wooded, the vigorous growth of timber ceasing only at elevations over 4,000 feet above the lake. No land exists suitable for agriculture, except on a very limited scale, on which much labour would not in the first instance have to be expended in removing the forest, but in course of time productive farms will doubtless occupy the areas of low land above indicated. The most promising localities are those near the extremity of the Salmon Arm.

Farming land limited.

The timber is not usually of very great size, but much may be found quite suitable for the manufacture of lumber. The Douglas fir, spruce, and cedar, are most abundant, the latter, however, being confined to certain localities. Timber for fencing and other purposes is already obtained from the lake for the supply of Kamloops and neighbouring portions of the Thompson Valley. The upper reaches of the Seymour and North-east Arms are evidently very deep, the rocky cliffs at their margins plunging at once into deep water, or ending in slopes of broken fragments which lie at a high angle. No soundings were made here, however, and in the lower reaches of the south-west arm the depth was found to be less than in Kamloops Lake. In mid-channel between Copper Island and the north shore it is 138 feet; between the same Island and the south shore, 198 feet. This was also found to be the depth of the centre of the lake a few miles south-west of Cinnemousun. In the centre of Little Shuswap Lake, 156 feet was found. Stern-wheel steamers of light draft, such as are usually employed on the western rivers, ascend the South Thompson with ease from Kamloops Lake, and all parts of the Shuswap Lakes are accessible to them. Passing into the Spallumsheen arm, they run up the river of the same name for about twenty miles to the settlement, and carry produce thence back to Kamloops. No regular communication by this route is, however, yet maintained, the steamer making several trips in the year, as occasion may require. With the North Thompson, which may be ascended by good steamers at most stages of the river as far as the mouth of the Clearwater, there is thus a connected system of water communication aggregating two hundred and fifteen miles by the travelled routes, and it is believed by those experienced in the matter that it may be possible to navigate at most seasons a considerable reach of the Thompson below Kamloops Lake. From a survey of the South Thompson made by Mr. Green, the shoalest water is found to occur within a mile of the outlet of Little Shuswap Lake, being five or six feet, while in the river con-

Depth of the lakes.

Water communications.

necting the Little and Great Shuswap Lakes the least depth is marked as five feet in two places. The date at which the examination was made is not, however, stated on the map. In the Cinnemousun Narrows, in August, 1877, I found the least depth to be sixty feet. The Shickmouse Narrows are only about two hundred feet in width, with a bar at the north end, over which less than six feet of water was found at the same date. The deepest channel at the same stage of the water across the bar at the mouth of the Shuswap or Spallumsheen was from six and one-half to seven feet, and must be much less in the early autumn. It is probable, however, both here and in the Schickmouse Narrows, that the water cuts away the sand deposit to some extent as it falls. At the mouth of the Salmon River is a bar with a depth, at the same stage of water, of about four feet. Within the bar this deepens at once to six and seven feet, but the river is narrow as compared with the Shuswap, and tortuous. The Indians report that it continues with little current to within a few miles of the waggon road crossing, but is now so much blocked with logs that not even canoes ascend it. Bars.

In the bay south of the promontory on the west side of the Spallumsheen arm is a spring, known to the Indians as Pil-pil-poopil, to visit which, it is affirmed, brings on bad weather with wind and rain. When examined, on August 7th, it was issuing in the bottom of a shallow bay, at a depth of over three feet. The water above it was thrown up into a little mound, an inch or two above the general level, and there was a constant boiling sound from the escape of large quantities of gas bubbles. The stones between which it issues are covered with a reddish deposit, the water having a very faint ferruginous taste, with traces of the smell of sulphuretted hydrogen. The gas would appear, however, to be little else than ordinary air, as it will neither itself ignite, nor extinguish flame. The water coming to the surface had a temperature of 70°, which, allowing for the depth, would be just about that of the lake itself, the surface being between 72° and 73°. The Indians state that in the autumn, when the lake falls so as to bare the spring, it emits a disagreeable odour. Remarkable spring.

The close dependence of the valleys holding the various divisions of the Shuswap Lake, on explicable geological facts, is interesting. The wide North-west Arm is excavated in flat-lying and comparatively soft limestones and schists. The greater part of the Salmon Arm appears to follow an anticlinal axis, which is also the case with the Spallumsheen arm. Other parts of the lake, which for long stretches cut directly across the strike of the rocks, are to be accounted for by lines of weakness produced by systems of cracks or joints, perhaps connected with faulting. In places these are frequently found running nearly parallel to the lake shore. It is probable that they may be grouped in two series, Dependence of lake-basins on rocks.

one in bearings nearly true north and south, the other nearly parallel to the magnetic meridian, though more extended examinations are required to render this certain. Even the coves and smaller bays along the rocky shores may frequently be shown to owe their existence to minor systems of jointage traversing the strata. The bold cliff at Cape Horn, with Copper Island, and the escarpment on the north-east of Blind Bay depend on a zone of rocks altered and rendered more resistent by a system of dykes and veins transverse to the strike.

Adam's Lake.

Adam's Lake, discharging by the stream of the same name into Shuswap Lake, was not examined. It is represented on Trutch's map as about ten miles in length, but from the accounts of the Indians must be much more extensive. It is said to be about two-and-a-half day's canoe journey from its lower end to its head, which would probably be at least fifty miles. It runs north-eastward for a few miles, and then turns north, or a little west of north, and runs quite straight in that direction. A river joining at its head, comes from another lake, which is not, however, described as being very large. The valley through which this river flows is said to be low, and to hold much fine timber, especially white pine (*P. monticola*). This, under present circumstances, could not be run down to Shuswap Lake and Kamloops, as Adam's Creek is almost completely blocked by drift-logs. No low land suited to agriculture is found on the borders of Adam's Lake, high mountains following along the east shore, while the opposite side, though lower, is still rough and rocky. The lake must be very deep, as it is reported not to freeze in winter, while the Shuswap Lakes are frozen completely over. A lake about the size of Little Shuswap Lake is said also to lie between Seymour and Adam's Lake, discharging into the latter. The head of Adam's Lake may be reached by a trail which leaves the North Thompson, near its juction with the Clearwater.

Fine timber.

Indian names of places.

The following Indian names of places in the neighborhood of Shuswap Lakes were noted, though in some cases it proved impossible to obtain even an approximate idea of their signification :—*

Cĭn-i-mousun—"the bend"—Cinnemousun of the map.

Shi-how-ya—"sudden melting away of snow"—Head of the North-east Arm.

Hun-a-kwa-a-tāt-kwa—"one lake only"—Little Lake between last locality and Seymour.

She-whun-i-mēn—"they go away"—Seymour.

Kwieshp (said quickly)—"buffalo creek"—Queest Creek of map.

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* In the spelling of these and other Indian names which are divided into syllables, the vowels have their "continental" values, oo, however, being sounded as in English *pool*.

Too-woot—Eagle Creek.

Skout-nun-hool-looh—Head of Spallumsheen Arm.

Shi-whoots-i-mătl—" many soap-berries" (*Shepherdia Canadensis*)—Head of Salmon Arm.

Hoom-a-tăt-kwa—Copper Island.

Hoop-a-tăt-kwa—White Lake.

Kwhe-koït—Scotch Creek.

Kwa-ow-oot—Little Shuswap Lake.

Spil-a-mi-shine—" flat mouth"—Spallumsheen of map.

Shick-a-mows—" in the middle"—Schickmouse of map.

Shtle-al-lum—" many bark canoes"—Head of Adam's Lake.

Country south of Thompson River and Kamloops Lake, to Nicola River.

A road is now in process of construction from Kamloops, to join with one already built from Spence's Bridge, at the mouth of the Nicola, to the head of Nicola Lake. In going southward from Kamloops at present, one of two trails may be followed. The first, leads directly southward, across the plateau, the second, diverging to the eastward, at about four miles from Kamloops, reaches Shumway's Lake, which lies in a valley of which the northern part is occupied by the upper part of Campbell's Creek—already noticed as running into the South Thompson—but which runs also continuously southward to Stump Lake, and thence to Nicola Lake. The two trails unite again a short distance north of the upper end of Stump Lake. Roads and trails.

On attaining an elevation of about 1,200 feet above Kamloops, a wide irregular hollow, or undulating plateau, bounded to the south-west by higher ground, runs south-eastward to Shumway's Lake. This follows the north-eastern margin of the igneous rocks of the Tertiary, which here overlap the older beds seen about Kamloops. On ascending this second rise, and looking from it back on the lower ground, the hillocks and ridges which before appeared irregular, are now seen to conform in their longer axes to general north-westward and south-eastward bearings. They are chiefly detrital, and probably owe their shapes to strong currents, at the time of their deposit. On this higher part of the plateau, with an elevation of about 3,200 feet, more or less rolled gravel and travelled material is found everywhere, and near the highest levels attained, large boulders of crystalline rocks, quite different from those on which they rest, occur. Many surfaces of the Tertiary igneous rocks are here ice-shaped, and some still retain their polish and striation. Ridges, somewhat like those just referred to, occur also on the summit of the plateau. Some of these are evidently almost entirely of solid rock, while others are probably in great part detrital. Their Wide hollow. Character of the higher plateau.

direction appears in the main to be nearly north and south. The general surface of the plateau thus forms a rolling or undulating region, with scattered groves and clumps of aspen poplar and Douglas fir, and hills and slopes covered with fine bunch-grass. In the hollows, many little lakes and pools occur, and are here formed generally by the inwash of the drift deposits interrupting minor valleys. If not too high for profitable cultivation, many parts of this region would make fine farming land, and it is probable that grain might be grown here without irrigation, as the vegetation indicates a rainfall considerably greater than that in the valleys. The pools are everywhere tenanted by innumerable waterfowl, and prairie chickens (*Pediœcetes phasianellus*) and the "blue grouse" (*Tetrao obscurus*) also abound.

Vegetation.

On August 30th Solidagos, Asters, *Artemisia frigida*, *Geranium Richardsonii*, and *Crotalaria crista-galli* were noticed in flower. To the west, and also eastward across the valley of Shumway's Lake, the plateau appears to become higher, and more rocky and densely timbered.

Chain of small lakes.

Shumway's Lake, above alluded to, is two and a-tenth miles long, with an average width of about 900 feet. The lower, or northern end of the lake is held in by a fan which has spread across the valley opposite the mouth of the little ravine by which the trail from Kamloops descends into it. The brook from Shumway's Lake running across this, in about three-fourths of a mile flows into another small lake, the cause of which was not ascertained. In following the valley southward, it is found to maintain very regularly an average width of a little less than half a mile. Low cliffs occur at several points, but as a rule the sides rise more gradually, and are covered with bunch grass and clumps of yellow pine. In a short distance a third lake is seen, about two and a-half miles long, and in width similar to Shumway's Lake. Still further up on the stream, a pond, called I was informed, Napier Lake occurs, and immediately above it a fifth small lake, less than a mile in length, All these lakes are formed by the interruption of the natural northward drainage of the valley, by the inwash of debris, chiefly consisting of the rolled and travelled material of the drift. A mile and a half from the head of Stump Lake, the valley becomes much contracted, the rocks pressing close on the stream, which immediately above this point turns abruptly, its water coming from the plateau to the north-west. The valley thus described, lies almost in the direct course of that of the North Thompson, but by comparison, is very small. The constriction at the point last mentioned is of such a character as to show that it can not at any time have been the channel of a large river. South of this, the valley is still continued, however, and becomes wider than before, holding Stump Lake, and the upper end of Nicola Lake.

Stump Lake, or Lac des Chicots, is a picturesque sheet of water five miles in length, and with an average breadth of over half a mile. It occupies nearly the whole of the flat bottom of the valley, and undulating grassy slopes rise steeply from it on both sides, till the higher and more densely timbered upper level of the plateau is reached. It derives its name from the fact that stumps and prostrate trunks of trees are found submerged along its edges, and even far out from the shore, showing that it cannot long have occupied this part of the valley. The Indians, indeed, say that some among them still living can remember the time when no lake existed here. I was also told that a few years ago, water, for some reason, ceased to flow from the lake, and that a few settlers lower down in the valley, who depended on it for irrigation, turned out and enlarged the channel at the lower end to prevent the threatened drought. The lake lies north-east and south-west, and receives at its upper end two large brooks, which descend from the plateau to the north-east in comparatively narrow valleys. There is no sign of any recent diversion of these streams, and the height of the land at the north end of the lake precludes the possibility of its having had at any time an outlet in that direction. The lower end of the lake is shallow and reedy, but is well rimmed round with bold mounds and ridges of drift material, on all sides but that now giving issue to the stream, showing that no former channel in a different direction is possible. The present stream, on leaving the lake proper, winds for less than one hundred yards through marshy land in a narrow channel depressed a few feet below the general surface of the hollow, and has evidently, as above mentioned, been artificially deepened. The current is pretty swift, however, even between the clayey banks, the width of the stream being about ten feet, with a depth of two. By removing the whole of the gravel and clay near the outlet, the lake might be lowered two or three feet, before the ledge of dioritic-looking rock over which the stream next falls in a little cascade of about ten feet, would form the actual dam. There is no stream at hand, or valley from which a stream might come to carry *débris* across the outlet of the lake, nor is there the least appearance of any movement in the surrounding country. No evident water-marks much above the present level were seen about the lake. A short distance beyond the actual outlet of the lake, stumps of the ordinary yellow pine (*P. ponderosa*) are found in the bed of the brook, where the circumstances render any diversion of the stream impossible. This tree never grows in damp ground, far less with its roots surrounded by water, but is frequently found on hillsides, rooting in the gullies down which a little water may run for a few days in spring. The valley now carrying the brook must have been of this nature at the time the trees flourished, and this

Stump Lake.

Of recent formation.

Character of outlet.

in itself would show either that the lake did not exist at the time, or that no water flowed from it.

Cause of the lake.

Taking all the circumstances into consideration, it appears impossible to account for this lake on any other hypothesis than that the water flowing into the valley originally sank, finding its way southwards in some direction below the drift deposits. The accidental stopping up of the subterranean outlet, must have resulted in the formation of the lake. This is not impossible, as in several other instances streams were found to disappear and reappear in these old drift-stopped valleys in a capricious manner. It is worth enquiring whether by cutting a deeper outlet to Stump Lake, a considerable area of good farming land may not be reclaimed.

Nicola Lake.

Nicola Lake, runs south-south-westward for six miles, and then turns abruptly to a nearly due east and west bearing, to which it conforms for six and a-half miles. It is irregular in width, but may average half a mile. At its angle it is joined by McDonald's River (of Trutch's map) a stream of some size, coming from the south, and the valley of which nearly falls in line with that which we have been following. Half way from the mouth of this to the head of the lake, a large stream, which continues to bear the name of the Nicola River, joins from the west. About the mouth of each of these streams is an area of nearly two square miles of level land, most of which evidently occupies the place of former arms of the lake, into which the rivers fell. The eastern side of the lake, in most places rises rapidly from the water's edge, spreading out above into rolling uplands well clothed with bunch-grass, but here and there showing rugged rocky patches of some size. The southern border of the lake, and its northern and western margin, are much more mountainous, especially the latter, which rises abruptly from the water to rocky mountains with a height of 2,000 feet or more. These, however, appear to fall rapidly to the north and east. The rocks in these mountains seem to be the same as those of the south shore, which the road follows, and where a careful paced section of a great thickness of beds, chiefly altered volcanic products of Triassic age, was made.

Nature of its outlet.

Nicola Lake appears to be very deep, though I had no opportunity of sounding here. It is probably held in by the gravel and boulders of a great flat fan, which extends across the valley, from its north side, at its lower end, opposite the mouth of a brook of some size. The river now flows out at the extreme southern edge of the valley, and, a short distance below the lake, falls about four feet over a rocky barrier, where a mill is being erected. It is probable, however, that the stream originally found exit on the opposite side of the valley, and its rocky bed at this place is no proof that the basin is rock-rimmed. Just above the outlet of the lake, a second large fan protrudes into it from the south side, and two miles further up, still another, projects from the north shore. This contracts the lake to a width of about 1,000 feet, and eventually, will no doubt divide it. The formation of these *fans* which often occur at the mouths of very small brooks, or even opposite gullies not continuously carrying water, depends in most cases on the abundant soft material, boulders, gravel, sand, etc., which the closing period of the glacial epoch has left banked against the sides of the valleys in the form of terraces, and spread more or less generally over all parts of the country. The presence of this drift is thus indirectly responsible for the formation of a great number of lakes. In other cases, however, fans are the direct product of the crumbling rocky fronts of the mountains, which first forming steep rock-slides, like those called *screes* in Cumberland, are afterwards washed down and spread out by water. Fans and screes.

The valley of the Nicola, above Nicola Lake, runs up east-south-eastward for about eight miles, to the lower end of Douglas Lake. It is wide and open, though the river itself flows in a little ravine with lateral gorges. The hills, which rise from 600 to 900 feet above the stream, show much bare rock in places, but are generally drift-covered, the deposit in some instances still retaining a perfectly terraced form. The plateau a few miles northward rises to a height of 3,500 feet. The lower end of Douglas Lake is surrounded by nearly flat land, and besides the Douglas Lake valley, which runs northward, a second, in which the upper course of the Nicola lies, stretches south-eastward. Upper Nicola Valley.

From the lower end of the lake, the Nicola Valley runs south-westward for seven and a-half miles, to the mouth of the Coldwater River. In the upper part of this length it averages about a mile in width, its south-eastern side being bounded by the terrace-like edge of a basaltic flow, which must originally have stretched across the valley. The slopes are not thickly timbered and show much good grazing country. At the confluence of the Nicola and Coldwater Rivers, the valley expands widely, and the area of flat land here—about six square miles—is the largest found in any one place in this valley. Most of this flat is cultivable and a great part of it is already fenced in. Water to irrigate the whole might be obtained from the Coldwater River, a short way up. At present small streams only are utilised for this purpose. Wide cultivable area.

In the south-western angle between the two rivers, the exposures of coal and associated rocks, elsewhere described, occur. The outcrop of these newer and softer beds, may explain the expansion of the valley at this place. In the angle on the opposite side of the Coldwater, is a broad-based mountain with a symmetrical, low, dome-shaped outline.

Though its slopes scarcely average seventeen degrees of inclination, and it is by no means imposing when viewed from a distance, it nevertheless reaches an elevation of 3,500 feet, above the valley, or 5,280 feet above the sea, which is considerably greater than that of most of the summits in the neighborhood. Near the top a deposit of specular iron ore exists, from which, as it appears to bear no other name, it may be called Iron Mountain.

Iron Mountain.

Wishing to examine the summit, I set out early on the morning of June 3rd for that purpose. We first rode about six miles up the valley of the Coldwater, and then began its ascent from the south-west side. As viewed from the Nicola, the mountain appears to be covered with terraces, and heaped with transported detritus about half way up, and above this to be composed chiefly of bare rock. On the south side, however, this appearance is not borne out, for there is no abrupt termination upward of the drift material. After mounting a number of very regular benches, rock begins to appear, and continues to increase in importance; but remnants of terraces more or less perfectly formed, are still to be found sheltering among the rocky knolls a long way up. Drift and rolled stones, boulders and perched blocks of foreign rocks—especially granitic and gneissic rocks—occur to the very summit. Where much rock surface is exposed, the *débris* resulting from its decay has generally masked the drift material, but it is everywhere distinguishable on a little search. The material of the upper benches, and drift, exposed where trees have been uprooted, resembles the ordinary boulder-clay, elsewhere described, though no glaciated stones were actually observed in it. The rocks appeared to be ice-smoothed in many places, but were found most distinctly so on the very summit, which not only shows in its rocks general glaciated forms, but in places perfectly preserved striation and polishing, on both horizontal and vertical faces. The summit, which is broad, appears to have been rough from weathering, along jointage or other planes, and the little knolls, though not removed by the ice action, have been smoothed off and polished down to agree with its direction in their longer axis, which, with the striation, have a bearing of S. 29° W. This is only one of many instances in which traces of a general glaciation have been met with at very high levels, but it is perhaps the most striking, and is again referred to in the section of this report treating of the glacial epoch.

Benches and drift deposits.

General glaciation.

Though, as above stated, Iron Mountain appears to be higher than any others in the immediate vicinity, the impression given by the view from its summit is, that several mountains, standing out of the plateau on various bearings, reach a height nearly as great. To the south-westward, higher summits, of the Cascade or Coast Range, appear about the sources of the Coldwater. These, however, do not reach a great elevation, and are between thirty and forty miles distant. Somewhat higher mountains probably occur within twenty miles, to the westward, but are not in the direction of the glaciation marks.

Vegetation on Iron Mountain.

On the southern slope of Iron Mountain, *Pinus ponderosa* disappears at an elevation of between 3,000 and 4,000 feet, and with it the bunch-grass (*Triticum repens* var. etc.) The Douglas fir replaces the former, and the place of the latter is taken by grasses of different aspect, not so nutritious, and generally known in the country as 'pine grass' or 'sour grass' (*Kœleria cristata* etc.) With evidence of increasing moisture, wild pease and vetches abound, and at about 4,300 feet *Pachystima myrsinites*, was found. On the summit, the Douglas fir, *Pinus contorta*, and *P. albicaulis* are abundant. The aspens and willows at the date of our visit were just opening their leaves.

Lower part of the Nicola Valley.

In following the Nicola Valley from the mouth of the Coldwater to its junction with the Thompson at Spence's Bridge,—a distance of thirty-five miles—it continues to show fine fertile flats of some width for about eight miles, but on the whole narrows, the mountains at the sides at the same time becoming rougher and higher. For about ten miles further, some ground suited to agriculture, continues to occur, but for the remaining seventeen miles of its course no flats thought worth cultivation are found. The general direction of the valley may be said to be about west, to Spi-oos Creek, but at that place it turns rather abruptly to the north-west, and at the same time becomes more contracted, the road being now obliged to follow the river very closely, and sometimes forced far up the sides of the valley by its bends. Four miles below the mouth of the Coldwater, a large stream from the north joins the Nicola. This is called on the map of part of the district published by the Land Office at Victoria, the Kozoom Kanaix, but as this name appears to be unknown both to the settlers of the vicinity, and to the Indians, I shall refer to it by the better known names of Guichon or Ten-mile Creek. Six miles further down, Spi-oos (or Speouse) Creek joins from the south. At eleven and three-quarter miles above the mouth of the Nicola, a large stream called Skuh-unh joins it from the north; and from the south, nearly opposite this, a second stream, probably of some size, falls in. Several other small brooks not worthy of special notice occur.

Tributary streams.

Climate.

The Nicola Valley, lying in the interior region of small precipitation, resembles in its vegetation, the Kamloops district, and that part of the Thompson Valley between Spence's Bridge and Cache Creek. The snowfall is so light, that sleighing is scarcely to be counted on, though the winters, here, as elsewhere in the interior are very variable in character from year to year, and short periods of extremely cold weather occur from time to time. Comparatively little flat land, however, exists, and what occurs is generally in the valley-bottom not far above the level of the river or lake. This, with the gently-sloping fan-like accumulations formed by some side streams where they debouch on the valley, constitutes the agricultural part of the region, and is farmed where water can easily be brought to it for purposes of irrigation. It is now beginning to be discovered, however, that fall wheat may be grown even on benches some distance above the bottom of the valley, without irrigation; and this may, here, as elsewhere in the interior, eventually lead to the utilization of a much larger area for the growth of this cereal. Grain of all sorts comes to perfection, and very fine crops are realizied. In June, 1876, summer frosts occurred on two or three nights, nipping, though without permanent injury, the potato-tops. Such summer frosts are however of rare occurrence. Cattle, sheep, and horses, must, however, constitute the chief wealth of the country, and for stock ranges, the greater part of the region on the route followed in the above description, from Kamloops to the mouth of the Coldwater, cannot be excelled. The lower part of the valley, owing to the height and rugged character of its bounding mountains, is not so well adapted for stock.

Farming and stock raising.

Settlers.

There are at present, in this valley—including the part of the Nicola above the lake, and the north and south valley leading across to Kamlops,—about forty-eight settlers with houses, of whom sixteen have families. There are two small grist mills, and one combined grist and saw mill, and a large number of cattle are owned.

Trails from Nicola to Kamloops.

A trail runs across from the mouth of Guichon Creek, on the Nicola, to Three-mile Creek on Kamloops Lake. By this I made a hasty general examination of the central portion of the plateau between the Nicola and Kamloops Lake, toward the close of field work, late in October. Guichon Creek—as is usually the case with streams and rivers—appears to have no general name among the Indians. About the mouth it is called Na-ai-ik, from the abundance of the bearberry (*Arctostaphylos uva-ursi*) which is used as a substitute for tobacco. Higher up it is called Ma-mīt, from the whitefish inhabiting the lake near Guichon's farm.

Indian names.

Old land-slips.

The valley of the lower part of this stream is very wide,—probably averaging a mile and a half, for at least ten miles. The east side, which is nearly open, slopes up very gently, showing low flat benches near the stream, but higher up broken into undulations, with innumerable hollows enclosing little lakes and pools. This arrangement I was at first inclined to suppose had been caused by the accumulation of morainic material, and the number of scattered erratics seen on the surface might support this view. Soft Tertiary clays and sandstones are, however, seen in places, and on a more careful inspection it would appear that these, before the formation of the lower benches, have been subject to frequent great land-slips. To these soft rocks, here running northward in continuation of those near the mouth of the Coldwater, the width of this valley is no doubt due.

Guichon's farm, the only one on this stream, is situated fifteen miles up it at the lower end of Ma-mit Lake, at an elevation of 3,000 feet. Grain of all sorts, with potatoes, are grown successfully, and the general elevation of the plateau about here is not much greater than that of the farm in the valley. Just below Guichon's the valley shows wide swampy flats, from which little steep-sided ridges project here and there in a remarkable manner. These are, in this case, evidently the remnants of former slides, surrounded by subsequent horizontal lake deposits. They resemble some seen formerly on the Lower Euchinico Lakes on the Blackwater, and on the Eu-chin-i-ko River, but these seemed to be modified moraines. * Ma-mit Lake.

Ma-mit Lake is about two miles in length, and has been formed by the damming of the valley by the brook entering from the eastward at Guichon's.

Leaving Guichon's Creek,—which turns to north-east—four miles above Ma-mit Lake, the trail continues in the main nearly due northward, gradually ascending to an ill-defined watershed, beyond which small streams flowing to the north are found. The country is a broad, gently-rolling plateau, with an elevation of about 3,600 feet, and showing occasionally large areas of almost flat terrace-like surface. In the watershed region are innumerable small lakes, pools and swamps, the basins of many of which are probably original irregularities in the surface of the drift, which here almost entirely covers the country, and appears to represent the true boulder-clay. It has a greyish-brown, rather earthy matrix, full of stones, mostly local, but some far transported. The whole region forms excellent grazing land, the swamps yielding grass for hay in abundance, while the dry ground produces fine bunch-grass, where not covered with open groves of Douglas fir and *Pinus contorta*. The Three-mile Creek, where first reached, flows eastward, but soon turns abruptly to the north, and in following it we descend rapidly from the plateau level to that of Kamloops Lake. About four miles from its mouth, a remarkably fine range of cliffs, which appear to be chiefly composed of Tertiary conglomerate, crown the hills on its west side. In these, dark-looking caverns or hollows have been formed along certain planes of the stratification, at a great height above the brook. The beds dip at low angles south- Rolling plateau Stock ranges. Remarkable cliffs.

* Report of Progress, 1876-77, p. 21.

westward, and appear again on the same strike below Nicola Lake, on the north side of the valley.

Country between the Nicola River and line of the Hope-Similkameen Trail.

Trail from Nicola to Boston Bar.

About thirteen miles south of the junction of the Nicola and Coldwater Rivers, up the valley of the latter stream, a trail strikes off, which leads directly across the mountains to Boston Bar, on the lower part of the Fraser River. This trail is constantly used by Indians, and though extremely hilly and rough, is not seriously encumbered with windfall. The portion of it nearest Boston Bar, was at one time a part of the route which led round among the mountains from Hope to that place. The passage of the cañons of the lower Fraser was thus avoided, and large quantities of supplies were formerly brought into the country by this now abandoned road. In making a traverse of the country between the Coldwater and the Fraser, it was hoped to obtain a good transverse section of the rocks, including those of the eastern or inner range of the Cascade or Coast Mountains. In this I was only partially successful, owing to the thickly wooded character of much of the country, and absence of proper exposures. The western edge of the Tertiary igneous rocks was however determined, and the southern extension of the Jackass Mountain rocks proved. On leaving the Coldwater Valley nearly at right-angles, the trail gradually ascends for about two miles, when the little lateral valley which has been below us on the left, runs out, and after crossing a ridge by a notch which connects the head of this valley with another, which runs westward, we find ourselves descending rapidly towards the main valley of Spi-oos Creek, a tributary of the Nicola which has already been alluded to. The height of this minor watershed is about 3,700 feet, the distance by the trail from the Coldwater River to Spi-oos Creek, six miles. Soon after leaving the Coldwater, bunch-grass disappears, and though replaced to some extent by the 'pine-grass' and pea-vine, the country becomes rough, thickly-wooded, and unsuited for stock ranges.

Coldwater River to Spi-oos Creek.

Valley of Spi-oos Creek.

The valley of Spi-oos Creek is a large and deep one, and appears to follow, where crossed by this trail, the line of junction of the Tertiary volcanic, and underlying granitic rocks. The lower part trends N. 38° W. and it may be traced running upward for eight miles or more, with a general course of S. 77° E. In one place a large face of brownish earthy boulder-clay is exposed, containing many boulders, some of them large and well striated. The trail follows up the valley of Spi-oos Creek for about four miles, crossing the stream several times in its windings. The Indian name implies that this brook is large and turbid at some seasons. On September 20th it was estimated at twenty feet in width by six inches in depth, with a rapid current and stony bed. When it leaves the stream, the trail turns due west, and ascends rapidly, following the side of a little gorge. This terminates, like that just described, in a notch, which leads across the ridge, and in the western continuation of which a small stream begins to flow toward Anderson River. This notch has rough broken cliffs at the sides, and below is choked with talus which has fallen from them. Its elevation is 4,400 feet.

Watershed.

The trail then follows the valley of the stream last mentioned,—which is known to the Indians by the name of Uz-tlī-hoos, or "water that boils,"—westward for about ten miles. In this distance it reaches a level over 1,500 feet lower than its sources, receiving only one tributary of any size, from the north. Some miles southward is a mass of mountains, not particularly rugged in form, but which must attain an elevation of over 6,000 feet. A large patch of snow lies throughout the summer on the shady side of the principal peak. Several narrow sandy benches were observed in the valley of the Uz-tlī-hoos, at different elevations. Its general character, however, is that of a deep gorge or ravine, with granite cliffs above, and often, great slides of rough angular masses reaching down to the water. The narrow bottom, wherever any flat land exists between the bends of the stream, is densely wooded with large firs, spruces and cedars. The hill-sides are also wooded, but often rise in their higher parts to bare rugged or rounded rocky summits, looking white at a distance. Many small rills and streams fall in, but do not generally rise far back. This valley bears about the same position relatively to the range as the upper part of the Coquihalla does, and has similar characters, though not quite so boldly developed as in the latter.

Valley of the Uz-tli-hoos.

Where left by the trail, the valley turns southward, joining the Anderson River in about four miles. A high ridge is then crossed, and in two miles an abrupt descent again made into the bed of a torrent, flowing also toward the Anderson River from the north. Two other small streams are crossed, and after ascending a second high ridge, the trail leads rapidly down by a series of rude zig-zags to Boston Bar on the Fraser River. The Anderson River, though flowing parallel to this part of the route, is not followed on account of its cañon-like valley. About the junction of the Uz-tlī-hoos and Anderson, the mountains have an average elevation of between 5,000 and 6,000 feet. Looking up the valley of the Anderson, in a bearing of S. 6° E., a great block of higher mountains at a distance of about thirteen miles, can be seen. On the west of the group is an irregular conical peak, nearly vertical on one side. These summits must reach an altitude of 7,000 to 8,000 feet. West of the immediate vicinity of the Coldwater,

Anderson River

on this line, no country suitable for stock-raising or farming exists. Fine timber occurs in some of the valleys, as in all those of streams draining the eastward slopes of the Cascades. Here, however, it is almost inaccessible. It is interesting to observe the oncoming of the coast flora in travelling westward, the same forms appearing in similar order whatever pass or river-valley be followed. The first specimens of *Pinus monticola* were here seen just after leaving the Spi-oos and soon became abundant. *Abies lasiocarpa* and *Menziesii* appeared soon after, and on descending into the valley of Uz-tlī-hoos *Thuja gigantea*, *Abies Mertensiana*, *Echinopanax horrida*, and others of the same group were found.

Coast flora.

Trail from Nicola to Hope

A good trail has been constructed, and is maintained by the Government of British Columbia, from the Nicola Valley, by the Coldwater and Coquihalla Rivers to Hope, on the lower Fraser, a total distance of about seventy-five miles. This route is that by which most of the cattle exported from the interior of the Province reach the coast. It forms a somewhat oblique line of section of the eastern portion of the Coast or Cascade Range, and is interesting both geologically, and as a good example of the change from the climate of the interior to that of the seaboard.

Valley of the Coldwater,

About seven miles up the Coldwater, a stream, estimated, early in June, to be ten feet wide by four inches deep, with a rapid current, is crossed. This follows a valley lying south of Iron Mountain, already noticed. About eleven miles further on a second large brook enters. This, with a rapid current, was estimated at fifteen feet wide by six inches deep. To this point, the valley of the Coldwater averages about a mile in width, and continues to show large areas of flat, or gently sloping ground, though the greatest extent of level land in any one plane would probably lie one hundred feet or more above the river. The hills immediately bordering the valley, maintain their height with considerable regularity, and average probably from 1,500 to 2,000 feet above it, or 4,000 to 4,500 feet above the sea. *Pinus ponderosa* has already become very scarce, being seen only in exceptionally dry situations. Bunch-grass is here also almost entirely replaced by 'pine-grass' and wild-pease and vetches. *Abies Douglasii* is increasingly abundant, *Pinus contorta* is now quite common, and *Pachystima*, *Epilobium latifolium* and a *Fritillaria* were noted as novelties.

Coldwater Bridge.

Nine miles further on, after crossing one other large stream from the eastward, the Coldwater itself is crossed, by a good bridge. In this stretch the valley becomes much narrower, the river itself being very crooked, and flowing against the steep banks and rocky slopes first on one side and then on the opposite. It is seldom, however, that steep slopes reach the water on both sides simultaneously. The bordering hills continue in height similar to those lower down, but still higher summits are seen from time to time behind them. At the bridge, the rocks of Tertiary age, chiefly volcanic, but occasionally interbedded with sandstones like those accompanying the coal at the mouth of the river, are left behind, and altered rocks of much greater age appear. On the east side of the valley the outcrop of the volcanic rocks forms a high cliff, over which a little brook precipitates itself in a series of cascades. The yellow pine is now quite lost, and the woods are much thicker. The aspen (*P. tremuloides*) is abundant on the slopes, and not, as formerly, confined to the valleys of streams and other damp localities. The first 'balsam spruce' (*Abies lasiocarpa*) was also seen here, with *Smilacina racemosa*, *Sambucus pubens*, and an *Actæa*.

Limit of agriculture,

Except near the mouth of the Coldwater, the flats in the valley bottom which would otherwise be arable, are probably rendered useless for the growth of any but the more hardy grains by summer frosts. This at least would appear to be indicated by the character of the vegetation and mountainous nature of the surrounding country. No certain rule can, however, be given with regard to the height at which such frosts occur to an injurious extent. Some places appear free from them and others subject to their occasional or frequent occurrence in an apparently capricious manner, when we near the upward limit of the cultivable areas. This depends on local circumstances, but nothing is more common than to find narrow valleys subject to frosts, while higher, and apparently more exposed ground in the same neighbourhood is free from them.

Head of Coldwater Valley.

The bridge mentioned above, is about forty-eight miles from Hope, by a measurement made at the time of the completion of the trail. In following the river-valley for some miles beyond it, slaty and schistose rocks are found. These are soon, however, replaced by highly crystalline rocks like those of the Cascade series, which continue nearly to Hope. Between the fortieth and forty-first mile-posts from Hope, a second bridge carries the trail over a large branch of the Coldwater coming from the south-west. The remaining branch of the river is then followed southward for two and a half miles, where it is crossed by a third bridge, and soon also turns off to the south-west. At about thirty-three and a half miles from Hope, the summit between the waters of the Coldwater and Coquihalla is passed, at an elevation on the trail of 3,280 feet, though this is probably at least a hundred feet above the notch-like valley which here runs across the range of mountains. The valley of the river, from the first bridge to the summit, is densely timbered in most places, and does not even afford a night's pasture for cattle travelling southward. The mountains near the forks of the river, attain an elevation of about 5,500 feet.

Watershed

'Poison weed.' We camped on the summit on the 8th of June, but without finding feed for the pack animals, which were tied up to prevent them from appeasing their appetites on 'poison weed' of the existence of which we had previously been warned. This plant turned out to be *Veratrum album*, which was just expanding its large green buds. At this date, the aspect of the pass was quite that of early spring, and it was evident that the last of the winter's accumulation of snow had not long left the ground. The dense shade of the large trees which are here thickly crowded together, may in a measure account for this, but they themselves appear here in virtue of some climatic influence, which, if not excessive rainfall, may probably be due in great measure to heavy snowfall in winter. The mere altitude is insufficient to account for the slow advance of spring, and species of trees composing the forest, which are not usually found till greater heights than this are reached, even much further north, about the sources of the Blackwater. *Abies lasiocarpa* and *A. Menziesii*, with *Pinus monticola* are abundant, the latter growing to a great height, with a tapering form, and heavily loaded above with its large cones. The hemlock and cedar (*A. Mertensiana* and *Th. gigantea*) with the devil's club, also first appear at this point. Large broken masses of granite push up through the damp mossy covering of the surface, everywhere, in this valley. They probably owe their present arrangement partly to ice action, but are not far removed from the parent rock.

Vegetation at the summit.

Upper Coquihalla Valley. Within a mile from the summit, southward, a descent of 850 feet is made to the bottom of the valley, in which the Coquihalla was found, at the date above given, as a rapid stream twenty-five feet wide by one foot deep. The valley takes a direct south-westward course for ten and a-half miles, when it is joined by Unknown Creek. On reaching the level of the stream one is at once in the country of giant cedars, and Douglas firs, with other accompanying plants of the damp and comparatively mild climate of the vicinity of the coast. The scenery, in this part of the cañon of the Coquihalla, is indeed magnificent, wooded, or nearly bare mountains and cliffs rising abruptly from the river to a great height on either side, with beautiful cascades pouring over them, in many places, from a higher country beyond. The river itself, working towards the sea in a bed encumbered with masses of rock, with a steady roar, beyond the sound of which one never passes, in all the windings and ascents and descents of the trail on the sides of the valley. The mountains and cliffs are not unlike those of the part of the Fraser similarly situated with regard to the axis of the mountains, but the small width of this valley gives them additional grandeur. In several places, where years ago great snow-slides have descended the mountains, broad well-defined belts have been completely cleared of

Rugged scenery

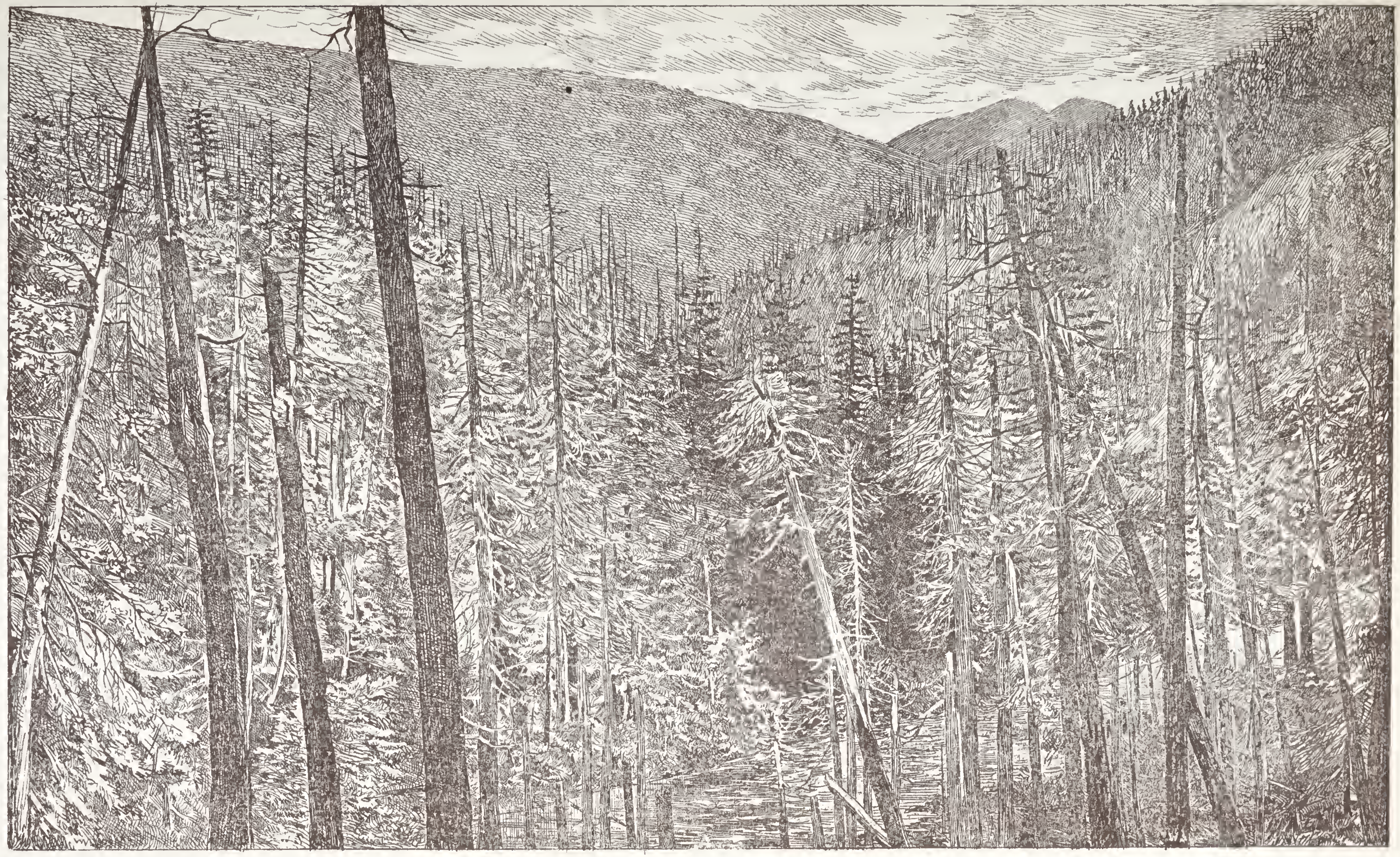

PLATE III.—VIEW IN THE COQUIHALLA VALLEY, COAST RANGE.

timber, the largest trees being swept away so close to the ground that scarcely even the stumps remain. In front of these slides, at the foot of the slope and in the river, the trees are piled together in tangled and splintered masses, of the most confused character, showing that the maintenance of either a common road or railway in this valley would be a very difficult matter.

Snow-slides.

Unknown Creek joins the Coquihalla from about N. 85° E., to which bearing the latter river immediately conforms, flowing S. 85° W. in a narrow valley, walled in by mountains, for four miles. The Coquihalla then receives Ladners Creek coming from S. 85° W. in the continuation of the same valley, which the main river here leaves, running south-south-eastward, toward Hope. The west branch of the Coquihalla, or Boston Bar Creek, which heads near some of the sources of the Anderson River, joins the main stream ahout a mile and a-half above the mouth of Ladner's Creek. There is thus in this place a remarkable conflux of the drainage of a considerable district, and further down, the Coquihalla is a large stream. The south side of the nearly east-and-west part of the valley, to the mouth of the west branch, is chiefly composed of black slaty rocks, while the north is almost entirely granitic. At the point last mentioned, the slates cross over, and characterize both sides of the valley for some distance below. The west branch at its junction with the main stream flows in a perpendicular-sided cañon with slaty walls 200 to 300 feet in height, very much shattered by jointage. The mountains further up the stream all appear to be composed of pale granitic rocks.

Tributary streams.

From the mouth of Ladner's Creek to Hope, where the Coquihalla empties into the Fraser, is, by the trail, a distance of seventeen miles. From the point just mentioned to the junction of the Coquihalla with the Nicolume—thirteen miles—the valley is much wider than before, and shows flats of some size either on one side or other. The surrounding higher peaks are, however, scarcely if at all lower than those before met with. Near the mouth of the Nicolume, the trail crosses the united streams at a picturesque cañon, by a good bridge, and the valley of the Coquihalla, turning abruptly westward, expands widely toward Hope. In thus coming down to the level of the Fraser river, and the climatic influence of the coast, the timber continues to increase in size, and various plants never seen east of the Cascade or Coast Range appear. These are those which not only require great moisture, but a climate not excessively cold in winter. Among others, the more prominent here observed were the vine maple, and broad-leaved maple (*Acer circinatum and A. macrophyllum*), the yew (*Taxas brevifolia*), the salmon-berry (*Rubus Spectabilis*) skunk cabbage (*Lysichiton Kamtschatense*), sal-lal (*Gaultheria Shallon*), and bracken.

Lower Coquihalla Valley.

Plants of the coast flora.

Trail from Nicola to Vermilion Forks.

Another traverse of the block of country now under consideration, was made from 'Princeton,' or Vermilion Forks, on the Similkameen River, to Nicola Lake, Two trails run from the Nicola Valley toward Vermilion Forks, one from near the mouth of the Coldwater, the other from McDonald's River. These unite after some miles, but both are indefinite and difficult to follow, as where the country is open no beaten track is to be found. The trail by McDonald's River, runs southward, nearly following the west bank of that stream (which flows in a wide valley) for a distance of about ten miles, where it has diverged nearly two miles from the river. Here is a pretty little sheet of water known as Lac a la Fourche, about a mile in length. Following a very small tributary of McDonald's River to its source, about two miles southward from the lake, the watershed between the Nicola and Similkameen on this line is crossed, at an elevation of 3,170 feet. On the hills west of the lower part of McDonald's River, many large boulders of basalt are scattered, and these are frequently found weathered into hollow shells of very remarkable appearance. They have evidently been broken from the bed along natural planes of jointage, near which, on both sides, the rock has become hardened, while the central portions of blocks included by systems of jointage-planes, has remained comparatively soft. The rocks seen along the trail, to this point, belong to the series exposed on Nicola Lake, though basaltic outliers may exist in places.

McDonald's River.

Streams flowing southward.

On the south side of the watershed, very small streams are found flowing toward the Similkameen, in broad marshy valleys, here and there holding little lakes, and terraced at the sides. These rills uniting southward, gradually cut to a deeper level in the plateau, till at about fourteen miles from the watershed, the trail descends into a narrow rocky valley, leading toward the Similkameen. This valley becomes depressed several hundred feet below the general level as it is followed southward, and is wide enough in a few places to afford meadows of some size. In it, within a distance of six miles, are five small lakes, the highest, and largest, being about a mile and a-half in length. The valley must at one time have carried a much larger stream than at present, and have been more cañon-like. Its sides are now degraded and crumbling, and in the material from them obstructing the course of the water, is to be found the cause of the lakes. Some of these are dammed in by actual rock slides, others by fans. In the upper part of the valley, no water flows between the lakes, in summer, on the surface. The rocks are here of the same series found on the northern part of the trail, but include much breccia, and are disturbed by numerous granitic intrusions of different ages. A few miles before reaching Vermilion Forks they are replaced by the Tertiary, the country at

Small lakes.

the same time falling in general elevation, and the valley opening widely.

For about twenty-four miles southward from Nicola Lake, the country is generally open, or lightly wooded on the higher parts only. The region is well clothed with bunch-grass, and there are many swampy meadows from which hay might be obtained; the whole constituting an excellent and very extensive stock range, which would support a much larger number of animals than are now pastured there. Fine stock range.

A trail, at one time of importance, but now scarcely ever travelled, connects Vermilion Forks with the west shore of Okanagan Lake. It has a north-east and south-west course, and afforded the means of making another traverse of the country north of the Similkameen. The trail leaves Okanagan Lake about forty-one miles from its north end, following up a stream which is probably Deep Creek of Trutch's Map, for two and a-half miles. At this point, a trail to Nicola Lake diverges, following the valley of a small brook. It appears to be very seldom used. The main trail, crosses Deep Creek—a stream of twenty-five feet wide by six inches deep, with rapid current—and ascending a long and steep hill, descends again to the valley of another stream, which I was informed, is called Trout Creek. The north branch of this is crossed, and the south-western followed up to its source, in some pools and swamps in the bottom of a wide valley, which runs through in the same direction, and holds the sources of a second stream. This flowing to the east of the trail, in about three miles joins a large stream, in a wide and deep valley, the name of which I could not ascertain, but which is seen to pursue a nearly direct south-eastward course for six or eight miles, and must also flow into Okanagan Lake. After following up this valley for about four miles, westward, it also turns to the north, and the trail leaving it passes by a flat bottomed, trough-like hollow, to Osprey Lake, which lies near the watershed between Okanagan Lake and the Similkameen. It is difficult to determine the actual position of the watershed in this valley which unites those of the two systems. Its height is, however, about 3,260 feet. Trail from Okanagan to Vermilion Forks. Persistent Valley.

Some structural diversity appears to have marked out the general course now followed by the trail. Most of the streams run transverse to it, but on reaching it, either flow for some distance in it, or receive tributaries on the same line. There is no reason to suspect the existence of a belt of softer rocks, and it is probable that some system of cracks or jointage-planes has produced the effect. In many places in British Columbia, both small and large features in the topography have been observed to owe their existence to such lines of fault or fissure. This break, if such it is, appears nearly to coincide with the direction of the central reach of Okanagan Lake. Cause of the valley.

Rough character of the country.

From Okanagan Lake to Osprey Lake, the general character of the country may be said to be mountainous, though like other similar regions, when viewed broadly, it may be considered as an irregular high plateau, the general level of the higher parts of which must be over 4,000 feet. Some very small meadows and open hill-slopes with pine-grass, occur on southern exposures, but most of the ceuntry is densely wooded, Douglas fir and the western scrub pine being the most abundant trees. No country suitable for stock ranges occurs beyond the immediate shore of Okanagan Lake. The whole surface is more or less thickly covered with drift deposits.

Osprey Lake.

Osprey Lake is apparently held in by morainic accumulations, or eroded bouldery terraces. Two and a-half miles beyond it is Chain Lake, a little over a mile in length. Its elevation is 3,110 feet. Still continuing in its south-westward course, the valley in about three miles, joins that of a larger stream coming from the north. From the lower end of Chain Lake, however, the trail, if such it can be called, ascends and crosses over a point of the plateau, to avoid rough ground in the valley below. The general elevation of the surface of the plateau at this place is about 4,000 feet. It is undulating, or even hilly, with knolls of decomposing granite projecting through a sandy and bouldery covering, which has once been clothed thickly with the western scrub pine, now generally in the state of *brulé* or windfall, among which dense thickets of young pines are struggling up. From this height all the valleys of streams and lakes, with their little meadows and grassy borders, are hidden, and the prospect is apparently of interminable dreary undulating hills, broken only to the south-east by the snowy peaks of the Cascade Range, which at this distance scarcely seem to rise much above the plateau. Where the surface of the ground has been protected by soil, which now, owing to the destruction of the forest covering, is rapidly wasting away from the more exposed points, polished and striated surfaces are seen, indicating a movement of ice S. 20° E. to S. 28° E. This is another striking instance of the preservation of evidences of a general north-to-south glaciation at high levels. The boulders are chiefly of granite, with a few of darker greenish rocks. The granite resembles that of the immediate neighbourhood, but as some movement from north to south of the loose material must have occurred, the granitic area probably extends some distance in the first mentioned direction.

High wooded plateau.

Glaciation.

The larger valley into which we now descend, runs for about ten miles a little west of south, and is bordered by hills of uniform contour of from 600 to 800 feet in height. It then turns abruptly to the east of south and breaking by a narrower and deeper valley through a higher range, reaches the Similkameen. The trail leaves it at the angle, and strikes across a lower portion of the plateau south-westward to Vermilion Forks, about eight miles distant. The upper part of the valley is from half-a-mile to three-fourths of a mile wide, and has flats of considerable size, but generally gravelly, and encumbered with windfall. When the trail leaves the valley, the open bunch-grass country begins. This is used as a summer range by Messrs. Allison & Hayes of Okanagan Lake, and Mr. Haynes of Osoyoos.

The rocks met with between Okanagan Lake and Vermilion Forks, on this line, ase almost entirely granitic and gneissic, but in the immediate vicinity of the latter place Tertiay rocks are found overlying these. Rocks.

Trail from Hope to Osoyoos Lake by the Similkameen.

This route, from its direction transverse to the main axis of flexure of the rocks, appearing to offer the best line for a section across the southern part of the country, was—with the exception of about seventeen miles, occupied by granite—carefully paced, and all the more important rock exposures examined and noted. The distance by the trail from Hope to Osoyoos is 124 miles, in a direct line ninety-three miles. The special geological features of the route are described subsequently. The main physical peculiarities of the country in the vicinity of the trail are here briefly noted.

The first twenty-five miles of the route, was constructed as a narrow waggon road, by parties of the Royal Engineers, occupied in determining the position of the 49th parallel, many years ago. The road has not been used for wheeled vehicles, however, and from the sliding of the banks has in many places been reduced to the width of an ordinary trail. Old Waggon Road.

At about five miles from Hope, the trail diverges from that leading to the Nicola Valley, already described, and at the same time leaving the main stream of the Coquihalla, follows up a small tributary named the Nicolume in a south-eastward direction. At a distance of ten and a-half miles from Hope, this stream is found coming from the north-west, while the trail continues to follow the same valley to the south-east, till the small stream which it carries beyond this point is lost, and at twelve miles from Hope, Beaver Lake is reached, with an elevation of 2,220 feet above the sea. Still following the same valley south-eastward, a short distance below Beaver Lake, the Sumallow River is found flowing towards the Skagit. It must derive most of its water from the south-west, as at three miles below Beaver Lake, and before it had received any important feeders from the north, it was estimated to be forty feet wide by one foot deep, with a very rapid current. At eleven miles from Beaver Lake, the trail leaves the Nicolume River. Watershed. Sumallow River.

Sumallow Valley before its junction with the Skagit, turning abruptly to the north.

Summit valley.

The valley which thus serves first as the channel of the Nicolume, and then of the Sumallow, flowing in opposite directions, in its general course not only coincides with that of the main axis of the Coast Range, but also with the strike of the rocks. It must, in most places, and especially about the summit, have been worn out and cleared to a much greater depth at one time, either by ice or water action, or both. It now forms for most of its course a cañon-like valley, with an average width of about a quarter of a mile in the bottom, between the steep sides, which rise in cliffs, or very abrupt slopes, to an average altitude of perhaps 2,000 feet above the trail. Higher, snow-covered summits are seen occasionally through gaps. The original chasm, about the summit, appears to have been filled in with huge masses of rock which have fallen from the sides. To this, and to the finer material afterwards washed in, the occurrence of Beaver Lake, with its surrounding ponds and swamps, is to be attributed.

Sources of the Skagit.

The Sumallow may be considered as the west branch of the Skagit River, and is joined by a stream from the north, and a second, of larger size, from the eastward. At the junction of these three sources of the Skagit, the mountains retire somewhat, leaving a wider valley than is usually found in this region. This is in connection with the occurrence of an area of Cretaceous rocks, which, though much altered, are not so hard or resistant as the crystalline and schistose series generally characterizing the mountains. From the point at which it leaves the Sumallow River, the trail runs northward across a boulder-strewn-terrace flat, with an elevation of 2,100 feet. Here, on the 14th of June, the beautiful *Rhododendron Californicum* was found abundant and in full bloom.

Course of the Skagit.

From this valley, hemmed in by mountains, the Skagit River cuts its way southward and south-westward, till, after a course of about a hundred miles, it flows into the Gulf of Georgia, near the entrance of Puget Sound. The view down the valley of the Skagit from this point reveals only tier upon tier of snow-clad mountains, which, though picturesque and rugged in the extreme, do not appear to attain a very great height. Similar mountains close in the view up both the valleys of the north and east branches of the river.

Crossing the north branch, the trail follows the north side of the east branch, in a general east-south-east direction for four and a-half miles, where the river forks, the main stream, or chief source of the Skagit, coming from the south-east; another, which is followed by the trail, from the north-east. After following this stream for nine and a-quarter miles, the trail crosses it for the last time at an elevation of about 4,300 feet. The valley is throughout bounded by mountains with rocky or tree-clad slopes rising from 2,000 to 3,000 feet above it, or attaining an average elevation of about 6,000 feet above sea level. At its head it expands into a magnificent though irregular amphitheatre, from the sides of which many rills and brooks fall in. At the crossing-place the Cretaceous conglomerates and sandstones are suddenly replaced by the gneisses and diorites of the Cascade Mountains, the two series being apparently faulted together. The path leads upwards from the crossing by a series of steep zig-zags to the summit of the range, which is attained in two and three-quarter miles, and was found to have an elevation of 5,808 feet. No low valley here leads across the range, which at its summit appears as a broad hilly plateau, with low rocky crags here and there rising above it, and small pools, which seem to be held in by loose material washed irregularly into the hollows. The elevation is above that at which trees cease to grow vigorously, and stunted and scattered spruces only appear. Higher, and heavily snow covered peaks rise here and there above the general level, but these are really separated from the summit-plateau by wide and deep valleys, which, though invisible from the summit itself, ramify in every direction toward the main streams.

Summit plateau.

In 1874 Messrs. H. J. Cambie and John Trutch, of the Canadian Pacific Railway Survey, made an examination of the branches of the Skagit for the purpose of ascertaining whether any practicable route existed for the line, across the Cascade Mountains. To complete this sketch of the upper part of the Skagit Valley, I quote from their report* the following account of the main stream of the east branch, and its sources. "Cedar Camp" is situated near the fork, and where the trail leaves the main stream.—"At Cedar Camp we divided our provisions, and, leaving half in charge of one man, proceeded in a general south-easterly direction up the main river, now reduced to a width of 120 feet. In half a mile we found the river issuing from a narrow cañon with precipitous walls of rock 200 feet in height. Passing round the obstruction, along steep side-hills, for another half mile, we again came to the river, which we followed to a point where it makes three forks, at four miles from Cedar Camp, in which distance the rise of the river was 600 feet. The left and right-hand branches, the Indian said, were valueless, coming out of high mountains; we continued to follow the middle or main stream, now only 80 feet wide, passing numerous small feeders on our way. At $7\frac{1}{2}$ miles, the river, 30 feet wide, turned abruptly to the south-west, through a heavily wooded narrow valley, which evidently rose rapidly. Here we left

Main Eastern Source of Skagit.

* Report Canadian Pacific Railway, 1877. Appendix E.

the main stream and followed a small branch up a valley which soon widened to half a mile. The timber, which from Cedar Camp had been green, with a dense undergrowth, was now burnt, a few scattered logs only lying on the ground. In two miles after leaving the main stream, the branch we were following ceased to run, and in another half mile we struck a large stream 30 feet wide, coming from the south-west, and now taking a general course to the east. This was a branch of the South Similkameen. We had thus gained the summit of the 'South' or 'Allison' Pass, which proved to be 4,400 feet above the sea level, the rise in 16 miles, from where we first struck the Skagit, being 2,500 feet."

South or Allison Pass.

General character of country.

The whole country from the banks of the Fraser, to the watershed between the Skagit and the Similkameen, is a veritable sea of mountains, a region of magnificent scenery, and interesting to the geologist, but, so far as at present known, of little or no economic value. Copper is said to have been discovered at one place on the Sumallow, but I did not succeed in finding it. In the almost complete absence of benches or detrital deposits of any kind from its banks, the Skagit Valley resembles those of other smaller rivers of the western slopes of the Coast Range. The contrast between these rivers and those draining the eastern side of the main watershed is always very striking. The vegetation of the valley is also like that of the country of great rainfall, in the vicinity of the coast, but lacks those coast plants which require an equable climate. The Cedar, *Pinus monticola* and *Abies Menziesii* occur. At our Camp of June 15th, at an elevation of 4,300 feet, at the western base of the main range, *Ribes viscosissimum*, and *R. lacustre* var. *setosum*, *Valeriana capitata*, *Amalanchier Canadense*, *Sambucus pubens*, *Castilleia pallida*, *Lonicera involucrata*, *Draba nemorosa*, var. *lutea*, *Tiarella trifoliata*, *Hieraceum albiflorum*, *Habenaria hyperborea*, *Streptopus roseus* and *Prosartes trichocarpa*, were found in flower.

Plants found in flower.

Drift-covered east slope.

On descending the eastern slope, from the summit, Whipsaw Creek soon appears on the right, and the trail continues to follow its valley. Between the summit and 'Powder Camp,' in a distance of about seven miles eastward, a descent of 2,240 feet is made. The hills bounding the valley soon appear to assume a height of 500 feet or more, but rise considerably higher at some distance back. The appearance of the eastern slope of the range is, however, entirely different from that of the western, above described. The surface is much more deeply and uniformly covered with loose material, causing large gaps in the rock section. Whether the whole of this is to be attributed to action during the glacial period, is not clear. Near the summit scarcely any transport of material seems to have taken place, and the rocks seem to have been broken up in place, as before described, on the summit of the trail from Hope to Nicola. The fragments are little rounded except in the case of granite, which naturally takes such forms on weathering. In descending, the stones are found to be of a more varied character, and water-rounded boulders become abundant. In a few places, clay is also seen, stony and stiff, and perhaps entitled to be called boulder clay. No distinct terraces are found at high elevations in this place, though much of the loose material may well be derived from terraces formerly present, but now modified and more or less completely obliterated by denudation. At Powder Camp, a terrace borders the valley at a height of thirty feet above the stream.

Eastern slope of the mountains.

The greater part of the eastern slope has been densely wooded with small trees, which have been removed by fire, or still stand in thick blackened groves. Grass, vetch, and lupin begin to cover the surface where it is thus exposed to the sunlight.

From Powder Camp, the Valley of Whipsaw Creek runs north-north-east. For about six miles its character is much like that of the portion above that place. The first abrupt rise of the banks, which occurs with very considerable uniformity, carries them to a height of from 500 to 700 or 800 feet. Above this the slope continues irregularly, and more gradually, till a height of 1,000 feet above the stream is probably in many places attained. Up to this point, the rocks occurring in the valley are chiefly hard greenish diorites, schists, etc., elsewhere more fully described. These are now succeeded by softer igneous and sedimentary beds of the Tertiary, and the whole aspect of the country at the same time changes for the better. The valley widens, and the brook cuts rapidly down to a lower level, running between high terraced banks with occasional cliffs of volcanic rocks. Open slopes occur, and the bunch-grass and *Pinus ponderosa* simultaneously appear.

Valley of Whipsaw Creek.

Edge of the bunch-grass country.

About three miles beyond this point, the trail crosses the Nine-mile Creek, so called from being at about that distance from Vermilion Forks. In Tertiary clays here, some interesting fossil plants, with insect remains, were found.

A short distance beyond Nine-mile Creek, the trail leaves the valley of Whipsaw Creek, and continues northward across broad benches, some of which appear to have been formed when the whole valley was filled with water at a high level; others, nearer the rivers and lower, by the action of the present streams in gradually cutting down their beds. The material of the benches or terrace-flats seems to be for the most part different from that of the underlying Tertiary rocks. The soil is sometimes fertile but occasionally sandy, and supports a light growth of *Pinus ponderosa* with bunch-grass, or pine-grass, where the shade

Flats and benches.

becomes more dense. Part, at least, of this region will probably eventually be used for farms.

Vermilion Forks or Princeton.

At Vermilion Forks, or 'Princeton' of some maps, the South branch of the Similkameen joins the Tulameen, or North branch of the same river. The elevation at the Forks is 1,885 feet. The valley opens widely and is surrounded by broad benches. Crops of various kinds have been tried here by Mr. Hayes, and the hardier grains and vegetables are found to succeed well when good soil is selected. It has proved impossible, however, to raise squashes, beans, cucumbers and other tender plants, owing to the liability to summer frosts. This place lies well within the central dry region of the province, as is evidenced among other things, by the appearance of the low-growing cactus, which was found in flower on the twentieth of June.

Tulameen River.

The North Fork of the Similkameen, or Tulameen, seems to derive the greater part of its water from the wild mountainous country near the northern sources of the Skagit. My time did not permit me to examine this region, which would no doubt prove interesting. At the Forks, the river can be forded easily in some places in summer, but its rapid current is very difficult to cross either by fording or canoe in the spring. The bridge once existing here has fallen down.

Remarkable cliff.

About three miles up the North Fork, a very remarkable cliff, from which the name Vermilion Forks is derived, exists. It is of Tertiary rocks, and appears to be in great part the accumulation formed in a lake in the vicinity of a siliceous spring. It has been altered subsequently by the combustion *in situ* of lignite, (which occurs interstratified with the other deposits,) and is striped with various more or less brilliant shades of red and yellow ochre. It has been resorted to from time immemorial by the Indians as a source of paint, and among other superstitions connected with it. they believe that stormy and wet weather are sure to follow a visit made to the spot.

South Fork of Similkameen.

Some miles up the South Fork, lignite coal again occurs, though in association with rocks of somewhat different appearance. The South Fork is fed by a number of streams rising in the immediate vicinity of the forty-ninth parallel, among high mountains. Mr. George Gibbs, who had an opportunity of traversing this rough country in connection with the United States Boundary Commission, describes the main, or western branch of the Similkameen, which heads near the sources of the eastern tributaries of the Skagit as follows:*—"The valley of the West Fork has quite a gradual descent, but nowhere exceeds a mile in width. It is divided into basins, irregularly lined with terraces, some of them level and rising in benches, others resembling rather,

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* Journal of the American Geographical Society, Vol. IV., 1874, p. 360.

slides from the mountains, subsequently modified by water, than original deposits. The soil is of fine sand mixed with gravel and boulders. The South Fork. (or Pasayten) is more rapid, and with a narrower bottom, and below the junction the river enters a cañon, which continues to near the mouth."

About two miles below Vermilion Forks, the Similkameen Valley again becomes narrow and steep-sided, the change being caused by the replacement of the Tertiary by massive granitic rocks, which continue for many miles. To the mouth of the Ashtnoulu River, a stream of some importance joining from the south, a similar character is maintained. The river is tortuous, generally margined on one side or other by narrow flats, above which the mountains rise steeply, and continue to increase in height as we descend. The rainfall is evidently less and the winter climate not so severe in the lower part of the valley. Saline incrustations begin to appear on the soil, with the salt-loving "rye grass;" (*Elymus condensatus*) and in addition to the cactus and *Artemisia frigida, Artemisa trifida* occurs, forming a bush of some size. The rattlesnake finds its upward limit near the mouth of the Ashtnoulu, and below this point is abundant in the valley. The valley below Vermilion Forks. Dry country.

Ten miles below the Ashtnoulu, Kerameoos Brook, a rapid stream, estimated on June 24th at twenty feet in width by three inches deep, enters from the north-west. Here the valley opens out, showing an average width of about a mile of flat land, some of which is so low and damp as probably to be capable of growing crops without irrigation. The height of the flat is about 1,390 feet. The Hudson Bay Company had at one time an establishment at Kerameoos, but it is now abandoned, Several farmers have claims, however, in this part of the valley, and Mr. Price is erecting a small steel flour-mill. Besides wheat and the ordinary cereals, tomatoes, corn, beans and other similar crops flourish here. The neighbouring hills afford extensive grazing privileges. Kerameoos.

For fifteen miles beyond Kerameoos the trail continues to follow the valley in a general south-easterly direction, when, in the vicinity of the boundary line, it turns eastward, and passes across a hilly region covered with bunch-grass and forming a fine cattle range, to Osoyoos Lake. The lower part of the valley does not continue to show flats so well adapted for farming as those about Kerameoos, but were there any demand for farm produce, many of them would be utilized to some extent. Eight miles south of the boundary line, the Similkameen joins the Okanagan near its efflux from Osoyoos Lake. The land in the angle between the two rivers is low, but high and rugged mountains border the Similkameen on the south-west. Lower part of Similkameen Valley.

The Okanagan Valley.

Lakes in the Okanagan Valley.

Okanagan Lake occupies the northern part of this valley, while Du Chien, Vaseux, Chutes, and Osoyoos Lakes occur in its course southward between the lower end of Okanagan Lake and the forty-ninth parallel. At Osoyoos Lake a trail from the Columbia enters, and there is a Custom Station in charge of Mr. J. C. Haynes. On entering the Okanagan Valley near Osoyoos Lake, it strikes one as being entirely different from that of the Similkameen, or indeed any of the valleys seen to the westward. It is a broad flat-bottomed trough, averaging here probably two miles in width between the bases of the rocky slopes. The bottom of the trough is formed of clean-washed and rounded gravel, generally rather fine, and sand. The sides are of rock, sometimes almost naked, but generally with more or less extensive remnants of drift covering, often in the form of imperfect and decayed benches, which rise in places to a height of at least 300 feet above the lake. Scarcely any trees are found in the valley-bottom, or on its lower slopes. It is scantily clothed with bunch-grass, now much reduced owing to the number of cattle; and here and there are thickets of ragged-looking 'Chaparaal' (*Purshia tridentata*) which give to the scenery a weird and desert aspect.

Osoyoos Lake.

The elevation of Osoyoos Lake is, by comparison of my barometer observations with those of the meteorological station at Spence's Bridge—860 feet. The lake is about nine miles in length, and averages probably a mile in width. It is said to be deep, but is remarkably divided near its centre by two spits, or bars. The northern of these is at the Custom House, and so nearly divides the lake, that a small rough bridge has been built across the gap. The second spit is about a mile further south, and has also a narrow channel cutting through it, in this instance near the east end. The spits are quite different in character from the fans previously described, several of which may be seen in other parts of the valley, but always in evident relation to entering streams, which these are not. The material, as far as can be seen, is chiefly fine gravel and sand, and the surfaces of the spits do not rise far above the water level. It can scarcely be supposed that these are moraines, as the material would probably be coarse in that case. I am inclined to refer them to the conflicting action of waves originating at opposite ends of the lake, under the influence of currents of air drawing through valleys differently placed with regard to the direction of its axis.

Gravel bars.

The lower terraces, and gravel deposits about the lake, are not regularly flat-topped, but full of large hollows and depressions, some of which hold little swamps. The material is also very frequently arranged in long boat-bottomed ridges, generally pointing up and down the valley, and the whole appearance is that which might have been produced by powerful currents affecting a sheet of water which stood say fifty feet above the present level of the lake. When still higher than this, there may also have been currents, but not, apparently, so strong. The valley being so low, must have formed an important strait or channel at one stage of the glacial submergence.

An interesting further question is as to the original mode of formation of the valley, which certainly has the appearance of being an older and more important efflux of the country than that of the Fraser. The mountains bordering it do not appear in any place to rise more than 2,000 feet above it, and are generally comparatively low, showing to some extent, a primitive and very ancient general slope of the surface hereabouts toward the great valley. The present level of the river and lake is not of course that of the bottom of the valley, which, judging from analogy, must at the time of its excavation have been V-shaped, or at least broadly U-shaped. By taking the average width of the valley, and slope of its rocky sides, at very moderate estimates, we may allow that it is filled with drift deposits to a depth of at least 500 feet. Were the whole of the Okanagan Valley cleared of these drift deposits, it would probably at the present day take the drainage of the basin of Shushwap Lake, in addition to that which it now receives. This it has almost certainly done at a former period, but to what extent its present diminished drainage area is due to the blocking of channels by drift, or how much to relative changes in elevation of different parts of the country, or to the cutting down of the beds of other rivers, such as that of the Fraser, it is impossible now to determine. Mode of formation of Okanagan Valley.

The lower end of Osoyoos Lake, is bordered by low swampy land which stretches for some distance, and there is no appearance of a rock barrier. A wide fan, spreading from the east side of the valley, is probably the cause of the lake. There is a considerable area of flat land in the neighbourhood of Osoyoos Lake, but the soil is light, gravelly and sandy, and moreover there are no streams entering the valley large enough for its irrigation. The valley at Osoyoos.

The trail followed northward from Osoyoos Lake, continues in the valley for about seven miles beyond the head of the lake, and then turning off to the westward leads past Chutes and Vaseux lakes on the high land, descending again to the valley near the northern end of Du Chien or Dog Lake. About six miles beyond the point at which it leaves the valley, the southern edge of an extensive area of Tertiary rocks is met with. It is marked by a wide valley, which is followed for a short distance by the trail, which then leaves it to continue Trail going northward.

northward. The plateau here overlooking the Okanogan Valley is irregular, and broken, with hills, which rise to a considerable elevation. Its average height is probably under 2,000 feet. There is much open country with fine bunch-grass, and also occasional small areas suitable for farming land. The upper end of Du Chien Lake is about a mile and a-half in width, and is separated from the lower end of the Great Okanagan Lake by what appears, from a height, to be a broad strip of flat land, occupying the valley-bottom for a distance of three and a-half miles. It is found, however, on further examination, that the lakes are really divided by two large coalesced flat fans, probably of subaqueous origin, and formed by the important streams here entering at opposite sides—one at the Indian Reserve, the other at Penticten. A considerable area of arable land exists in the low strip between the two lakes, and the brooks above-mentioned give abundance of water for irrigation. The Indians on the west side of the Okanagan River—which runs from Okanagan into Du Chien Lake—cultivate the soil pretty extensively, while Mr. Ellis, on the opposite side, has a fine farm known as 'Penticten.' Du Chien, and the lower part of Okanagan Lake are fringed with terraces along the shore, which on the upper end of the former are quite narrow, and interrupted from time to time by rocky bluffs. The material of these terraces is, for the most part, a white silt, but near the north-west end of Du Chien Lake is replaced by a fine white sand, in beds generally an inch or two in thickness, but sometimes as thin as paper. These are often observed to lie in broad undulating curves, indicative of current structure. The banks are hard enough to form vertical or nearly vertical faces, in which layers slightly hardened by ferruginous cement are sometimes seen. These sands probably represent merely a coarser portion of the white silt deposits, elsewhere more fully noticed.

Outlet of Okanagan Lake.

Silt and sand deposits.

Formations represented.

Granitic and gneissic rocks evidently form the mountains on the east side of Du Chien Lake down nearly to its lower end, where the north-eastern border of the Tertiary volcanic rocks seems to cross the valley. The brook of the Indian Reserve probably marks the north-westward continuation of the same line. The mountains north of the brook have the appearance of being of the granitic and gneissic series, for some miles, when the Tertiary is again seen to resume, dipping north-eastward and forming a broken escarpment running to the north-west. Nearly on the line of strike of this outcrop, a small broken reddish hill appears between the trail and the shore of Okanagan Lake, on the east side, which with little doubt forms a Tertiary outlyer.

Trails run up both sides of Okanagan Lake. That on the east side forks, nine and a-half miles from the lower end of the lake, one branch continuing to follow the lake shore, the other striking north-northwestward over the mountains, and thus avoiding the rough, rocky side-hills by which the lake is often bordered, and also cutting off the knee which the lake here makes. The latter route was followed, and was estimated to be about seventeen miles in length between the forks and the crossing of Mission Creek. In crossing the mountains, an altitude of 3,740 feet is reached, and this suffices to cause a change from the dry and bunch-grass-covered slopes of the Okanagan Lake, to a region characteristically damp and northern. In ascending, and again in descending the northern slope, terraces are found at many different elevations. These are mentioned more fully in describing the drift deposits. The summit is strewn with large granitic boulders, which appear to be of the rock of the country, broken down and weather-rounded nearly in place. Pools and swamps are frequent. Among the plants in flower on July 2nd were noted:—*Linnæa borealis*, *Spiræa betulifolia*, *Lonicera involucrata*, and *L. occidentalis*, *Lilium Canadense*, *Cypripedium occidentale*, *Pedicularis racemosus*, and *Nuphar polysepalum*. A few small trees of larch (*Larix occidentalis*) were also, for the first time, observed here.

Trail to the Mission.

Mountain vegetation.

The Mission Settlement occupies a large flat, formed by the detritus brought down by the stream known as Mission Creek. This flat area does not extend far into the lake, as many fans and stream-deltas do, but fills what must at one time have been an extensive bay. The total area of arable land must be about six square miles, of which most is already taken up. With irrigation, crops of all sorts, including beans equal to those of Lillooet, can be grown. The settlement dates from about eighteen years back, and now consists of seventeen families in all, mostly Half-breeds speaking French. A considerable proportion of the land is under cultivation, with fine-looking crops. The farm buildings are in some cases substantial, there is a school with about twenty scholars, and a church and mission buildings under the care of two French priests. Rich gold placers were at one time worked on Mission Creek, and though not now yielding largely, still employ a few men. They are described in another part of this report.

The Mission Settlement.

Okanagan Lake.

Okanagan Lake has a total length of sixty-nine miles, with an average width of nearly two miles, which is maintained with considerable regularity. Its elevation above the sea level is about 1,270 feet. Though a line drawn through its opposite extremities is nearly due north and south, it makes, in its southern half, a very considerable bend to the west, and its northern extremity turns eastward. It occupies the bottom of one of the great trough-like valleys common in this country, and though much longer, in its width, and mode of formation closely resembles Kamloops Lake, described on a preceding page.

As already mentioned, the lower portion of the lake is fringed with benches of white silt, which occasionally form a nearly flat, or gently sloping surface for a short distance back from the shore. These do not appear on the northern part of the lake, however, being seen last nearly opposite the Mission. The shores may as a whole be said to be bold, and rise generally pretty steeply from the water's edge to mountains of considerable height. This is more especially the case on the west side, which is also more thickly timbered than the east, and shows a comparatively small proportion of land fit for the support of cattle. On the west shore, near the northern end of the lake, there is a little flat cultivable land fringing its margin, or in the form of projecting fans. This is chiefly taken up by Indians. Opposite the Mission, at Allison's, a wide bench occurs, but the greater part of its extent is only fit for grazing land. The eastern side of the lake, especially toward the northern end, is in many places an open bunch-grass country, and the hills separating it from the parallel chain of lakes which is followed by the waggon road, are low.

Banks of the lake.

The lake is probably very deep, except in the vicinity of those places where deltas of streams have been encroaching on it, but I had no opportunity of sounding it. It seldom freezes over, but has occasionally been known to do so completely. Opposite the Mission, at the 'Narrows' the bottom, formed of the subaqueous extension of the Mission fan, or delta, can, it is said be seen all the way across, and is probably not in any place deeper than twenty to thirty feet. On the west shore, at this place, are two remarkable acute triangular points of sandy material. These are not in connexion with any entering streams, but are pretty evidently the result of the convergence of waves originating in differently-trending reaches of the lake. They are of the same nature, but not so well developed as the spits in Osoyoos Lake. The rocks bordering the lake are Tertiary, underlain by ancient metamorphic and granitic materials, with limestones of intermediate age toward the northern end. A remarkable line of fracture and disturbance runs parallel to the northern part of the lake, on its eastern shore.

The Narrows.

The Mission is connected with Kamloops by a good waggon road, which, however, does not follow the shore of Okanagan Lake, but a parallel valley lying a few miles east of it, occupied by the smaller lakes above alluded to. The first or southern lake, about a mile in length, is called Duck Lake. The second, generally known as Long Lake, is thirteen and a-half miles in total length, but is almost completely divided four miles from its southern end by a very narrow transverse strip of low land, known as the 'the Railway.' This is supported in the centre by a little rocky mass, but otherwise resembles

Parallel chain of lakes.

the spits of Osoyoos Lake. The southern portion of Long Lake is separately distinguished as Primeewash Lake on Trutch's map. Long Lake has an average breadth of over three-quarters of a mile, and appears to be very deep, a shallow border of variable width fringing the shores, which drops suddenly at its outer edge to deep water. It is 133 feet higher than Okanagan Lake, and discharges into it at its northern end,

Shoal borders of lakes.

It was at first supposed that the flat submerged border, well marked in the lakes above mentioned, but also seen frequently elsewhere, implied a comparatively recent elevation of the lake waters. It would appear, however, that it is really due to the distribution by the movement of the water of the lake itself, of debris from the shores. At a depth so great as to render the surface movement inappreciable, the material forms a steep talus sloping down to the deeper portions of the lake bottom. Thus where the lake is wide and the force of the waves great, the shallow border is proportionately increased. This feature has important bearings on the formation of lakes generally, and explains several circumstances connected with those lying in the great valleys of the interior.

Country north of Okanagan Lake and between Cherry Creek and Kamloops.

Valleys running from head of Okanagan Lake.

About the north end of Okanagan Lake, is an extensive region characterized by broad open valleys, separated by lower ranges of hills, and affording not only fine stock ranges, but much arable land. The valley holding Okanagan Lake is continued north-north-eastward for thirty miles to the southern extremity of the Spallumsheen arm of the Great Shuswap Lake. This is known as the Spallumsheen Valley, and is already occupied by a number of farmers. By it, as before mentioned, the Shuswap basin has originally been drained to the Columbia. Running north-westward from the head of Okanagan Lake is a second wide valley, which in eight miles leads to the elbow of the Salmon River, and there divides into three valleys of equal width to itself. One running for some miles nearly parallel to the Spallumsheen valley, eventually unites with it, a second runs northward to the Salmon Arm of Shuswap Lake, and is followed by the lower portion of the Salmon River. The third carries the upper part of the same stream, and extends westward. The Coldstream Valley, which runs westward from near the head of Okanagan Lake, is the last of these great depressions, and will first be noticed.

Coldstream Valley.

Two miles north-westward from the north end of Long Lake, is Mr. Vernon's farm, called Coldstream, from the large springs which here issue, giving rise at once to a brook of some size, which flows toward Long Lake. The temperature of the spring water on July 8th was found to be 48· 5°. The wide Coldstream Valley is in connexion westward, by low ground, both with Long, and Okanagan lakes. The hills to the north are for the most part open, and covered with bunch-grass to the very summits; those to the south, somewhat higher, when seen from a height, coalesce to form an irregular plateau, with an elevation of probably between 3,000 and 3,500 feet. They are more rugged and thickly timbered, and are capped by nearly horizontal Tertiary volcanic rocks. The bottom of the valley is composed chiefly of wide coalescing fans, with gentle slopes, with here and there between them portions of nearly flat land consisting, apparently of the bottom deposit of an ancient lake. Ten miles eastward from Coldstream the main valley seems to turn northward to that of the Shuswap River. It receives near the angle, at Bull Meadow, two streams coming from the eastward. Between Coldstream and this point, at Dutot's, is the watershed between the Shuswap, draining to Shuswap Lake and the Fraser River, and the Okanagan flowing to the Columbia. Its elevation is about 1,600 feet. Nelson's (or Dutot's) Brook here enters from the north, forming a fan of the usual character. It turned originally to the west, joining the Coldstream Brook, but for irrigating purposes a portion of it was diverted eastward, and the channel so formed has now become the principal one—the stream though still contributing a portion of its water to the Columbia, having by a very small amount of labour been turned into a tributary of the Fraser.

Watershed between Fraser and Columbia.

Mode of formation of Coldstream Valley.

The wide Coldstream Valley has not been formed under present conditions, but implies the prolonged action of a large stream at some former time, the subsequent presence of a great body of water, which was gradually lowered,—probably towards the close of the glacial period—and lastly, of the continuance, for a considerable time, of circumstances like the present, during which valleys were in some cases stopped by the encroachment of fans, in others cut deeper by the action of streams. The original river may have been one deriving its supplies from the present drainage area of the Shuswap, and consequently representing the modern stream of that name. It is difficult, however, in a country in which so many and so deeply drift-buried ancient channels occur, to arrive at certainty on such points.

Trails to Cherry Creek.

The Cherry Creek mines are situated twenty miles east of the Bull Meadow, on Cherry Creek, a branch of the Shuswap, or Spallumsheen River, among the western flanking mountains of the Gold Range. From this point, three different trails lead to the mines. The first and oldest route crosses the Shuswap River twice, running north of its southward elbow; the second, used only when the water in the

Shuswap was so high as to render the first impassable, follows the valley of one of the streams, before mentioned, eastward, south of the Camel's Hump Mountain, traverses a summit at an elevation of 3,524 feet, and crosses the sources of Ferry Creek; the third, cut out only last summer, follows a route selected by Mr. C. Vernon, going north of the Camel's Hump, but without crossing the Shuswap. This will probably be the only route followed in future, and by it a waggon road might easily be made if required.

The summit on the southern trail is nearly equal in height to most of those of the surrounding hills, which, as previously observed, in many places, when viewed from a height, resemble the fragments of a once regular plateau. In the general form of its minor features it shows evidence of a heavy glaciation, and on hard quartzose veins the striation and polishing can still be found, though in this place the former is subsidiary and not strongly marked. The higher parts of the hills are covered with a pale-brown earthy boulder-clay, which, however, generally forms but a thin coating, through which much rock projects. The included stones are here more angular than usual. Mountain trail.

In following Mr. Vernon's trail from the Bull Meadow, a narrow, rocky pass leads through to the Shuswap, which here, at its southern elbow, flows in a wide valley, with occasional flats of some size, but all more or less completely covered with forest or windfall. It is bounded to the north by a range of steep, rocky mountains, which appear to be of granite and gneiss, and rise to a height of about 2,000 feet above it. To the south, the hills are somewhat lower, but consist of similar rocks. Shuswap Valley.

Above the mouths of Ferry and Cherry Creeks, and extending up the latter as far as the mines, is a considerable area of flat or undulating land, the occurrence of which among the western mountains of the Gold Range is rather remarkable. It is now for the most part either wooded or rough with burnt timber, windfall and second-growth, but even in this state might afford much feed for cattle and horses, from swamps with coarse grass, pine grass in the open woods, and lupin and vetch in the burnt areas. The general elevation of the country is about 2,256 feet, and much of it may be considered as a terrace-flat at this elevation. Its area is probably about twelve square miles, and it may at some time be occupied by farms, notwithstanding its proximity to the higher mountains of the range, which may render it more liable to summer frosts than its elevation would lead one to suppose. It would not require irrigation. Flat land about Cherry Creek.

Both branches of Cherry Creek, cut deep but narrow valleys in this lower area, and beyond it are bordered immediately by high, rounded mountains, which have at one time been for the most part densely wooded, but are now, owing to the spread of fires, covered with almost Valley of Cherry Creek.

impenetrable windfall. These mountains do not carry snow during the summer months, but are sufficiently high to conceal the axial summits of the Gold Range, which, from points further westward, are seen to form a lofty snow-clad sierra, some of the peaks probably attaining an elevation of 9,000 feet, and sheltering among them numerous glaciers.

Trees.

A few specimens of larch and cedar occur as far westward as Coldstream, thus overlapping by about thirteen miles the range of *Pinus ponderosa*, which here finds its eastern limit near the longitude of the Camel's Hump. In the vicinity of Cherry Creek *Pinus monticola*, *Abies lesiocarpa*, and other plants requiring considerable rainfall flourish, especially on the higher slopes of the hills. *Sphœralcia acerifolia* was noted in the same locality.

There is still room for several good farms in the Coldstream Valley, but at present there is so little demand for produce, that cattle, which can be driven to the coast market, are more profitable than the cultivation of the soil.

Spallumsheen Valley.

The Spallumsheen Valley, running from the north end of Okanagan Lake to the Spallumsheen arm of Shuswap Lake, is already an agricultural district of some importance, and constitutes the largest area of available land found together in any one valley of the interior of the southern part of the Province. The valley probably averages two miles in width, and is flat-bottomed, with low benches rising along the sides. Through its centre winds a slough, or swamp, generally about 500 feet wide, and sometimes occupied by pools. This has all the appearance of having been at one time a river-bed, and as already stated, has in fact probably carried the upper part of the Okanagan River, at a former period. The level of the slough appears to be nearly the same throughout. To the south it is partly blocked by detrital material, but gives issue to a stream of some size, which enters the head of Okanagan Lake. I had not time to make a careful examination of the Spallumsheen Valley, and did not visit its northern end, which can be reached by a steamer ascending the Shuswap River from the lake of the same name, and is the point of shipment of grain and other produce to Kamloops. The portion of the valley examined is partly prairie land—most of which is already taken up,—and partly wooded. The climate is such that without irrigation fine crops of all sorts can be raised. The soil of the lower benches and bottoms is clayey, deep and rich, that of the higher benches is lighter, but still good. The subsoil shows a tendency to resemble the white silt deposit; but is not well characterized as such. The total area of available land in this, and the branch valley running toward the elbow of the Salmon River, may be about forty square miles, and there is still room for

Irrigation not required.

many good farms, though most require to be cleared of timber. The stock ranges of this vicinity though good and extensive, are not sufficient for the comfortable support, on the present system, of a number of cattle and horses very greatly in excess of those now pastured here.

The Salmon River Valley, from the point at which it turns northward, to its mouth at the Salmon Arm of Shuswap Lake—a distance of twenty-one miles—was not traversed. In viewing it, however, from the north and south ends, it does not appear in its physical features to differ essentially from the Spallumsheen Valley, though somewhat narrower, and more or less densely timbered throughout. It must share the climatic conditions of the Spallumsheen Valley, and when the growth of grain and other agricultural products receives an impetus by the opening of easy communication between the west end of Kamloops Lake and the coast, will no doubt be cleared and tilled. *Salmon River Valley.*

From the point at which the road from the head of Okanagan Lake to Kamloops first touches the Salmon River, near its elbow, it follows the valley of that stream westward for about nine miles. This part of the valley is not so wide as that just described, and shows little flat bottom-land. There are still, however, considerable areas which if cleared—which they no doubt eventually will be—may be successfully cultivated. Near the point last defined, and a short distance beyond the bridge by which the road crosses the Salmon River, the valley bifurcates, one branch running up north-westward, the other—which is that followed by the road—westward. Six miles further on, the valley widens to form the Grande Prairie, an area of flat land some thousand acres in extent, on which two good farms are already placed. This is evidently the filled up or drained bed of an old lake, in which the detritus carried by the streams has formed broad, sloping fans. The elevation of Grande Prairie is about 2,000 feet, and irrigation here again becomes necessary. The rocks, which about the head of Okanagan Lake and in the Spallumsheen and lower part of the Salmon River Valleys are like those of Shuswap Lake, elsewhere more fully described, are covered, near Ingram's, in Grande Prairie, by Tertiary igneous products, which continue to characterize a wide region to the north-west and west. (See Plate IV.) *Grande Prairie.*

The stream flowing through the Grande Prairie Valley, still continues to bear the name of the Salmon River. It derives a great part of its water, I believe, from a large spring rising near the northern edge of the prairie, and fed, probably, by the subterranean drainage of the drift-blocked valley which the road follows north-westward from this place to the Thompson River. The upper part of the Salmon River Valley runs south-eastward from Grande Prairie for about sixteen *Upper Salmon River Valley.*

miles, when the sources of the stream are reached. The portion nearest Grande Prairie, though, like the prairie itself, hemmed in by mountains of considerable height, for some miles continues to show lightly-timbered flat land suitable for cultivation. It is then, for about eight miles, narrow and steep-sided, bounded occasionally by high cliffs, formed of volcanic breccias of Tertiary age. Towards its sources it opens again more widely, and stretching southward toward Chaperon Lake, and westward, is a wide, open, undulating country, admirably suited for stock, and probably, in part at least, for farming, though at an average elevation of nearly 3,000 feet. Near the head of the Salmon River, on September 1st, on the site of an abandoned Indian camp, at an elevation of about 2,800 feet, oats, wheat of two varieties, and barley were found growing. The first was ripe, the others just beginning to turn yellow. The grain had been accidentally scattered on a dry hill-side, and had reached the stage at which we found it without irrigation. We were afterwards informed that the Indians had been camped there in June.

Wide open country.

Grande Prairie to Thompson River.

From Grande Prairie to Duck and Pringle's on the south Thompson River, a distance of fifteen miles, the road follows a valley in which a little chain of lakelets draining toward Grande Prairie lie. Beyond these, the summit, with an elevation of about 2,300 feet, is crossed, and another stream flowing in the continuation of the same valley, followed down to the Thompson. The little lakes in this valley pretty evidently depend, as in so many other cases, on the interruption of the drainage by the irregular inwash of drift from the sides. Some of these have been since entirely filled with *débris*, forming swamps, with grass suitable for hay.

GEOLOGICAL OBSERVATIONS.

Arrangement of matter.

In the foregoing pages, an account has been given of the general geographical and topographical features of the country embraced by this report. Many facts connected with the former glaciation of the region and its superficial deposits have also been included, as they bear so directly on its present form and character. These are summarized and supplemented by additional information under the head of *Superficial Geology*. The general distribution of the various rock formations has also been referred to in so far as it appears important in connexion with the topography. The remaining facts bearing on the areas occupied by the different rocks are incorporated in the map, and in the following pages are only incidentally referred to.

PLATE IV.—GRANDE PRAIRIE, B. C.

In treating of the geological structure of the region, no attempt will be made to describe all the very numerous localities visited and examined. The rock formations are taken up in order, beginning with the oldest, and in each case those exposures and sections which appear to offer points of importance are treated of in some detail. It is proposed to group the observations under the following general heads:—(1. *Older rocks, chiefly Palæozoic and Triassic,* (2.) *Newer Mesozoic,* and (3.) *Tertiary,* without attempting more minute subdivision. The rocks of each locality will, however, be compared seriatim with those of the minor groups already established for other parts of the Province, and also referred as closely as their contained or associated fossils admit, to their absolute positions in the general geological scale. Cassification adopted.

OLDER ROCKS, CHIEFLY PALÆOZOIC AND TRIASSIC.

The rocks below the Jackass Mountain series—now known to be Cretaceous,—in the provisional classification adopted in 1871, were included under the following names:—Upper Cache Creek group, Lower Cache Creek group, Anderson River and Boston Bar group, Cascade Mountains and Vancouver Island Crystalline series, and Granite, Gneiss and Mica-schist Series of North Thompson etc. The region at present described includes rocks referable to all these groups, and embraces the typical localities of several of them. Fossils of Carboniferous type have now been found in a number of localities in such association with the Upper and Lower Cache Creek groups and Vancouver Island crystalline series, as to prove that a greater part at least of the rocks of these divisions are referable to that era of geological time. A portion of the Granite and Gneiss series of the North Thompson etc., with some of the crystalline rocks of the Cascade Mountain and Vancouver Island series may eventually prove to occupy a lower position in the Palæozoic, but no evidence favouring that view has yet come to light. Provisional classification.

On the western side of the main summit of the Cascade or Coast Range, between the head waters of the Skagit and Similkameen, a well exposed section of the highly crystalline rocks, generally found about the axial regions of the mountain ranges of this part of the country, occurs. To the south-west, where the last branch of the Skagit is crossed by a bridge, the crystalline rocks are faulted into contact with Cretaceous sandstones, elsewhere described, the line of the fault running about N 64° W. The general direction parallel to which the rocks of this part of the range are folded, is almost exactly the same with that of the fault. In a direction at right angles to this, the distance from the line of fault to the summit of the pass is about two and a quarter miles. The rocks may be characterized, broadly, as Section at summit, Hope-Similkameen trail.

gneissic, but pass in some cases into materials so massive as to be indistinguishable from granites. Hornblende and mica both occur, the former, however, not in so great abundance as in most other exposures of rocks of this age. The beds are generally pretty regular, but in some places more or less corrugated. They are all nearly vertical, and when showing any departure from verticality, generally dip south-westward. The angles of dip are, however, so high that they cannot be accepted as showing on which side the beds may have rested before their upturn. The appearance of the section, would lead to the belief that it represents a great consecutive series, of which, in that case, the south-western beds must be the newer. It would, however, on this supposition be necessary to allow that the formation, as represented between the fault and the summit has a thickness of about 10,000 feet. No limestones, quartzites, or thick beds sufficiently different in appearance from the rest to serve as a clue to the discovery of possible repetitions in the section were seen, but on the most probable view of the method of folding, shown in Section No. 1, the minimum thickness must be over 4,100 feet.

Beds at high angles.

Probable thickness

Segregation veins traverse some of the rocks, especially the coarser and more granitic. These are composed of a mixture of coarsely crystalline white quartz and felspar with pale-green silvery mica, and occasional small crystals of garnet.

On the hypothesis that the rocks form a continuous descending series, they may be described in sectional form as follows :—

	FEET.
Fault.	
1. Pale greyish and purplish felspathic gneiss, with some dark hornblendic schist. Poorly exposed	989
2. Thin-bedded, pale purplish, felspathic gneiss	1,733
3. Hornblende-schists, with interbedded grey gneiss	960
4. Grey and nearly white gneisses, with some hornblende	2,100
5. Hornblendic gneiss, with some hornblende-schist and coarse pale-grey gneissic or granitic interlaminations	1,760
6. Coarse pale-grey hornblendic gneisses, with granitoid gneiss, containing black mica and hornblende (to summit)	3,200
	10,742

In descending the north-eastern slope of the range, for about two miles, transverse to the general strike of the beds, the rocks are generally concealed by drift deposits. The surface is, however, strewn with large blocks probably not far removed from their matrix. These consist of a rock closely allied to the last, but showing little or no trace of bedding. It must, therefore, be classed as a granite, though it is doubtful whether it has resulted from the more complete metamorphism of beds like those first observed, or is intrusive. It is composed

Gap in section.

of white quartz and felspar, with scattered black hornblende and mica crystals in variable proportions. The next rock met with, is not dissimilar in lithological character to that described last, and holds occasional micaceous and hornblendic layers differing from the rest, by which the attitude can be determined. The dip is still south-westward, at an angle of 75°. This continues for about 2,660 feet, when coarse, dark-green, bedded diorite appears, and seems to be the most important rock, though poorly exposed, for about 4,000 feet.

Green schistose rocks.

This is followed for a width of probably at least 1,300 feet by thin-bedded and schistose rocks, which are found in the bed of the brook to dip S. 78° W. $<$ 60° to vertical. These rocks vary considerably in texture and appearance, but may be characterized as schists, hornblendic, micaceous and felspathic. One abundant variety, with a dark-green colour and finely schistose structure, has its surfaces thickly scattered with small acicular green hornblende crystals. The base is felspathic and finely granular. Another may be called a mica-schist, but differs from the highly crystalline micaceous rocks of the former part of the section. It is a fine-grained grey felspathic rock, on the divisional planes of which thin flakes of brownish mica are scattered in sufficient quantity to give it a glistening appearance. The actual junction of these rocks with the coarser wholly-crystalline series before described was not seen, but material apparently transitional in character strews the surface in loose fragments. It will be observed that these rocks appear to dip beneath those of the axis of the range, though there is reason to believe that they may form the base of the Triassic division.

Altered agglomerates amygdaloids, etc.

For 9,160 feet, still measuring at right angles to the general strike, no rock in place was seen, but at this point a pale-greenish felspathic rock, with an almost silky appearance on some surfaces, and including occasional rather large pale-green hornblende crystals, occurs. It is composed, in some layers pretty evidently, of fragments, which have been squeezed into lenticular forms, and no doubt represents a metamorphosed volcanic breccia or agglomerate. It dips S. 69° W., at an angle of probably about 45°. For about 6,770 feet the measures are again concealed, when, in the vicinity of Powder Camp, coarse diorites composed of green hornblende with pale-greenish felspar, and associated with spotted greenish felspathic rocks are found. Still measuring at right angles to the strike, at a distance of 1,600 feet north-eastward, after an interval of concealment in which only loose fragments of green schistose rocks are found; a grey-weathering, red schistose material occurs, which is evidently an amygdaloid much altered and compressed. This dips S. 78° W. $<$ 45°.

Thus far the rocks have been so nearly vertical that the distance horizontally measured across the strike, on the whole coincides closely with their probable actual thickness. Allowing now for an angle of 45°, we find no exposures for a distance representing a thickness of about 1,600 feet of rock, but from angular fragments abundantly strewing the slopes, a prevalent rock in this part of the section would appear to be a green-grey, probably bedded, diorite. At the distance above-mentioned, however, rocks different from any yet seen are found. They are hard, black schists or slates, sonorous under the hammer, and with a glimmering appearance when turned before the light, due to incipient crystallization. These dip N. 66° W., at an angle of from 45° to 60°, which would appear to carry them below those last seen. Their thickness is at least 800 feet, and, by search, a few obscure fossils were discovered in them. These taken by themselves could scarcely be identified, but on comparison with good specimens of *Monotis subcircularis*, from other parts of the Province, are found to resemble this species so closely as to leave very little doubt that they are referable to it.

Argillites with fossils.

Dipping below the schists, greenish and blackish diorites are again found, though the precise line of junction of the two classes of rock was not seen. At a distance representing a thickness of 1,060 feet of strata below the last outcrop of the slates, the diorites are replaced by a green-grey spotted felsite, slightly calcareous, and evidently an altered amygdaloid. This is associated with a reddish-grey conglomerate containing small rounded pebbles of quartzites and highly calcareous. Beyond this point a considerable gap occurs in the section, the trail and valley of Whipsaw Creek nearly following the strike. When the rocks are again met with they are found to be much confused, and of such a character as to afford little indication of their attitude. Assuming, however, a continuance of the same strike and angle of dip last observed, we have a further thickness of about 7,200 feet, made up of grey and greenish diorites, compact bluish-grey and greenish felspathic rocks spotted with epidote, and occasionally with hornblende, and, lastly, beds of hard, grey volcanic breccia or agglomerate. At this point, eleven miles from Vermilion Forks, the Tertiary rocks appear, as shown on Section No. 1, concealing the older strata, as described in a former section of this report (p. 49).

Repetiton of agglomerates, etc.

The beds first described in the foregoing section represent those to which, in the provisional classification, the name of Cascade Crystalline series was given. The apparently massive granite rocks of the east side of the pass may also be classed with these, which might further include a considerable proportion of the crystalline rocks in the remainder of the section. These, however, though they cannot be separated from the former in this section, at least, are much more closely allied to the dioritic and felspathic rocks of Nicola Lake and

Age of the rocks.

other localities subsequently described. The occurrence of *Monotis subcircularis* in the hard argillites would characterize them as probably Triassic, though the attitude of the beds would not only lead to the supposition that they were conformable with the dioritic and felspathic rocks, but that they actually dipped beneath the whole crystalline series of the range. On close inspection, however, it is found that the beds composed of altered volcanic materials are repeated on the two sides of the argillites, showing that these probably form a synclinal or anticlinal, pinched closely together, and eventually, with the contiguous folds, overturned to the eastward. It becomes, in fact, evident that the whole section has been overturned in this direction, and that, in the absence of good exposures and a very minute examination, it is impossible to ascertain with certainty the actual thickness of the formations represented, or the equivalency of the beds in the different parts of the series. The felspathic and dioritic series of Whipsaw Creek Valley, might well, if further altered, supply material for a gneissic and granitic series like that of the axis of the range; but, on the other hand, the probable diversity of the two sets of rocks is indicated by the close junction of coarsely gneissic materials with the finely laminated hornblendic and micaceeus schists which apparently dip beneath them. The greater part of the rocks of the Whipsaw Valley are quite evidently volcanic in origin, though in many cases so much altered as to resemble the older crystalline schists, to which such origin is not usually granted by geologists.

Argillites form a compressed fold.

The Palæozoic rocks lying between the western edge of the area of Mesozoic of the upper part of the Skagit Valley, and the Fraser River at Hope, are not so well displayed as those just described. On the road below the Mill at Hope, rocks representing the typical Cascade Crystalline series are well shown. They consist of grey diorites and white felspathic beds, in which, often, very small streaks only of darker colour are found. There are, however, some darker layers of considerable thickness in which a characteristically felspathic base is darkened by a little ordinary argillaceous material. The rocks are all distinctly bedded and contain very little quartz. In one of the darker felspathic layers, small rounded pebbles are included, the largest of these, of the size of a pea, was sliced, and found to be a fine grained quartzite, in which layers of nearly transparent silica alternate with others densely opaque. These fragments indicate rocks of greater antiquity than any yet recognized in this region, and of changes the history of which yet remains to be discovered. The most noteworthy feature in the exposures here is the great mass of pale felspar rocks. The beds dip south-westward, at an average angle of about 50°, and on their strike run up into and form a part of the Fort Hope Mountain. The white

Cascade Crystalline rocks near Hope.

felspathic belt may be seen as a wide band running completely across the face of this mountain, and—judging from the loose fragments brought down in slides at its base—continues to maintain a character much the same as that at the place above described. Below the white rocks, on the eastern flank of the mountain, is a mass of darker beds, and above them, a second series of dark beds, forming the summits. The mountains on the opposite or north side of the Coquihalla, appear from a distance to be formed of the same series of rocks with the Hope Mountain, repeated on the opposite slope of an anticlinal, which must in that case run up the Coquihalla Valley.

Limestone

About four miles above Hope, on the same side of the river, a limestone occurs, from which lime has been made. It is reported to be impure, but I have not visited the locality. It may probably represent the continuation of the limestones described below, on the trail south-east of Hope.

Rocks on the Nicolume.

In following the Similkameen Trail, already described, (p. 45) the only rocks seen in its immediate vicinity for nine miles from Hope, are granites and coarse diorites, either intrusive, or bedded deposits altered beyond recognition. The granites are black and white, spotted, and usually contain more hornblende than mica, passing over in some cases to a material which may more appropriately be styled diorite. These rocks seem to form an extensive intrusion, in which it is probable, occasional small areas of the sedimentary rocks have been caught up. At the distance above named, bedded rocks begin to be found, and continue to characterize the south-eastward-trending valley which holds the Nicolume and Sumallow rivers, for fourteen miles. The valley has been excavated on a belt of schistose and slaty rocks, with limestone, the strike of which it follows so closely, that though a considerable volume of beds must be represented, it is impossible, in their much disturbed state, to form even an approximate estimate of their thickness. The rocks in the upper part of the Nicolume are chiefly grey, glossy argillites, or argillaceous quartzites, and blackish schists or slates, with interbedded cherty quartzites. About Beaver Lake, and for some distance down the Sumallow, is a great mass of bluish- and greenish-grey felsite, of fine grain, in some places massive, but often schistose and distinctly bedded. This rock has all the appearance of a highly metamorphosed fine volcanic ash, but in the absence of other evidence it is impossible to affirm that its origin may not have been more analagous to that of an ordinary argillite. It fuses pretty readily in thin splinters before the blowpipe.

Rocks on the Sumollow.

Further down the Sumallow, blackish schistose argillites, with quartzites and felsite like that above described continue to occur, till, at eight miles beyond Beaver Lake, limestones appear. These are not found close to the trail, but can be seen in the cliffs at a great height above, and are abundantly represented by loose blocks in the bottom of the valley. The commonest variety of this rock is bluish-grey, thin-bedded or laminated. This, however, often becomes blotched with white by more complete metamorphism, and in one place it was found converted into a pure white saccharoidal marble. No organic traces could be found, but the limestone evidently belongs to the schistose series above described, and in some places becomes interleaved with thin beds of these rocks.

In almost every instance in which the attitude of the rocks in this valley could be ascertained, they dip south-westward, or toward the coast, conforming in this respect with those of the main summit of the range east of the Skagit Valley. The angle of inclination may average about 40°, though in several cases it is considerably less than this. Just above the first limestone exposures the strike appears to cross the valley, and this, together with the arrangement of the rocks themselves, would lead to the belief that they form together a tightly compressed anticlinal, overturned eastward. In this case, the limestones must overlie the schistose argillites and quartzites. The argillites resemble in most respects those of the Boston Bar group of the waggon road, and the cherty quartzites *etc.* are like those of the Cache Creek group. The two rocks are here, however, so closely blended that it is impossible to separate them.

General South-westward dips.

Relations of the beds.

Near the mouth of the Sumallow, whitish and yellowish quartzites, much broken and altered, occur, and are soon replaced by a mass of whitish granite, beyond which the Mesozoic rocks elsewhere described, set in.

Further north, on the trail between Nicola and Hope, the axis of the range lying immediately east of the Fraser River is again crossed, and is found to be characterized by rocks very similar to those just described. At the first bridge on the Coldwater River, forty-eight miles from Hope, the Tertiary rocks are replaced by an older series of schists and slates. These are seen in the vicinity of the river, which nearly follows the strike, for three miles south-westward, and are for the most part felspathic and not of the character of true argillites. Dark greenish argillaceous or felspathic schists, chloritic on the surfaces, alternate with others more decidedly felspathic pale greenish-grey, and bright-faced with a talcose mineral. These, in some cases show porphyritically imbedded felspar crystals, and appear to pass into rocks which, with a fine-grained granular base of greyish or pinkish-grey felspar and a little hornblende, hold larger pale porphyritic felspar crystals.

Rocks on trail from Nicola to Hope.

It is impossible to estimate the thickness of these beds, as the valley nearly follows the strike, which is rather irregular. They appear to form a synclinal, the dips varying from 20° to 30°. At the south-western end of the series of exposures, the last rock seen is a grey-green silvery schist, rather quartzose. This is followed, in apparent conformity by a coarse-grained gneiss, in which whitish felspar and quartz in nearly equal quantity, are interleaved with black mica in undulating layers. This is at least several hundred feet thick, and the appearance would lead to the belief that the schistose series rests conformably on the gneissic. This would further seem to be indicated by the fact that a layer only a foot or two in thickness of a similar gneissic rock, is intercalated with the schists a little above their junction with the main mass. The line between the schistose and coarse gneissic rock, is in both cases quite sharp. The comparatively little altered character of the schists, however, tends to throw doubt on the theory of their intimate connection with the gneissic rocks, and it is possible that an unconformity too slight to be detected in beds at such high angles (in this place $< 80°$) exists, or that the seemingly gneissic rock is really intrusive, its apparent bedding being due to pressure, or the position of the plane of cooling.

Junction of schists with massive gneiss.

Cascade Crystalline rocks.

The coarse gneiss, however, evidently belongs to the crystalline series of the axis of the range, and it must be remarked that in the Cascade Crystalline series as originally constituted both bedded rocks and structureless masses of similar composition were included. From this point to the summit between the Coldwater and Coquihalla, exposures are few, but boulders of highly crystalline gneisses and of granite continue to abound. At the summit, grey fine and coarse grained gneisses, with white plagioclase feldspar, milky quartz, and black mica occur. They hold a few garnets in some layers and are mingled with other rocks without evident bedding, and traversed by many small quartz veins, and others with quartz, felspar and pale-green silvery mica.

Rocks of the Upper Coquihalla.

In following the Coquihalla from the summit to the mouth of Unknown Creek, rocks referable to the Cascade Crystalline series continue to appear. In some places they are well stratified, but the dips are discordant, and the greater part of the exposures are of rocks so massive that they may represent strata changed almost beyond recognition in place, or exotic material. True granites holding a considerable proportion of quartz, with abundant scales of black mica and little hornblende, are here much more abundant than in the sections on the Fraser River above Yale, where the series has a less acidic character. Some beds of glossy dark-green hornblende-rock are, however, found. In one granite, containing hornblende as well as mica, abundant small yellowish crystals of sphene occur. Near the junction of Unknown Creek with the Coquihalla, and on the latter, bare shattered cliffs of massive grey granite, border the valley. The rock is conspicuously jointed in several planes, one of these being nearly horizontal and simulating bedding. The rock thus divided falls in great fragments into the valley below, its polygonal blocks resembling those seen at Hell's Gate Rapid on the Fraser. Several dykes of a very tough, fine-grained greenish diorite, with scattered particles of iron pyrites, and crystals of pale-green orthoclase felspar were observed on this part of the river.

Between the mouths of Unknown Creek and Ladner's Creek (see Section No. 2) in a distance of four and a-half miles, the chief exposure of slaty rocks, alluded to in a former page of this report, occur. The granite near the mouth of Unknown Creek is massive, and, if formed from the alteration of rocks in place, has lost all trace of bedding; included fragments of slaty rocks occur in it, and rest upon its flanks in a much altered state. At the mouth of Boston Bar Creek, these rocks finally replace the granites. They are here highly metamorphosed, and traversed by many cross-joints and small faults which confuse the section very much. The schistose rocks are highly altered argillites, black, or rusty from partial decomposition, spotted in many places with imperfectly developed chiastolite crystals, and the division planes bright with minute mica scales. Specimens somewhat less altered, very much resemble the beds found to hold *Monotis* on Whipsaw Creek (p. 66). Still less changed beds are ordinary hard argillite, without any sign of crystallization. A short distance above Ladner's Creek, extensive exposures again occur, from which it is evident that the rocks are really schists and not slates, as their layers follow parallel to the divisional planes. Though carefully examined, no fossils could be found in these rocks. The general dip is southwestward at very high angles, though, owing to disturbance due to the intrusion of the granite, the direction of dip varies between wide limits. The thickness of the schistose argillites must be very considerable, though it cannot be determined with any accuracy, as the main folds shown on the section are probably complicated by many minor flexures.

Section No. 2.

Belt of argillites and schists

Complicated folding.

Shortly after crossing Ladner's Creek, the schists become less uniformly flat-bedded, being undulated and even crumpled in places. They also become more siliceous, and in some layers even cherty. Still further down the valley, cherty quartzite begins to form important beds, and alternates with silvery and siliceous schists and felspathic rocks. In other places, dark argillaceous schists occurring in considerable thickness, are corrugated by excessive folding, so that they break, on weathering, into grey pencil-like fragments, precisely like

Cherty layers.

those seen in some exposures of the Boston Bar rocks, near the place of that name on the waggon road.

Attitude of the strata.

The rocks thus generally described, occupy the Coquihalla, below the mouth of Ladner's Creek, for about ten miles. Taking the average strike of the rocks at N. 21° W., the transverse measurement of the belt must be about six miles. In this distance, at least one synclinal fold probably occurs, besides many lesser corrugations not represented on the section, so that the thickness of the series, though very great, is not that which would be given by the entire width of the nearly vertical strata. The synclinal fold brings in the shattered argillites described in the last sentence of the preceding paragraph, and these may be regarded as being not improbably a repetition of a part of the greater mass first described. To the south-westward, these rocks are cut off by the mass of structureless granite already described as characterizing the Coquihalla Valley immediately above Hope, and about the mouth of the Nicolume stream.

Correlation of the beds.

The quartzites referred to above, are in intimate association with the schists. They precisely resemble those elsewhere characteristic of the Cache Creek rocks, being dense and cherty, and vary in colour from black, through grey to pale greyish-green. The schistose argillites have already been described, the felsites are greyish and greenish, massive or more or less slaty; and in some cases resemble those elsewhere known to result from the hardening and alteration of fine sediments of volcanic origin. The resemblance of these rocks is, on the whole close, to those described on the Sumallow and Nicolume, and, if not a portion of the same belt, they may represent a nearly parallel fold of this series of beds. The great width of argillites below the mouth of Unknown Creek, is on the strike of the rocks of Boston Bar on the waggon road, and in all their main features the rocks of the two localities are identical, and without doubt represent the same band. It would thus appear, that we have here a series of folds of strata forming, in the main, a trough among the more highly crystalline rocks, and representing the Boston Bar series of the provisional classification, but closely associated with more typical Cascade Crystalline rocks, and showing points of resemblance or identity with portions of the Cache Creek series.

Section No. 3.

In crossing the mountains from the mouth of the Coldwater to Boston Bar (see Section No. 3), the first rocks of the old crystalline series are found on the west side of Spi-oos Creek, not far west of the last exposures of the Tertiary series. From the quantity of boulders in the stream, which resemble the greenish rocks met with on Whipsaw Creek east of the wholly-crystalline axis, it is probable that a belt of these rocks may occur here, but the exposures are not sufficient for its definition. The trail crosses the crystalline rocks nearly at right angles to their strike, and they continue to appear for a distance of twelve or thirteen miles. The eastern exposure alluded to, is of grey granite and gneiss, with black mica, and stratification planes very faintly indicated. Westward, all trace of stratification is lost for great distances, and massive granitoid gneiss, or absolute granite, grey and micaceous, continues with great uniformity. Towards the western end of the section the rocks become, however, decidedly more hornblendic, and are generally somewhat schistose, greenish and grey. After an interval of concealment, quartzites of the Jackass Mountain series are found, and rocks of this age continue to the hill-top above Boston Bar, and almost appear to be followed conformably, on the western slope of the hill, by the hard, slaty argillites of the Boston Bar series. The zone here characterized by granites and granitoid gneisses, evidently corresponds to that east of the schistose argillites on the Coquihalla, and east of the summit between the Skagit and Whipsaw Creek. Granite and gneiss on Spi-oos Creek.

At Boston Bar, the hollow marking the course of the schistose belt of rocks, and in which the Anderson River runs, becomes the valley of the Fraser. The schistose and slaty rocks of the Boston Bar series, are exposed in many places northward, near the waggon road. They are described in a former report, and, in the absence of a more careful examination, need not be referred to here at length.* Some notes in connexion with their relation to the overlying Jackass Mountain rocks will be found on a succeeding page. Layers of cherty quartzite, resembling that before mentioned, occur in the shales in some places, with occasional thin limestones. About a quarter of a mile south of the fortieth mile-post, grey, streaked shaly beds, in layers several inches thick, are immediately overlain by grey laminated limestone dipping N. 50° E. $<$ 62°. The thickness of this bed is under 100 feet, and it is overlain by soft grey-green, almost nacreous schist, a few feet only of which is seen. Boston Bar Rocks. Limestone.

In following the axis of the eastern portion of the Coast or Cascade Range still further northward, we find on the north bank of the Thompson River above Lytton, fine exposures of granitic and gneissic rocks, but these have not yet been examined. On the east bank of the Fraser River, from Lytton to Forster's Bar—a distance of about twenty-one miles—the older crystalline rocks are the most abundant, though areas of Mesozoic rocks also occur. Twelve miles above Lytton, about the mouth of Iz-man Creek, is a thickness of at least 500 feet of well bedded rocks, which may possibly represent, in a highly Older rocks above Lytton.

* Report of Progress, 1871-72, p. 62.

altered state, the green series found east of the summit on Whipsaw Creek. The rocks here are greenish felspathic schist, hornblendic quartz rock, impure greyish-green chloritic schist, granulite and gneiss. Most of the older rocks met with on this part of the Fraser River are, however, either beds so much altered as to have lost all sign of stratification, or intrusive granitoid masses. These are chiefly grey, coarse, hornblendic granites, passing probably in some cases into diorites; and large exposures of a peculiar granitic rock, containing dark mica and hornblende, but also holding spots and streaks of epidote. The quartz occurs in little irregular masses, and is not infrequently slightly opalescent. Several bare, white mountain slopes appear to be composed entirely of these wholly-crystalline rocks in a crumbled state. The fragments spreading down from the shattered peaks in long steep slopes. The rocks are not decomposed, but broken by the weather along the innumerable jointage planes by which they are traversed.

Granitoid masses.

Older rocks east of the Coast Ranges.

East of the inner ranges of the Coast system of mountains, to which the observations hitherto detailed may be considered as belonging, great areas are covered by rocks which may be correlated with little doubt with the green series of the upper part of Whipsaw Creek, and assigned with probability to the Triassic age. As being a characteristic exhibition of these rocks, the section found on the south side of Nicola Lake, from which it is proposed to designate these rocks as the Nicola series, will be first noticed.

Section No. 4. Nicola Series.

These rocks are exposed between the mouth of McDonald's River, and the bridge across the Nicola at the outlet of the lake, a distance of seven and a-half miles. (see Section No. 4.) With the exception of the limestone, they appear to be entirely of volcanic origin, consisting of agglomerates, with beds made up of fine volcanic debris, and others which have originally been sheets of molten matter. All these have been indurated, perhaps in some cases re-crystallized by metamorphism, and have since suffered a greater or less amount of that alteration by decomposition of original constituent minerals, so common in the older volcanic rocks. Taken as a whole, the series is now distinctively felspathic, and in colour, green of various shades. Lithologically the rocks are of great interest and would require for their elucidation much more careful study than can now be accorded to them. The limestone bed, above alluded to, is seen on the west side of McDonald's River, and about half a mile south of the waggon road, where it forms a prominent bare cliff about sixty feet in height. It has been burnt here, and found to produce good lime. At first sight this bed appears to pass below the volcanic rocks with a low westward dip, but on more careful investigation it is found that it is separated

General character of the rocks.

from the mass of these rocks by a fault, which runs about S. 14° E, with the downthrow probably on the west side. The existence of this fault is so far unfortunate, as it to some extent obscures the relation of the limestone with the volcanic series, which is a matter of importance. I believe, however, that the very great probability,—almost amounting to certainty—of the limestone belonging to the volcanic series can be shown in several ways.

Associated limestone.

The limestone is very much broken and disturbed, but on the whole appears to dip westward at an angle of about 20°. The volcanic rocks on the west side of the fault seem, in so far as their attitude can be ascertained, to lie in a similar position. In its normal form, the limestone is grey, granular, but not very highly crystalline, evidently composed of organic fragments, among which joints of crinoidal stems are most abundant. A few obscure larger fossils are also occasionally present, including a *Terebratula*. In some places, however, it becomes filled with green granules, which project on weathering, and by examining various parts of the exposure these can be found at times to be much more abundant, so much so as to form a coherent mass after the whole of the calcite has been removed. In other layers the limestone is almost altogether replaced by this material, which is pale green in colour, and holds only scattered calcareous particles, among which crinoidal joints can at times be made out. On removing the limestone by an acid, the residuum appears to be felspathic, and fuses pretty readily on the edges before the blowpipe. It resembles the finer constituents of some of the volcanic agglomerates to the westward, and has without doubt been a volcanic ash or sand, mingled in varying proportions with the limestone toward the close of its deposit. The fossils in the limestone are believed to be of Triassic age, and are noticed on a later page.

Reasons for believing the limestone a part of the series.

Imbedded volcanic ash.

On the opposite side of the fault, the first rock seen is an amygdaloid, which though its cavities are in places charged with a siliceous mineral, is generally highly calcareous, and in some layers appears to be more than half composed of calcite. Though owing to the fault the precise relation of this rock to the limestone can not be made out, it would appear that calcareous matter was still very abundant at the time the amygdaloidal material was poured out over the bottom. Further down the lake, a zone of coarse agglomerate is found to be highly charged with fragments of limestone precisely resembling that of McDonald's River, and holding a similar proportion of crinoidal matter. As the other rock fragments in this agglomerate are of nearly contemporaneous, though underlying, volcanic materials, it is probable that the limestone included with them occurs in the same series and about the same zone.

Calcareous amygdaloid.

Agglomerate with limestone.

The blending of volcanic matter with the limestone, and of calcareous matter with the neighbouring volcanic rocks, taken also in conjunction with the analogy of this limestone and the volcanic rocks with those of other localities where their relation is more clearly seen, appears to leave little room for doubt that the limestone really forms a part of the series shown on Nicola Lake.

Amygdaloids & hornblende-porphyrite.

The amygdaloid mentioned as occurring on the west side of the fault, may then be supposed to lie somewhat higher in the section than the limestone. The base is a greyish-green or purplish hornblende-porphyrite, which on weathering becomes vesicular. In some layers part of the vesicles are rounded and have contained bubbles of gas, while others are angular and have the form of prismatic crystals with pyramidal terminations. The hornblende-porphyrite is also found compact, and at times with green hornblende crystals of considerable size. These are always decomposed more or less comptetely, and are much softer than normal hornblende. Rocks of this character are seen in occasional exposures for about 5,400 feet at right angles to the presumed direction of the strike, but were observed to be amygdaloidal only in the immediate vicinity of the limestone. They were not again seen in the section on Nicola Lake.

Altered diorites and felsites.

For about 13,500 feet westward, across the beds, the exposures are few, and the attitude of the rocks was not ascertained; it is probable, however, that they either lie in a low, wide synclinal, or form a series of minor folds. The rocks, so far as their character can be ascertained, show little variety. They include a great mass of altered diorite, of a kind very characteristic of rocks of this old volcanic series. It is generally green in colour, and composed of a pale-green granular felspathic base, in which dark-green hornblende crystals are scattered. The hornblende is decayed and soft, and the general colour of the rock is, no doubt, due to the minerals produced by its decomposition. With these, occurs a compact, fine-grained bluish or greenish-grey rock, which is probably a felsite.

Anticlinals.

Beyond this, a further distance of 8,000 feet across the strike is occupied by rocks which are represented on the section as forming two compressed anticlinals with an intervening synclinal, and not improbably hold this form. The two anticlinals, while showing felsitic and altered diorite rocks like those above described, are characterized by thick beds of glossy, green, impure chloritic schist, the surfaces of which are often undulated, and occasionally sharply corrugated. Some of the more massive rocks in the eastern anticlinal, are largely epidotic, and hold occasional small veins with quartz and a little specular iron. The rocks of the intervening synclinal appear, with the exception of one or two beds of compact felsite, to be altogether agglomerates, or volcanic breccias. Those are seen in numerous exposures, and, with the exception of the limestone fragments alluded to, are entirely composed of greenish felsite, altered diorite, and other rocks similar to those above described.

On the west side of the schistose beds of the western anticlinal axis, the agglomerates reappear, and occupy a breadth of 3,300 feet at high dips. West of these, for 6,670 feet, to the end of the section, the exposures are few and poor. The rocks seen are, however, chiefly greenish and bluish-grey felsites of close grain. Their attitude is uncertain, but the last exposure is a compact, fine-grained, whitish-grey quartzose felsite, or quartzite, not observed in any other part of the section, which, as it dips eastward, may not improbably occupy another synclinal, and hold a position above all the other rocks.

Arrangement of strata.

The arrangement of the beds, as shown on the section, can only be considered as that most probably correct. In some places, the exposures are poor for considerable distances, and massive beds occupy such great breadths that it is almost impossible to arrive at certainty as to the flexures of the strata. Most of the dips are westward at an angle of about 50°, or less. Adopting the probable flexures shown on the section, the thickness is found to be about 8,000 or 9,000 feet, which, subject to future correction, may be supposed to be composed of the following main divisions, from above downward:—

Supposed thickness.

	Feet.
1. Whitish quartzose felsites, near Nicola Bridge; highest rock seen (?)	——
2. Massive altered diorites, and greenish aud bluish-grey felsites	3,000
3. Green agglomerates, beds at the base holding limestone fragments	800
4. Green agglomerates, with some fine-grained felsites interstratified	1,760
5. Chiefly impure green chloritic schists	530
6. Purplish hornblende-porphyrites, decomposed; probably underlying No. 5	2,600
2. Limestone, with greenish volcanic ash; probably underlying No. 6	80 or more.

Local irregularity.

The agglomerate shows a pretty well marked tendency to thicken westward, which may account for the fact that it seems to be present in very small thickness near the east end of the section, where according to the attitude adopted it should reappear. The schistose band is also lost sight of at the eastern end of the section, which may however arise from its concealment, where the exposures are only partial, from its having been thrown out of sight by some unrecognized fault, or from its actual thinning out in that direction. Beds like these, of volcanic origin, are especially liable to great alteration in character within short distances, which adds to the uncertainty necessarily attaching to sections not absolutely continuous.

Strike of limestone.

The strike of the limestone at the east end of the above section, probably nearly coincides with the course, southward, of the valley of McDonald's River, and may also have some connexion with the northern reach of Nicola Lake. The rocks underlying the limestone are concealed, but in following the road north-eastward the first exposure, after leaving the flat land of the delta of McDonald's River, is of a greyish hornblendic granite, evidently intrusive, and which seems to cross the lake with a bearing of N. 10° W. The rock is composed of clear quartz, with a white plagioclose felspar, black mica, dark bottle-green hornblende, and many small crystals of honey-yellow sphene. The width of the granitic mass is not great, and between it and the mouth of the Nicola River, rocks of the green series again appear. On the south side of the Nicola river, greenish altered diorites, like those formerly described, occur, holding epidotic veinlets in which traces of copper were noted; and in following it up they continue, with little alteration in appearance, to the vicinity of Douglas Lake. No trace of bedding was noted in the exposures, and from the great horizontal extension of similar rocks it would appear probable, either that they are here little disturbed, or that while forming a number of small folds, the same strata continue to appear on the surface.

Granite.

Rocks of Upper Nicola Bridge and northward.

At the bridge over the Nicola, near its junction with the lake, the rock is a very hard, dark greyish-green material, probably a diorite, less altered, and in consequence not so green as many of those formerly observed. Northward, similar rocks are found, the green altered diorites still preponderating, but mingled with felsite-like rocks, and nearly abreast of the lower end of Stump Lake, on the trail, with a fine grey rock, evidently fragmental in origin, and though apparently chiefly felspathic in composition, perhaps most appropriately classed as a felspathic quartzite. At the outlet of Stump Lake, the rock is a compact greyish diorite, like that mentioned as occurring at the Nicola River Bridge, but somewhat coarser.

Decomposed granite.

North of the belt of Tertiary igneous rocks which crosses the valley above Stump Lake, a coarse hornblendic granite appears. In this, quartz occurs in very small quantity, while large white twinned felspar crystals, with black hornblende and a little mica, make up the mass of the rock. Near the edge of the Tertiary, the granite is rotten and decomposed to a considerable depth, the felspar being kaolinized, while the hornblende crystals are represented by chlorite, or green earth. North of the granite, near Shumway's Lake, the valley is chacterized by a belt of argillaceous and schistose rocks, which are, however, but a part of the great volcanic series, with the more typical rocks of which they show a complete interlocking in lithological characters and stratigraphical position. Their thickness is about 500 feet. They dip westward at angles of 40° to 70°, and are overlain at the south end of the lake by massive greenish-grey rocks resembling those of the Nicola Bridge, which are, however, often distinctly brecciated. At the north end of the lake, on the east side, similar massive rocks of igneous origin are seen to underlie them. The argillites are, in some places, blackish, highly calcareous, and though hard, not crystalline. Some beds become minutely wrinkled or reticulated and glisten dimly, owing to the presence of microscopic mica crystals. Others are greyish and have become well characterized, though fine-grained, mica-schists, while yet other layers are black, compact and lustrous from minute acicular crystals, ring under the hammer and break with a sub-conchoidal fracture. Worm burrows, filled with a material coarser than the surrounding rock, were found in one specimen of the last described material. These are about one-fifth of an inch in diameter, and one of them expands into a broad flattened form at its extremity. Altered argillites.

On the plateau between Stump Lake and Chaperon and Douglas Lakes, rocks similar to those described in the Nicola Valley continue to occur. Soon after leaving the lower end of Stump Lake, green, silky schists are met with, and are followed—though whether in ascending or descending order it is impossible to tell—by a belt of grey, slaty argillite, this is succeeded by a grey-blue compact felspathic rock, and this again by green altered diorite of the usual character, which here, as elsewhere in this region, is the prevalent rock. About half-way from Stump to Chaperon Lakes, near one of the innumerable little pools which occur everywhere on the plateau, a more important band of hard altered argillite, some layers of which are glossy, as at Shumway's, crosses the trail. This is nearly vertical, and, unless forming a tight-pressed fold, must have a thickness of considerably over 1,000 feet. It is followed, westward, by a grey-spotted felsite. The general strike of the rocks appears in this region to be about N. 40° E. Similar rocks found eastward

Behind the town of Kamloops, rocks underlying the Tertiary igneous products which compose the high hills to the south-west, appear in numerous exposures, projecting from the hill-sides, or cut into by the gullies which seam their flanks. These rocks closely resemble those of some parts of the North Thompson, described on a succeeding page, and are probably like them Carboniferous or at least Palæozoic in age. They are for the most part felspathic or dioritic, but hold some pale- Rocks behind Kamloops.

greenish schistose beds. The rocks of Mount St. Paul, on the opposite side of the river, are similar, but at the summit of the mountain blackish silicious beds occur, with some fine brecciated layers, composed apparently of the same material in a comminuted state.

Rocks of the South Thompson.

Between Kamloops and Little Shuswap Lake, on both sides of the South Thompson, rocks belonging to the Nicola series, with older rocks referable to the Cache Creek group, occur.

Extensive limestone exposures.

The most interesting feature of the rock series on the South Thompson, is the large outcrop of limestone found on the north bank, about ten miles above the town of Kamloops. The limestone is easily distinguished from the other side of the river by its pale colour. The mountain side is composed of it from the first exposures above the alluvial bench to the summit. The width covered by the exposures is nearly a mile. The rock is grey, more or less coarsely crystalline, and holds obscure fossils. It has evidently been much disturbed—one is almost tempted to say kneaded together—in many places. Some parts of it are full of little veins and seams of dolomite, while other portions—apparently certain zones following the bedding—have been shattered throughout, and the fragments recemented. There are also in some places siliceous or cherty layers, a few inches in thickness, which have originally conformed to the bedding, but have been so thoroughly broken up, that they now appear in angular fragments irregularly scattered through the limestone, and standing boldly out on weathered surfaces.

Chert.

Microscopic analysis.

Under the microscope, the limestone is found to be a coarsely granular aggregate of fragments of calcareous organisms, about half of which are crinoidal, and have a pale-brown colour, which distinguishes them from the rest of the mass. Their minute structure is well preserved. The remaining moiety of the rock is principally composed of fragments of small corals. *Fusulinæ* are also abundant, well preserved and characteristic, and differ from the crinoids and corals in the milky opacity of their shells. Several brachiopods in poor preservation were also found, among which is a *Rhynchonella* and a shell which may be *Hemipronites crinistria*.

Unconformably overlying series

The rocks immediately overlying the limestone to the east, are well-bedded calcareous sandstones and fine conglomerates, with water-rounded fragments. They rest unconformably on the limestone, and dip S. 88° E. $<$ 50° at the line of junction, but flatten out rapidly to an angle of about 30° eastward. The conglomerates and sandstones, though highly calcareous, are usually sufficiently compact to cohere when all the calcareous matter has been removed by an acid. The fragments are for the most part siliceous, and pale in tint. Many seem to be almost pure white quartz, while others are derived from the cherty layers in the limestone. There are also, in some places, aggregations of pale-green particles resembling those found in the limestone at Nicola Lake, and, like these, probably felspathic. The breccia has intercalated beds of hard, purplish, felspathic material, and passes upwards into felspathic and dioritic rocks. Among which are some beds of breccia, composed of fragments of volcanic origin, like the neighbouring rocks, and showing occasionally some traces of water-rounding.

Among the rocks collected in continuation of the series overlying the limestones, on the north and west bank of the river, from the limestone outcrop toward the Little Shuswap Lake, are—greyish-green porphyrites, in some cases fine-grained and tending toward felsites; diorites more or less decomposed, but not so decidedly green as in some other places, and wide exposures of a dull-purple, fine-grained porphyrite, with large crystals of hornblende scattered through its mass. This last resembles closely the hornblende-porphyrites seen near the limestone on Nicola Lake. Rocks of Nicola series.

Two miles southward from little Shuswap Lake, on the east side of the river, regularly bedded, greyish, and rather coarse-grained micaceous quartzites with gneiss, appear. These belong to the gneissic series of the Shuswap region, and their relation to those above described is not clear. Gneissic rocks.

Twenty-five miles above Kamloops, a mass of structureless granite, probably intrusive, projects into the river on the east side, and forms also a steep hill overlooking it. The rock is grey, and rather fine-grained, with hornblende, which is in part decomposed, preponderating over mica. It is not everywhere shattered by jointage planes, and might, I believe, be quarried in blocks of fair size for masonry. Granite suitable for masonry.

Westward from the limestone exposure first mentioned, an anticlinal appears to occur, bringing up blackish fine-grained silicious argillites or quartzites, with some beds which would seem to imply an origin from volcanic materials. In about a mile, the last outcrop of the limestone appears, the bed here having a thickness of nearly 100 feet. From this place to Kamloops the rocks may lie in several low flexures, ending at the east bank of the North Thompson in a synclinal, which includes the rocks of Mount St. Paul.

The limestones of the South Thompson, though they resemble lithologically that of the Nicola Lake section, lie unconformably below the representatives of the great volcanic series, with which it is closely interlocked. The occurrence of *Fusulinæ* shows the Carboniferous age of the former, while the latter, as we have seen, is probably Triassic. The calcareous sandstone, forming the base of the igneous Horizon of the Nicola limestone.

accumulations on the South Thompson, probably represents the horizon of the limestone of Nicola.

Rocks on the lower part of the North Thompson.

On the lower part of the North Thompson, beds representing the underlying series seen on the South Thompson, are found. They are pretty well exposed in the banks on the east side, and might repay the labour of making a careful measured section. The river crosses the strike obliquely, the former maintaining an average direction of N. 10° W by S. 10° E. with considerable regularity. For some miles from the mouth of the river, the rocks, seen in a few places only, are massive fine-grained, grey-green, probably felspathic and of volcanic origin. These are associated with blackish cherty rocks, and dark, banded, hard shales, often more or less calcareous, all dipping at high angles. If no unseen complications of a serious character affect the beds, the thickness represented here must be over 10,000 feet. Mount St. Paul, already noticed, lies on the strike of these beds. Overlying them, opposite Station No. 4,269, (C.P.R.S. Location Line 1877) a bed of limestone sixty to eighty feet in thickness appears in the hill-side. Though not so thick, this rock precisely resembles in general appearance and degree of crystallization, that seen on the South Thompson, and like it holds abundant crinoidal fragments, though not so well preserved as in the first described locality. Good lime might be manufactured from this limestone, but like most of the rocks in this region it is too much fractured to be of use as a building stone. Overlying the limestone is a great mass of grey-green compact rock, probably felspathic, but seen in a few places only. In about two miles by the trail, the limestone again appears, with a reversed dip to the south-eastward, and forming the opposite side of a synclinal trough. It is here seen to be immediately overlain by a fine breccia or conglomerate, and is underlain by a massive grey-green rock, which is followed in descending order by a great thickness of blackish and dark-coloured thin cherty quartzites and argillaceous beds. Some of the quartzites are precisely like those supposed to characterize the typical Cache Creek group, and an argillaceous layer charged with anthracitic carbon, like those found in rocks of the Cache Creek group on the Blackwater and elsewhere, was also observed.

Limestone.

Slaty limestone

Further on, about a mile and a-half above Sullivan's, the dip is again reversed, and in the return of the beds just described a slaty blackish limestone was observed, which had not been seen before. Its thickness was not ascertained, and no fossils were found in it; but it closely resembles the shaly micaceous limestones of Shushwap Lake, though not quite so much altered. The higher mountains to the east are now formed of granite, probably intrusive, but nearly following the strike of the beds. This may not improbably be connected with the mass observed on the South Thompson, but is of a darker pinkish-brown colour. The granite forms the hills on the east side of the valley, for about two miles by the trail, when a greenish speckled felspathic rock, which may perhaps be called a porphyrite, replaces it. Some layers are, however, distinctly fragmental, while others ar ealmost silky in lustre and thinly bedded. Further up, the river valley turns north-eastward and narrows, crossing several folds, with some rocks like that last described, but chiefly blackish micaceous argillites, becoming in some places true mica-schists, with well developed mica laminæ scattered over the divisional surfaces. These dip at high angles.

Felsite and diabase.

Immediately north of Louis Creek, a grey schistose felsite, or felsitic argillite was examined. A mile below the Barrière River a green-grey diorite, with rather pale-colored hornblende crystals, occurs. From the Barrière River to the Indian Reserve, grey and greenish-grey felspathic rocks, generally of fine grain, continue. A compact dark-grey material, abundantly represented in the mountains above the little area of Tertiary rocks holding the coal, on the Reserve, has been sliced and examined microscopically. It looked not unlike a fine argillaceous quartzite, or felsite, but proved to be a fine-grained diabase.

General arrangement of the rocks.

Taken in conjunction with the sections examined on the South Thompson and elsewhere, the exposures on the North Thompson would appear to indicate, that we have, composing this formation, a considerable thickness of cherty quartzites, argillites with occasional layers of anthracitic shale, felspathic, micaceous and chloritic schists, with felsites, and blackish shaly or slaty limestone bands—some of the rocks being evidently volcanic in origin. These hold, probably near the summit, one or more beds of pale and purer limestone, containing, among other fossils, *Fusulinæ*. The strata thus broadly characterized closely resemble those of the Bonaparte River, elsewhere described, but want the true serpentines there forming a part of the series, and have not such thick beds of limestone.

Rocks near Savona's Ferry.

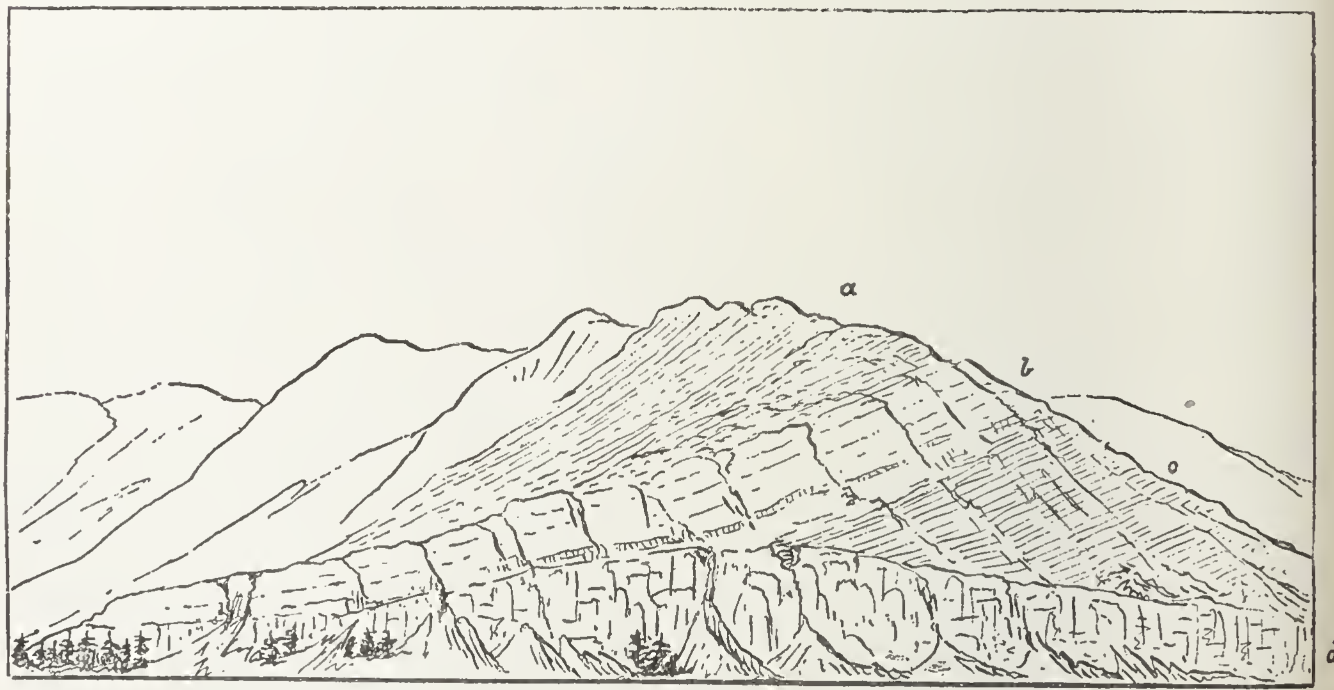
On Kamloops Lake, and the Thompson River below Savona's Ferry, old rocks underlie the Tertiary volcanic products. They are chiefly of volcanic origin, like those of the South Thompson, and, as they appear only in small exposures, it is often difficult to recognize them. The outlines of the areas occupied by Tertiary and older rocks are indicated as far as possible on the map.

Rocks below Vermilion Forks on the Similkameen.

The older rocks of the upper part of Whipsaw Creek, one of the western branches of the Similkameen, have already been described at some length. Those occurring after an interval of concealment by Tertiary strata, on the lower part of the Similkameen, from Vermilion Forks eastward, do not require detailed notice, as though carefully examined, the nature of the exposures is not such as to afford certain data for arriving at their thickness or order of succession. They appear on the north bank of the river, about two and a-half miles below the Forks, as a compact grey-green material, probably a somewhat altered diorite, and continue for about half a mile only, when a rock of granitic appearance, composed of salmon-red felspar with dark chloritic blotches, which is seen at first forming narrow dykes, becomes preponderant, and a little further on is again found in dykes, but now cutting a pale, coarse hornblendic granite. This last shows no sign whatever of being a bedded mass. It holds two varieties of felspar, black hornblende and mica, milky quartz, and occasional crystals of sphene. Other specimens consist almost entirely of a single variety of plagioclose felspar, with abundant and well-formed hornblende crystals and many crystals of sphene. Hornblendic granites of this type characterize the valley for over twelve miles, and are traversed by jointage planes in two or three directions, which cause the rock to break off and fall in large masses into the valley. It is also cut by other planes, which must have been cracks of an earlier date, now completely closed. Along these, hydrothermal or other similar action seems to have penetrated, the hornblende disappearing in their neighbourhood, and the rock taking a pale-green tint probably from the development of epidote.

Hornblendic Granite.

Jointage planes



STRIPED MOUNTAIN.—SIMILKAMEEN RIVER.

a. Siliceous and argillaceous beds. *c.* Siliceous and argillaceous beds.
b. Limestone. *d.* Granite.

Twenty-mile Creek.

The granite is succeeded eastward by greenish-grey and black quartzites, often almost cherty in texture, and all highly metamorphosed. These continue for about two and a-half miles, to a large brook. They are at first nearly vertical, but gradually turn over, till near the west bank of the brook, they lie at comparatively low angles.

They are everywhere much disturbed and altered, and the cause of this becomes apparent in the mountain on the east side of the brook, in which they are seen to rest on a great mass of granite like that already described. This has evidently been thrust up into the overlying beds, melting its way before it, as the strata in a great part of the mountain are not spread over it, but abut with their ends against it. The granite rises in the mountain side, about 200 feet above the flat at its base. Its junction with the overlying rocks may in some places be defined to within half an inch, and near this line it becomes paler and less coarsely crystalline, appearing in some places as a granular mass of felspar and quartz. There is, at the same time, no passage between the granite and the overlying rocks.

Contact of granite and bedded rocks.

The whole exposure is a very interesting example of intense local metamorphism. The change has been widespread horizontally, and has affected several hundred feet, at least, vertically. In the mountain on the west side of the creek, some of the siliceous and argillaceous beds have become black, compact and almost cherty, while others are whitened and perfectly porcelainized. This bleaching seems to have affected certain layers with comparative ease, and may be seen in others spreading irregularly in blotches. Some earthy arenaceous and calcareous layers are apparently little changed. On the east side of the brook, the slaty and argillaceous beds have been altered as before, but there is here, in addition, a belt chiefly composed of limestone, with a thickness of about 150 feet. Some siliceous beds intercalated in this are red from the rusting of pyrites in the joints. The limestone is blue-grey to nearly white, granular to coarsely crystalline; in some places crumbling easily. It may not improbably have been actually slacked by the heat applied from below. No organic remains were detected. In this mountain the succession and thickness of the altered beds, in descending order, is somewhat as follows:—

Local metamorphism by granite.

Section in Striped Mountain.

		FEET
1.	Grey and red, siliceous and argillaceous beds	300
2.	Limestone, with some siliceous layers	150
3.	Grey and red, banded, siliceous and argillaceous beds	600
		1,050

The rocks probably represent a portion of the Cache Creek group of the preliminary classification. The mountains on both sides of the brook are distinctly and beautifully banded by the outcropping edges of the beds. That on the east side, of which a sketch is given, may be called Striped Mountain. Half a mile below the locality above described, the massive granite again rises to the summits of the hills, cutting out the stratified formation. It continues for about two and a half miles, and is then followed by sedimentary rocks, again much altered near the line of junction. These continue to form the mountains to the mouth of the Ashtnoulou River. They seldom show satisfactory indication of their attitude, but seem to change gradually from altered rocks like those of the striped mountain, to blackish and greenish beds, some probably in origin volcanic, but in the main quartzites, cherty, like those of the Cache Creek formation, and occasionally brecciated. The great spread of these, with their uniform character, would show either that they are many times repeated by folding, or that they are in general nearly horizontal.

Rocks near the Ashtnoulou.

A short distance above the Ashtnoulou River, fragments of limestone appear in some of the slides from the mountains. They hold obscure fossils, some of which are minute branching tabulate corals, and lithologically precisely resemble those elsewhere known in association with quartzites similar to those of this locality, and proved to be of Carboniferous date by their fossils.

Ashtnoulou to Keremeoos.

From the mouth of the Ashtnoulou to Keremeoos Brook, rocks evidently belonging to the same great series continue to appear, with general northerly and southerly strikes, and dips varying in direction and degree, in the few places where they were observed in the vicinity of the trail. The cherty quartzites, though still not in frequently black, are often pale in tint, greenish-white or reddish. They are associated with green felspathic rocks, apparently in some cases more or less epidotic, but generally owing their tint to the decomposition-products of hornblende crystals which have been scattered through the mass. In some places, these beds become more or less schistose and distinctly chloritic. Three miles above Keremeoos, a reddish bed, over 200 feet thick, was seen far up on the mountain-side. Blocks which had rolled down from it, proved on examination to consist of breccia, of which the greenish base, with some calcite and chlorite, holds fragments of schistose red hæmatite. The rocks of the mountains, are everywhere traversed in all directions by innumerable jointage planes. Exposed faces are thus easily crumbled down under the influence of the weather, and contribute annually to the great slopes of broken rock, or *screes*, by which the valley is here fringed.

Cherty quartzites.

Schistose hæmatite.

About eight miles below Keremeoos, on the north-east side of the river, a mass of grey hornblendic granite appears, underlying broken and much altered and disturbed greyish diorites, and quartzites. It resembles in lithological character that seen higher up the valley, and is evidently intrusive, forming the continuation of a mass much more prominently displayed in the hill on the opposite side of the river. With this exception, rocks not unlike those already described continue to occupy the valley for about thirteen miles, when—and again with evidence of intense local metamorphism to the stratified rocks—a great structureless granitic mass appears. It is highly probable that similar granitic rocks underlie the whole of this region at no great depth, which would account for the appearance of great change by metamorphism which the beds have undergone.

The wide valley entering the broad flat below Price's at Keremeoos, marks the appearance of schistose and often silvery rocks, in colour varying from blackish and greyish to greenish. These are frequently quartzites, with division planes rendered lustrous by talc on imperfectly crystallized mica. They bear a pretty close resemblance to the rocks on the lower part of the Coquihalla, and also to those of some parts of the Cariboo gold series. Many quartz veins, white or rusty, penetrate the strata, but were not observed to hold anything of value. Further on, these are replaced by greener rocks, often felspathic and occasionally schistose, which become in places actual coarse green decomposed diorite, with veins of epidote, and so massive that it is impossible to ascertain their attitude. These rocks are again followed by pale banded cherty quartzite, interbedded with greenish schistose rocks, hornblendic or chloritic, which lie against the great mass of intrusive granite above referred to. From this point, (near which the trail leaves the Similkameen Valley,) and on the hills crossed on the way to Osoyoos, coarse grey diorite, and hornblendic granite, without any trace of bedding or lamination, continues. In a few places, quartzites and rocks like those before seen, are found resting on it, and after the descent is made into the Osoyoos Valley, bedded quartzose and felspathic rocks are seen in a few exposures, but very much altered.

Lower part of Similkameen Valley.

The general impression conveyed by an examination of the rocks from Vermilion Forks, by the Similkameen River, to Osoyoos, is, that with the possible exception of some of the more massive felspathic and hornblendic rocks, (which may represent a portion of the green series of Nicola and Whipsaw Creek,) there is represented but a single great formation; or, that if two or more of the greater geological divisions are included, they have been folded together at one period. There seems to be further, in several places, a blending of materials originally volcanic, with quartzose sediments, which here greatly preponderate. Limestones seem to hold an unimportant place in the series. These rocks, as a whole, may be taken as representing the Cache Creek group, and referred by analogy to the same age.

The rocks of Cache Creek age.

The rocks on the west side of the Osoyoos Valley, southward from the Custom-house, are pale diorites, or dioritic granites, and form a part of the great mass already described. Northward from Osoyoos Lake, the rocks seen are chiefly quartzites, sometimes cherty, but also often schistose, and even micaceous. Greenish, fine-grained rocks,

Rocks at Osoyoos Lake.

probably felspathic, also occur, and at about eight miles from the lake, a short distance from the place at which the trail leaves the main valley, a bed of coarsely crystalline and rather crumbling limestone, about fifteen feet thick, was found, but yielded no fossils. The general strike of these rocks is nearly parallel to the valley, and they doubtless belong to the series seen on the Similkameen. They are much altered, and granite intrusions occur among them. Northward, they disappear beneath an area of Tertiary.

Section No. 5. In the general section from Lillooet to the Bonaparte River, by Marble Cañon, and the lower part of the valley of Hat Creek (see Section No. 5), it will be seen that almost the entire length of Marble Cañon, is occupied by beds referred to the Cache Creek group. These also doubtless underlie the Tertiary of the lower part of Hat Creek, and reappear over a considerable area near the conflux of that stream with the Bonaparte. In the limestones of Marble Cañon, occurs the remarkable foraminifer originally discovered here by Mr. James Richardson, which I have called *Loftusia Columbiana*, and which has been fully described elsewhere.*

Loftusia Columbiana.

West end of Marble Canon. Near the waggon road, at the west end of the cañon, the rocks of this older series are first clearly seen. They are generally greenish or greenish-grey in colour, and apparently include some diorites and epidotic rocks, but are chiefly of compact grey-green material, which is apparently felspathic, but may, in some beds, be much altered claystone. It quite resembles rocks elsewhere commonly found in the Cache Creek series. Quartzites of the usual grey, cherty character also form a considerable part of the series. These rocks are soon succeeded by granite, which forms mural cliffs, and is intrusive, holding angular, darker fragments of surrounding rocks. This extends for about one-third of the length of the first lake, in the cañon, and is then followed—though the junction was not seen—by hard argillites, cherty in some layers and often schistose, and more or less evidently lustrous. These dip N. 75° E. at angles of 70° to 80°, and are followed, apparently in ascending order, by a great mass of limestone, which continues in almost uninterrupted exposures in the sides of the cañon from this place to its eastern end, at the head of Hat

* Quarterly Journal of the Geological Society. Vol. XXXV., p. 69. The formal description of the species is as follows:—"*Loftusia Columbiana*, sp. nov.—Test oval; circular in transverse section; the ends rounded or very obtusely spindle-shaped; chambers many, narrow; septa very oblique, more nearly parallel to the sides of a cylinder than than is the primary lamina; primary lamina and septa, or 'secondary' ingrowths, supported by pillars or 'tertiary' ingrowths; pillars numerous, arranged in parallel lines transversely and longitudinally, expanding laterally at their distal extremities to form imperfect chambers, which are filled with a loose, granular, cancellated growth. Exterior of test frequently becoming irregular and acervuline. Length of test about thirty hundredths of an inch, width of test about nineteen hundredths of an inch; intervals between successive folds of the adult primary lamina about one hundredth of an inch."

Creek,—a distance of about seven miles by the trail, or five, at right angles to the strike of the beds.

Limestones of Marble Canon.

Throughout this distance the limestones occur almost to the exclusion of other rocks, though in a few places holding slaty or schistose intercalations of small width. In one of these, a blackish schist with lustrous faces due to a chloritic or talcose mineral, a lenticular mass of amygdaloid was observed. The base is fine-grained, and very dark in colour. The cavities have been filled with calcite, which now forms little lenticular masses, all flattened parallel to the direction of lamination in the schist. This is important, as it shows that volcanic action was still in progress to some extent during the formation of these thick limestones.

Contained fossils.

The massive limestones or marbles, though everywhere shown on a great scale, seldom allow the dip to be determined, rendering it impossible to ascertain their true thickness, or to demonstrate their exact relation to the siliceous and felspathic beds first met with, which, on lithological grounds, would be referred to the Cache Creek group of the provisional classification. No forms more characteristic than the joints of crinoidal columns were, for some time, found in association with the *Loftusia*, but by careful search in microscopic sections, prepared by Mr. T. C. Weston, characteristic specimens of *Fusulinæ* were discovered, thus bringing these into relation with the fusuline limestones found elsewhere in the Province, and very widely over the western part of the American continent.

Mode of occurrence of *Loftusia*.

"In certain beds of the limestones of Marble Cañon the *Loftusia* occurs almost to the exclusion of other forms, characterizing the rock, and having been the agents in its production just as *Fusulinæ* occur in the best examples of *Fusulina* limestone, or *Globigerinæ* in the Atlantic ooze. Other beds, of a nearly white colour, and almost porcelainous aspect on fracture,—though purely calcareous—are found, on microscopic examination, to consist of the comminated remains of smaller foraminifera, resembling a thoroughly hardened chalk. Through these a few more or less perfect *Loftusiæ* may be scattered. *Fusulinæ* appear to be very scarce in the Marble Cañon limestones. They are much more abundant in limestones in other parts of the country, composed principally of crinoidal fragments. They seem to have preferred a bottom composed of the debris of the larger calcareous organisms to the fine, oozy bed most congenial to the *Loftusia*.

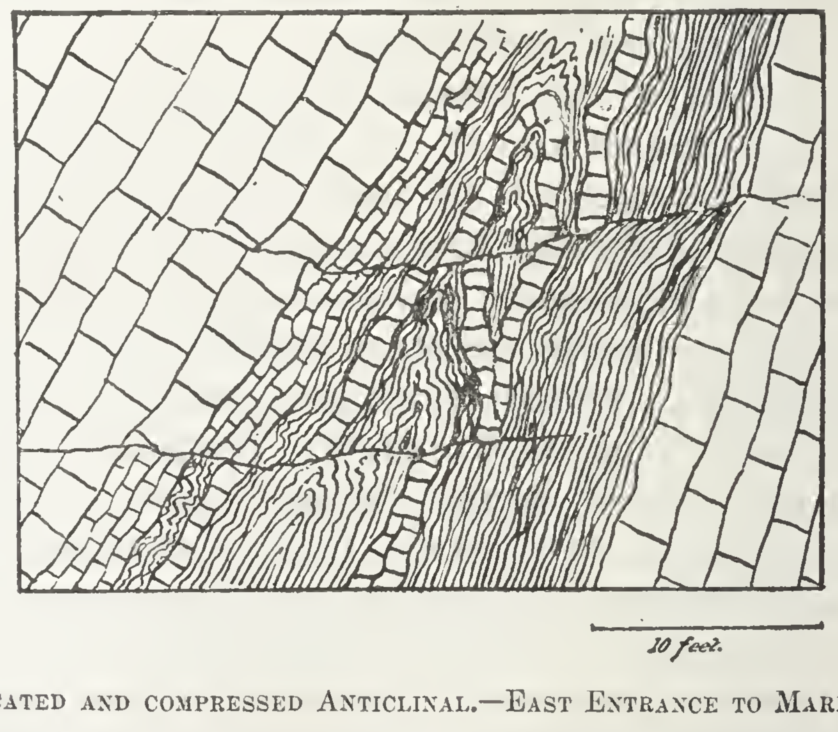
"The typical and most abundant form of *Loftusia*-limestone is a pale or dark-grey cryptocrystalline rock, in which the more perfect specimens of *Loftusia* appear thickly crowded together, as paler spots, generally pretty sharply defined. The limestone breaks freely in any direction, the fracture passing equally through the matrix and included organisms which it is impossible to separate from the stone. The matrix, generally, seems to be composed in great part of granular calcareous matter similar to that employed in building up the test of the *Loftusia*, but more irregular in size of grain, and with an occasional fragment of a crinoid, or example of some smaller foraminifer."*

Evidence of great lateral pressure.

A key to the true character of the limestone exposures of the cañon, and an explanation of their great extent, was found in the rocky hill on the north side of the eastern entrance, where the presence of various interstratified beds different in character, enable the structure to be made out. It is here evident, that the limestone and associated rocks have not only been very sharply folded, but that, in this instance at least, the folds have subsequently been overturned. It is thus probable, that in the wide limestone belt cut across by the cañon, we have merely a succession of folds or wrinkles, superimposed on a synclinal or anticlinal of much greater extent, by which the limestone strata have been brought to the surface.

Compressed and overturned folds.

The section examined here, shows a compressed and overturned anticlinal, which has even been subsequently faulted, and portions of the rocks shifted relatively to each other along nearly horizontal planes by the same pressure which has caused the overthrow. The diagram represents the central fold of the anticlinal.



DISLOCATED AND COMPRESSED ANTICLINAL.—EAST ENTRANCE TO MARBLE CANON.

The part of the formation here represented, appears to have been near the edge of the area of limestone deposit, or perhaps represents a period when the deposit of purely calcareous matter was coming to a close, or just beginning. Incursions of water turbid

* Quarterly Journal Geological Society, *loc cit.*

with very fine sediments, must have occurred, and by the deposition of these the pale-red, grey or greenish-grey schistose rocks, and cherty quartzites were produced. One bed of black, very finely laminated, scarcely lustrous schist, is evidently carbonaceous, and holds small crystals of selenite in cracks which traverse it. An additional evidence of the somewhat littoral character of the deposit, is found in the fact that the repetitions of the same bed in the two sides of the fold, do not correspond very closely, showing that the deposit was here rather irregular and local in character.

Slaty beds included in the limestones.

The subjoined section, gives the thickness of the beds, as measured first on the eastern, and then on the western side of the anticlinal axis, the position of which is marked by the letter *a*. The beds marked *c*, *c*, *d*, *d*, and *e*, *e*, correspond. The whole series now dips westward at angles of 60° to 80°.

Section across an anticlinal.

			FEET	IN.
1.	*e.*	Greyish, and greenish, cherty quartzite, with shaly layers of very fine argillaceous material of same colours. Layers undulating, and averaging about one inch in thickness	27	0
2.	*d.*	Fine-grained, white, crystalline limestone, much fractured by jointage planes	18	8
3.	*c.*	Greyish, and black, carbonaceous, finely laminated shales, calcareous, and with thin layers of crystalline limestone, selenite in cracks	10	0
4.	*b.*	Fine-grained greyish crystalline limestone	32	4
5.	*a.*	Greenish, greyish and reddish cherty layers, with fine schists, and thin beds of crystalline limestone	16	2
6.	*b.*	Fine-grained greyish crystalline limestone	32	4
7.	*c.*	Green-grey, and reddish schists	2	0
8.	*d.*	Crystalline limestone	16	0
9.	*e.*	Greenish, and reddish, cherty quartzites, and schistose beds, with an irregular calcareous band	3	0
10.		Crystalline limestone	10	8
11.		Reddish, and greenish, cherty quartzites, and schistose rocks	10	8
12.		Grey-green schist, with crystalline limestone	2	8
13.		Red, and greenish, calcareous schists	5	4
14.		Crystalline limestone, with some schistose intercalations	10	8
15.		Fine-grained, greyish, crystalline limestone	53	4
16.		Reddish, thin-bedded calcareous shales or schists	16	0
17.		Greyish crystalline limestone, at least	106	0

In following down the north-west bank of Hat Creek, from the eastern end of Marble Cañon, similar limestones, but perhaps somewhat less altered than before, continue for about three miles, when the edge of the Tertiary, which has nearly followed the line of the stream,

Rocks on Hat Creek.

overlaps them. In this distance, at least one band, over 100 feet thick, of greyish-green fine-grained rock, probably felsite, is included. Still further on, about seven miles from the end of the cañon, on Hat Creek, a considerable mass of older rocks is found projecting through the Tertiary conglomerates and sandstones. This consists of green agglomerate, evidently of volcanic origin, and very compact, with a grey rock, of almost granitic aspect, but apparently without quartz, and perhaps best named a hornblende-porphyrite. This appears to be bedded and dips about east at an angle of 30°. The aspect of these rocks is peculiar, and though older than the Tertiary, their relations were not more definitely ascertained.

Quartzites and Serpentines.

For two miles above the bridge, which crosses Hat Creek near its junction with the Bonaparte, old rocks again occupy the valley. Though broken and confused, these are seen in very many exposures, and have an average strike of nearly north and south, but dip irregularly, eastward or westward. The section (No. 5), for some distance, nearly follows the strike, and does not therefore properly represent the nearly vertical attitude of the beds. Cherty, dark-coloured, quartzites, and quartzose argillites, which are often glossy-faced, largely preponderate. With them are associated some much shattered dioritic rocks, and on reaching the waggon road, the series is found to include a bed of undoubted serpentine, very pure, and varying in colour from dark blackish-green, to pale pistacheo-green.

General silicification of beds.

Here, as elsewhere, the Cache Creek cherty quartzites, are threaded through with quartz veins and seams, generally quite small. These have been produced, no doubt, by the same action as the general silicification of the beds, which would appear to have been caused by thermal waters. This action has so thoroughly permeated the beds, that it is not improbable that some of the fine cherty layers may, originally, have been argillites, into which exotic silica has been brought.

Relations of Cache Creek series.

The rocks along this part of the waggon road, have already been noticed, and included in the preliminary classification under the Lower Cache Creek group.* They were there separated from those of Marble Cañon, etc., which were called Upper Cache Creek. The progress of our knowledge of these rocks, however, renders it probable that the division established between these groups cannot be maintained. In addition to the general description of the formation given in the place just cited, a few remarks may be added, the result of an examination—though without accurate measurements—of the waggon road between Hat Creek and Clinton, and on the Bonaparte River. In the region thus designated, it would seem, that rocks not far from

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

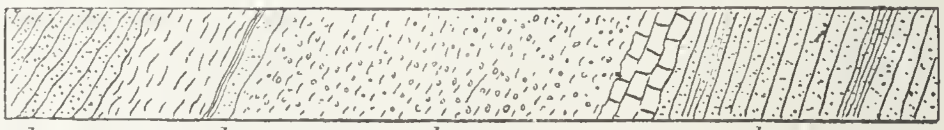
the same geological horizon are repeated by folding, so that one bed may appear again and again, even in localities widely separated.

The only fossils discovered in association with these rocks, at the time of the report above referred to, were two species of *Cyrtina*, a *Spirifera* and *Rhynchonella* which, according to Mr. Billings, were held to "indicate almost certainly a horizon between the base of the Devonian and summit of the Permian." These were from a locality about ten miles above Spence's Bridge. Whatever uncertainty might remain with regard to the region now in question, in which at that time no fossils were found, has been set at rest by the discovery of fusuline limestone on the Bonaparte, interbedded with the siliceous and serpentinous rocks. The occurrence of serpentine and other metamorphic rocks of ancient appearance in beds of Carboniferous age, is in itself a point of considerable interest. In the place above referred to, it is said that "the limestones holding these fossils are so intimately associated and interbedded with the serpentines and other crystalline rocks above described, as to leave no doubt that they all belong to the same series." This statement I have been able to confirm by the examination of many additional localities. The age of the formation.

Between Hat Creek and 124-mile post, (Mundorf's) numerous exposures in the road-side, show the intimate association and interbedding of the cherty siliceous rocks with serpentines, pure and impure, and of the latter with volcanic breccias of greenish-grey colour. Some of the fragments in the breccias, are from four to six inches in diameter, while in other beds the material is fine, and must originally have been of the character of volcanic sand. Schistose layers in the breccias have a greasy lustre, and appear to have more or less serpentine developed in them, while portions of the fragments which have been vesicular are now filled with soft green chloritic matter. An igneous rock similar to that forming the breccias, is found in other beds in a compact state, of dark grey-green colours. It has been altered since its eruption, and would require a more careful examination than I have been able to give it to determine its true lithological character. Lenticular masses and streaks of limestone occur, both in the breccias and serpentines. They do not resemble the limestones found elsewhere in the formation, being highly crystalline, and without any trace of organic origin. They may probably have been segregated in the mass. Association of serpentines, quartzites and agglomerates.

On the Bonaparte, between Mundorf's—where the waggon road leaves it—and that part of the river nearest Clinton, the same series of rocks continues. The serpentines may often be recognized at a distance by the bluish banks, bare of vegetation, which they produce on weathering. Here, the relation between the serpentine and other Sections on the Bonaparte.

rocks, was most clearly seen, and is represented as displayed in one place, in the annexed sketch section. There can be little doubt, that serpentines, in this group of rocks have been igneous materials of some sort, and perhaps owe their conversion to serpentine to the same hydrothermal or other action which has produced from siliceous sediments, the great mass of cherty quartzites.



a. Serpentine. *c.* Pale serpentinous schist.
b. Quartzite. *d.* Greenish amygdaloid and breccia.
e. Limestone.

SKETCH SECTION SHOWING THE MODE OF OCCURRENCE OF SERPENTINE IN THE CACHE CREEK SERIES.

Fusuline limestone, and serpentines.

The limestone band shown in the above section, was not observed to hold any characteristic fossils, but a short distance up the river a limestone in similar association and holding *Fusulinæ* was found. It is very similar in appearance to that already described from the South Thompson. Over two-thirds of its mass is composed of crinoidal fragments, and in one of the specimens, a minute tabulate coral was recognized. There are abundant, small, but poorly-preserved, foraminifera, many of which may belong to the genus *Trochammina*. *Fusulinæ* are characteristic, and well-preserved, but not abundant.

Rocks near Clinton.

Between Mundorf's and Clinton, on the waggon road, greenish volcanic rocks, generally brecciated, occur frequently for some miles, but near the chain of little lakes south of Clinton, are replaced by shaly, or schistose, blackish and greyish rocks, some of which are pretty evidently composed of fine felspathic fragments like volcanic ash, while others quite resemble the hard and glossy argillites of Boston Bar. In one place, a limestone over twenty feet in thickness was observed to be intercalated with these, resembling in its appearance, and association, that found on the waggon road not far above Boston Bar.

Strata on Clinton-Lillooet Road.

An examination of the rocks in the vicinity of the waggon road which connects Clinton with Lillooet, was made from the first named locality as far as Kelly's Lake, chiefly for the purpose of connecting with Mr. Richardson's observations of a previous year. Great beds of limestone are seen in the mountain-sides of the lower part of the valley, which the road follows, and in an exposure midway between the forty-fourth and forty-fifth mile-posts from Lillooet, in which a grey limestone with pale yellow-grey cherty layers dips S. 64° W. $<$ 60°, scattered specimens of *Loftusia Columbiana*, the Marble Cañon foraminifer, were detected, thus adding to lithological similarity the more certain evidence afforded by identity in fossils. The strike above given, appears to be the general one in this locality. About two miles below Kelly's Lake, on the northern side of the valley, a section about two and a-half miles in length was very carefully examined and measured by pacing. The rocks seem to be affected by innumerable minute folds, which are superimposed on larger flexures, and the whole not infrequently overturned, which complexity of structure, with the probable occurrence of faults which could not be defined, and the gaps of concealment in the section, have rendered it impossible to learn from the measurement, either the actual thickness of the series, or the order of succession in the beds. The dips are almost invariably at high angles, and generally westward, as in the exposures mentioned further down the valley. It is here, as in many other places, found that the main overturn of the crumpled strata has been to the east, and caused probably by pressure acting from the west.

Complicated section.

The beds in this section, are so much like those formerly described in other places, in their general character, that it will be unnecessary in the absence of certainty as to their attitude, to enter into a minute description of them. The series is built up of blackish, to pale greenish, and nearly white cherty quartzites; quartzose and felspathic schists with glossy faces, and occasionally minutely wrinkled; felsites, greenish and greyish-green, and grey to white crystalline limestones, in which no fossils were here detected. One bed—a compact dark-grey felsite, mottled and streaked with dull red—occurs near both ends of the section, which might in consequence be supposed to be in the main an anticlinal or synclinal, but the beds associated with this one differ in the two cases, which must either be caused by the presence of unrecognized faults, or the fact that it forms in one case a synclinal, in the other an anticlinal axis. The thickness of this bed appears to be 550 feet, and it is evidently of igneous origin, it is now serpentinous in joints and cracks, and is traversed by occasional small veins filled with crystalline calcite and chrysotile.

Composition of the series.

Massive felsite

On a new road, leaving the Clinton-Lillooet road at Kelly's Lake, and running westward toward the Fraser River, and then north-westward toward Canoe Creek, many exposures of limestone occur. The valley followed by the road appears to mark the run of an extensive band of slaty and schistose rocks like those described on the waggon road south of Clinton. Where the road turns north-westward, it follows a wide valley, the north-eastern side of which is formed by a range of magnificent mountains, very lightly clad with vegetation, and showing white limestone rocks from base to summit. Many of the peaks probably reach an elevation of 6,500 feet. These limestones are

Remarkable limestone range.

no doubt the continuation of the great mass of similar rocks before seen on Marble Cañon.

ROCKS OF THE SHUSWAP LAKES.

It has been decided to treat separately of the older rocks in the vicinity of the Shuswap Lakes, and Okanagan Lake, because of the difficulty which has been found in satisfactorily correlating these with those above described. The knowledge gained is here briefly summarized, and may serve as a guide in future explorations, which are urgently required in this district.

Difficulty in correlating these rocks with others.

The rocks seen on the Shuswap Lakes, are so much disturbed and altered, that though about two weeks were given to their examination, and the exposures on the lake shores are generally good, much uncertainty yet remains with regard to their relations among themselves. The chief difficulties found here arise from the extensive overturning of tightly compressed folds, accompanied by important dislocations, and the different appearance of the same bed when more or less affected by the alteration which has probably been contemporaneous with the folding of the strata. Certain zones can, however, be traced for considerable distances along their strike, and as the chief uncertainty is in regard to the character and number of the folds to which these have been subjected, it will be best in the first instance to define the zones as well as may be, as to their distribution and composition, and subsequently to indicate what is believed to be the most probable structural explanation of the horizontal section afforded by the surface of the country.

Calcareous belt, (B)

On both sides of Blind Bay, near the outlet of the Great Shuswap Lake, are limestones, generally in rather thin flaggy layers, and of grey or blackish colour, but toward the top, on the north-east side of the bay, becoming rather shaly and intercalated with greyish and greenish almost nacreous schists. The average angle of dip is here from 20° to 30°. It is higher in an exposure at the bottom of the bay, where the strike also changes, and it is probable that this band characterized by limestone, may occupy a portion at least of the valley of White Lake in the form of a compressed anticlinal, before sweeping southward to the Salmon Arm. Limestones of this band are next seen at Cliff Point on Salmon Arm, where they are still flaggy and generally distinctly micaceous. The dip is at an angle of 45°, and the beds continue to abut obliquely on the shore for a distance of over two miles. Eastward, the strike carries them inland, and running across Canoe Point, they come out on the west shore north of the mouth of Eagle Creek. At this part of their course they appear to make an abrupt bend, most of which is concealed below the lake, and then to pursue their course to the vicinity of the mouth of Eagle Creek, just skirting in their way the first point north of it on the east shore. This band then passes out of the area which has been examined. It is believed, however, that the Salmon Arm, from Cliff Point to Canoe Point, occupies the axis of an anticlinal fold, on the south side of which, the beds of the belt just described, must recur, forming the summits of the mountains on that side of the lake, and still further south-westward, Mount Ada. This anticlinal would also appear to inosculate laterally, with a second, but very irregular fold, of the same character, the centre of which is occupied by the Spallumsheen Arm. In this case the limestone band probably also forms the crests of the range on the west side of Spallumsheen Arm. It crosses the valley near the mouth of the river, where it is well exposed, and is supposed thence to run along the summit of the range on the east side of the lake to Eagle Creek. Only a portion of the width of the band is shown in the exposures just mentioned. It has here, for the most part, assumed the appearance of a white marble, which is highly siliceous in certain layers, the silica being generally in granular concretions distributed along the bedding planes. Some layers pass into grey calcareous gneissic rocks, and in others, the carbonaceous matter which elsewhere gives a dark colour to the limestone, has become concentrated into minute crystals of graphite, with which the rock is speckled. The characteristically calcareous band just traced, may be denominated by the letter B.

Outcrop of Division B.

The limestone in the last exposure, dipping southward, at an angle of about 30°, overlies a blackish granular hornblendic rock, which constitutes the upper member of the series characterizing the immediate shores of the Spallumsheen Arm, which may be called A. The rocks of this division are here very much disturbed, and hold granitic intrusive masses, but may be said to consist of grey thin-bedded gneisses, with blackish hornblende-schists. Some specimens of the gneiss are garnetiferous, and pretty coarsely crystalline. On the Salmon Arm, the same underlying belt of rocks is characterized chiefly by greyish gneisses or mica-schists, which are frequently rusty from decomposing pyrites, often pretty highly quartzose, and occasionally thin and silvery. Hornblende-schists also occur.

Division A. Gneissic rocks.

Near the outlet of Great Shuswap Lake, greenish and grey schists, apparently chloritic, and sometimes lustrous, occur in a disturbed state. These constitute the western extremity, on the lake, of a band which may be called C. Eastward, this band seems to cover the whole width between the north point of Blind Bay and Cape Horn, on the opposite shore of the lake, including Copper Island. It must then run north of

Division C. Bluish and greenish schists

White Lake, and comes out on the shore of the next division of Shuswap Lake, between Canoe Point and Cinnemousun, nearly at right angles, with a width of about three miles. The rocks composing this zone are distinctively greenish or bluish-grey in general tint, and are for the most part thin and schistose, frequently soft and finely undulated or crimped. Some of the schists are even nacreous in appearance, with talc or hydro-mica abundantly developed; other layers are distinctly chloritic. North of Blind Bay, these beds dip at an average angle of about 40°, while between Canoe Point and Cinnemousun, the dip at the south side of the belt is at 50°, decreasing to 16° at the north. On Copper Island, a portion of the schists are more than usually thin-bedded, soft, and minutely corrugated. They are traversed by small quartz veins, which do not appear to hold any valuable mineral. Bright copper-staining is seen, however, on the south side of the island, and a band of the schists about six feet in thickness, is found to be impregnated with copper pyrites, in process of decomposition at the surface. This metalliferous character of the schists, is probably assumed in connexion with a line of disturbance which here crosses the lake, and is subsequently noticed.

Copper Ore.

Division D. Limestones and schists.

Rocks which are supposed to constitute the western extremity of the next band (D) on the lake, are seen between the mouths of Adam's and Scotch Creeks. These are mica-and hornblende-schists, with felspathic schists, and some beds which appear to represent ordinary argillites. But a small vertical thickness is, however, shown in these exposures, and quartzose intercalations, in the form of lenticular veins, with other evidences of extreme alteration, are found. Eastward, rocks of this division characterize both sides of the lake to Cinnemousun Narrows. On the north shore they are seldom well seen, but on the south occur in almost continuous exposures for long distances, dipping northward, at angles of 20° to 40°, to Dyke Bay, when the strike begins to turn south-eastward, and they cross the peninsula south of Cinnemousun. Immediately south of Cinnemousun Narrows, they form a synclinal fold, the beds seen on the north of the Narrows dipping southward at high angles. This zone is not clearly separable from the last described, consisting in part of grey and greenish chloritic, talcose, and micaceous schists; it contains, however, a large proportion of limestones, which are generally dark and shaly, frequently micaceous, and are interstratified with wrinkled calcareous mica-schists of dark colour, precisely resembling some of those at Cariboo. There is also a bed of white granular marble, of considerable, though undetermined thickness, which occupies the centre of the synclinal immediately south of Cinnemousun, and crossing the lake westward, appears for some miles, high up on the slopes of the Angle

Mountain. Some of the schists of this zone are highly quartzose, and in part of their extent become true quartzites.

In a highly disturbed and altered region north of Cinnemousun, the band called C, seems to reappear to the north of the synclinal. It forms in plan a U-shaped bend, open northward, and crosses the promontory which here separates the Seymour and North-east Arms, a short distance north of its extremity. The rocks, so far as examined, are thin hornblende-schists and hornblendic gneisses, generally dark-greenish or black. Highly altered rocks.

North of this zone, the rocks become so much altered, that though folded nearly parallel to a single main direction, it becomes impossible to define the first-described series of strata, which may reappear here on the north side of the Cinnemousun anticlinal. A limestone, probably representing the return of part of zone B, is seen north of the last belt in one place, but most of the rocks are highly crystalline grey gneisses, with occasional hornblendic schists, the whole becoming coarsely granitoid, and even losing all trace of bedding in some places.

The section (Section No. 6) displays the arrangement of the strata which is supposed to exist, on a line drawn through that portion of the area for which most data have been obtained. It runs N. 8° W. from a point near the mouth of the Spallumsheen River, to one between Canoe Point and Cinnemousun, and thence turning to N. 21° E., continues to the vicinity of Seymour, being a total distance of thirty-five miles. The line, first cuts across the south-western corner, of the anticlinal in which Spallumsheen Lake lies. Division B, dipping north-westward from this, is supposed to pass below an area of C, and then reappears in the mountains south of Salmon Arm, sharply reversed, and followed by the rocks representing Division A, which, with general northerly dips, forms an overturned anticlinal. This is followed by the first-described zone of Division B, which is succeeded in ascending order by C and D, forming a regular synclinal. On the section the position of B, is merely indicated on the north side of the synclinal, while the whole region beyond this point is shaded in the same way with Division A, of which it is probably in great part, though not exclusively formed. Section No. 6.

Approximate estimates of the thickness of the various divisions of the Shuswap section, may be given, based on the arrangement of the beds supposed to obtain. It must be borne in mind, however, that besides the uncertainty on this point, a considerable error may arise from unobserved minute repetitions, or faults. For each division of the section, the thickness given below may probably, however, be accepted as a minimum; while, should it be found that more repetition Thickness of the series.

of the members occurs than the section indicates, the aggregate thickness may be too great.

		FEET
Division	A	7,800
"	B	5,800
"	C	9,900
"	D	8,800
		32,300

Line of disturbance.

A somewhat remarkable line of disturbance crosses the south-west arm of the lake at Copper Island, in a north-west and south-east bearing. Near Cape Horn, felspathic dykes and quartz veins traverse the schistose rocks, which in some places are so much broken as almost to resemble a rough breccia. Quartz veins also cross Copper Island, and dykes run parallel to the north-east shore of Blind Bay. Notch Hill lies on the same line, as do also certain porphyritic diorite, granite, and felspathic intrusions seen on both sides of the Salmon Arm. The point opposite Cinnemousun Narrows, is composed of a highly siliceous granitoid rock, in an intrusive mass, apparently of considerable size. In the vicinity of Cinnemousun, and probably in more or less intimate dependance on this mass are very numerous quartz veins traversing the rocks. Some of these follow the bedding, while others cut more or less directly across it. Most are clearly lenticular, but several occasionally run together, giving a considerable aggregate thickness of quartz, in a certain zone of rock. The veins hold iron pyrites in considerable quantity. In most cases, they do not average over a foot in thickness, but sometimes reach four or five feet.

Pyritous veins.

Nature of granitic alteration.

The very great alteration, and highly crystalline character of the rocks about the heads of the Seymour and North-east Arms, has already been alluded to. These reach furthest toward the axis of the Gold Range, where, from analogy, great masses of homogeneous intrusive granite may be supposed to exist. No great area is characterized, however, by rocks of this class on the lake, where a more or less distinctly bedded character is in general found, even in the coarsely crystalline parts of the formation. On approaching Seymour, however, it is observed that the dips rather show a tendency to become more moderate, than to increase in pitch and irregularity, and at Seymour what bedding can still be discerned is nearly horizontal. A similar phehomenon has been observed, even more markedly, in Okanagan Mountain, and conveys to the mind the impression, that a plastic mass of granite may have been slowly pushed upward through the strata; rendering them also plastic on its approach, and reducing, to a great degree, the flexures with which they were already affected.

In the more highly altered regions, the gneissic rocks are everywhere traversed by granitic veins, composed of quartz, white felspar—sometimes of two kinds—and silvery mica. Small garnets also frequently occur in these, but hornblende is apparently entirely absent. In a few places, true veins of this character were observed, intercalated between the gneissic strata to such an extent as to form a large proportion of the mass of the rock. In some cases, the crystallization of the quartz and felspar has proceeded so nearly simultaneously, that these minerals are arranged somewhat as in graphic granite. Many of the granitic veins are highly siliceous, and it seems that the silica in some places becomes so greatly preponderant, that these pass into true quartz veins. There is little doubt that in this district the granitic veinstones owe their origin to the same causes as those of quartz; and that both were formed about the same time. Granitic and quartzose veinstones.

It was thought that some unconformity, or definite lithological break, might in this region be found between the grey gneissic series and the greenish and dark schists; but neither on the ground nor afterwards, in arranging the work on the map, has such been discovered. It is possible, however, that the close folding of the strata, may have resulted in obliterating an unconformity which may not have been in angle very great. The probable equivalency of these rocks with those of other parts of the region is elsewhere discussed.

The rocks on Little Shuswap Lake are highly altered, being for the most part gneisses, sometimes porphyritic, and apparently passing into granite by the obliteration of bedding planes. The strike is nearly parallel to the axis of the lake, bending more to the southward beyond its lower end, where the rocks are thin calcareous gneisses, of grey colours. In a granite with large twinned orthoclase crystals, porphyritically imbedded, which occurs at the first rocky point from the east end of the lake on its north side, are irregular quartz veins, some as much as six inches in width. These hold long prismatic crystals of bismuthite. At the next point veinlets were found with cubical crystals of fluor spar, of pale-purplish tints. This is the only known locality of occurrence of these minerals in the Province. Rocks of Little Shuswap Lake. Bismuthite Fluorite.

Rocks South of Shuswap Lake, and East of Okanagan Lake.

On the trail which leads from the lower end of Okanagan Lake, across Okanagan Mountain to the Mission, gneissic and granitic rocks only are seen, and it is probable that similar rocks also occur on the lake shore, between the two points just named. Okanagan Mountain, as a whole, must either be a dome-shaped projection of the strata, the summit of which has been removed by denudation, exposing the older Rocks of Okanagan Mountain.

and more highly crystalline beds, or it may represent a centre of granitic alteration, similar to those which have already been described as occurring among the gneissic rocks of Shuswap Lake. The central and higher portions of the mountain, or detached block of plateau country, is composed of rather coarsely crystalline, whitish hornblendic granite, with little quartz, and in some places characterized by small honey-yellow crystals of sphene. On descending, whether northward to the valley of Mission Creek, or southward, the granite begins to become gneissic by the appearance of bedding planes, which are at first very indistinct, but soon become exceedingly regular, and divide the rocks into thin layers. This is especially the case on the eastern margin of Okanagan Lake, to the south of the mountain. The beds here dip at low angles toward the lake, and show an altogether exceptional constancy in direction of strike, degree of inclination, and uniformity of thickness in the layers. They are nearly free from irregular jointing, and from veins, circumstances indicating that they have escaped to a great degree that crumpling and fracture subsequent to consolidation, which most of the rocks in this part of the Province have suffered. In composition, the rocks are generally highly felspathic, but contain more hornblende than mica. They are usually rather fine in grain, but hold scattered rounded crystals, of white or pale-pink orthoclase felspar, frequently half an inch or more in diameter. Round these the layers of the rock bend.

Granitic core.

Well stratified gneisses.

The rocks on the northern side of the mountain, and where they were also seen crossing Mission Creek at the Mining Camp, are so similar, as scarcely to deserve separate mention. On looking back at the western slopes of the mountain from the Mission, the general westward dips of the gneissic rocks can be traced in the form of its spurs. There appears, indeed, to be a quaquaversal dip from the central granitic masses.

Line of fracture and disturbance.

From Mission Creek to the north end of Okanagan Lake, most of the rocks seen in the vicinity of the road are probably about the same age with these just described; but a line of great fracture and disturbance seems to run parallel to the direction of the lake, and may very probably be accepted as the initial cause of the depression which has here been worn out. Gneissic rocks, in some places becoming greenish and dioritic, are most common, but are associated in an irregular manner with great masses of granite, which may, in some cases, represent a further stage of alteration of the gneissic series, but is probably more frequently intrusive. There also occur reddish massive crystalline felspathic materials, which appear to be newer, and may be of Tertiary date. It is possible that this may have been a region from which some of the Tertiary igneous rocks of the neighbourhood have originated, and that these have since been removed from the surface of the older rocks by denudation.

About the north end of Okanagan and Long Lakes, and eastward to Cherry Creek, granitic and gneissic rocks, with limestones and micaceous or argillaceous schists and slates, prevail. Their relations are complicated, and require further and more detailed investigation, before certain conclusions regarding them can be arrived at. It is not improbable that a portion, at least, of the rocks of granitic and gneissic character, unconformably underlie the schistose series, in which are included the limestones; but in other cases, gneissic rocks are distinctly intercalated with these. The region is an interesting one, and a portion of it being open country, may be examined with comparative ease. At present it will be unnecessary to do more than indicate in a general way the observed distribution of the rocks.

Rocks between Okanagan and Cherry Creek.

At Nelson's Creek, about five miles east of Mr. Vernon's farm, a massive grey cryptocrystalline limestone appears, forming a gentle anticlinal in the valley of the brook, and rising in cliffs on both sides of it. This is overlain, on the east side of the brook, by a massive-looking breccia over 100 feet thick, which crumbles away pretty readily under the weather, though the component parts are hard, consisting of dioritic and felspathic rocks, and limestone. The fragments are quite angular, closely huddled together, and seem to be separated into zones in which fragments of a certain kind, as for instance of limestone or felspathic rocks, quite preponderate. This breccia, might be supposed to be an outlier of a formation unconformable to the limestone, but occurs again several miles westward, at the head of Long Lake, in similar relation to it, and is most probably a breccia formed by explosions, or some such violent action, shortly subsequent to the deposit of the rocks, which has shattered the various beds without much displacing their fragments.

Limestone anticlinal.

Friction breccia

To the west, it is followed probably by the same brecciated material, and this by hard shaly beds, which often become micaceous schists, and dip westward at low angles. At the eastern end of the grass-covered mountain north of Mr. Vernon's, they hold a slaty grey-blue limestone of considerable thickness. The dip here becomes higher, and it is probable that a synclinal occurs in the central part of the mountain, though in the short time at disposal I was unable to examine its western slopes for the return of the limestone beds.

Slaty limestone

Returning to the eastern side of the Nelson's Creek anticlinal, the brecciated material appears to be followed, by a considerable thickness of schistose rocks like those just mentioned, and these by gneissic rocks, which even become granitoid, and seem to occupy a synclinal between Nelson's Creek and the large stream met with five miles further on. Between this place and a point four miles up the eastern branch of this stream, on the mountain trail to Cherry Creek, limestone, evidently part of the same bed represented at Nelson's, again appears in great mass, and is followed eastward by rocks which seem to be for the most part trachytic, and may represent an outlier of Tertiary volcanic age. Granitic and gneissic rocks, with quartzites, then resume, and continue till the lower country of the vicinity of Cherry Creek, characterized by softer rocks, is reached. Similar granitic and gneissic rocks extend northward, appearing, almost to the exclusion of other materials, on the northern or new trail; and also forming the high hills which rise on the northern bank of the valley of the Shuswap River, in this part of its course.

Rocks at Cherry Creek.

The depressed area surrounding Cherry Creek, in a region otherwise mountainous and high, has been noticed on a former page. This, including the whole length of the main stream which has been worked for gold, and at least several miles of the lower part of the course of the North Fork, is characterized by slaty or schistose rocks, which appear to belong to a single series, and are folded up, with general easterly and westerly strikes, in many close wrinkles. The rocks vary, from soft black, and probably graphitic shales, to hard black and shining, dull rough grey, or fine glistening grey, and occasionally become silvery from talc or mica. These hold hard and more massive calcareous bands in many places, and also at least one bed of considerable thickness of dioritic material, which is in age contemporaneous with the slaty rocks, and graduates into them. It crosses the creek at the cañon between the lower and upper workings. The rocks generally show distinct bedding planes, which are marked by differences in their colour and composition. Cleavage also, however, occurs, and is found to cut across the beds where they lie at low angles, probably in the axes of synclinal or anticlinal folds. No fossils were observed. The general similarity of these beds to those of the auriferous series at Cariboo is quite marked.

Contemporaneous diorite.

Rocks of head of Okanagan Lake.

On the road round the head of Okanagan Lake, and to the first crossing of the Salmon River, micaceous schists, often blackish and evidently in part argillaceous, are associated with gneissic rocks. These resemble those described east and west of Nelson's Creek. Between the first and second crossing of Salmon River, a great series of blackish schists or hard shales occur. These are frequently micaceous and occasionally more or less chloritic, and in some places intercalated thin bands of limestone are common. Pyrites occurs in disseminated crystals, and quartz veins are abundant, but I am assured that gold in paying quantity, has never been found in this region. These rocks evidently, however, represent the schistose series already described in several places, and probably also the series of limestones and mica schists developed on Shuswap Lake.

Agglomerate with limestone.

At the west end of the bridge, at the second or western crossing of Salmon River, a massive green agglomerate, like those found on Nicola Lake, appears, and holding fragments of limestone. The relation of this to the rocks just noticed, or to the limestone which is found further westward—a mile east of Ingram's on Grande Prairie—is not known.

West side of Okanagan Lake

On the west side of Okanagan Lake, micaceous schists, associated with some quartzoze beds almost cherty in aspect, and with limestone, occur for a distance of about nine miles from the head, when they are replaced by granites, and much disturbed and fractured gneisses and hornblende-schists, on the whole similar to those described as occurring on the road between the Mission and north end of the lake on the opposite side. Nearly opposite the Mission, volcanic rocks of Tertiary age appear, and between the northern edge of this formation and the rocks just noticed, some exposures of limestones and associated fine-grained grey argillaceous or quartzose beds, are again found. On the trail between Okanagan Lake and Vermilion Forks, a great area characterized by generally granitic rocks is crossed. These in several places, graduate into distinctly bedded gneisses, which are similar in composition, and also resemble the granites in holding scattered porphyritically imbedded, orthoclase felspar crystals, which are occasionally as much as three inches in length. Some parts of these rocks are micaceous and others hornblendic. Their whole aspect favours the idea that they represent those already described in Okanagan Mountain, but which have here been completely softened, and metamorphosed to such a degree, that they have lost nearly all trace of their original bedding, and become much more coarsely crystalline than elsewhere.

Okanagan Lake to Vermilion Forks.

Porphyritic gneisses.

Newer Mesozoic.

Cretaceous rocks on Skagit River.

The most southern area of well characterized Mesozoic rocks met with during the season, is that already referred to, on the head waters of the Skagit. It lies immediately west of the main axis of the range which forms the watershed between that river and the Similkameen. The trail traverses the area in a general north-east direction for nearly thirteen miles, but the boundaries of the area of Mesozoic rocks in its opposite, and probably longer diameter were not ascertained. North-eastward, at the base of the range already spoken of, they are faulted into contact with gneissic and granitic rocks of much greater age.

Composition of the series.

The series is much disturbed, lying at all angles up to vertical, and has suffered considerable hardening and alteration. It consists, broadly, of sandstones, conglomerates and argillites, the first named rock greatly preponderating. The sandstones are frequently so much changed that they might appropriately be called quartzites. Two varieties may be distinguished, one fine grained, grey or bluish-grey, graduating into argillites in some places, but often rather coarse-grained, and holding much felspar; the second composed almost entirely of particles of quartz, felspar, and mica derived from the decay of granitic rocks, little altered or rounded. These sandstones are occasionally quite coarse-grained, and can scarcely be distinguished from true granite. A fragment of some other, and less crystalline rock, however, occasionally occurs, and demonstrates the sedimentary origin of the mass. The conglomerates are often coarse, and charged with well-rounded granitic and dioritic fragments, up to nine inches in diameter. The argillites are hard, and nearly black, and generally intercalated with the darker and finer-grained sandstones. In some beds, a slaty cleavage has been developed. The average direction of the strike is about north-east, and does not differ much from the probable course of the fault already referred to.

Recomposed granite.

Conglomerates

The entire thickness, and precise interrelation of the rocks of this series, were not ascertained. The following section occurs on the trail, immediately east of the crossing of the north branch of the Skagit. The section is in descending order, the lowest beds being in the vicinity of the bridge by which the above named stream is crossed.—

	FEET.
1. Poorly exposed, but probably for the most part sandstones, with massive beds of conglomerate. Probable dip of upper beds, $< 50°$.	1,860
2. Hard sandstones. Lower beds dipping $< 80°$..................	530
3. Conglomerates and sandstones, hard greyish-green, with numerous specimens of *Aucella*, and fragments of plants................	240
4. Blackish argillites with fossils..............................	20
5. Hard, bluish-grey sandstone, or quartzite......................	40
6. Black argillite...	8
7. Fine-grained conglomerate, or breccia, holding some fragments of rocks like those surrounding it..............................	58
8. Hard sandstones, with some argillite layers, also including a thick mass of dioritic rock, which may probably be intrusive. Nearly vertical...	613
9. Chiefly hard sandstones or quartzites, poorly exposed. Dip at base $< 30°$	1,060
	4,429

Comparison with other Mesozoic Rocks.

The sandstones composed of little-changed granitic materials, do not appear in great force in this section, but characterize, probably, a portion of the series not fully represented in it. The occurrence of these, constitutes the greatest point of difference between the Mesozoic rocks of this area, and those of other parts of the Province previously examined. With this exception, they resemble very closely the strata of Jackass Mountain, on the waggon road, and those of Tatlayoco Lake, with which their fossils also correlate them. These are, as determined by Mr. J. F. Whiteaves, *Aucella Piochii*, Gabb; (=*A. Mosquensis*, Von Buch); *Belemnites impressus*, Gabb; *Yoldia* ? (sp. undt.), an obscure valve, *Physa* ? (sp. undt.) and an *Ostreæa* or *Gryphæa*. The two first-mentioned species are present in great abundance, in certain beds. The *Aucellæ* appear to have formed dense colonies, on banks at an inconsiderable depth, while portions of the belemnites are frequently rounded by water action, to forms like those of the pebbles in the conglomerates. This was also observed with the belemnites found on Tatlayoco Lake. Fragments of wood are seen occasionally. Besides these fossils, however, near the north-eastern margin of the area, an exposure showing rather soft sandstones, with argillites, less altered than those of most parts of the region, yielded a few obscure dicotyledonous leaves. These, together with the softer character of the beds, may indicate the existence here, of rocks belonging to a stage considerably above that of the marine fossils just noticed, and possibly equivalent to a portion of the coal-bearing Cretaceous of Vancouver Island. Though Carbonaceous matter occurs in some of the argillites, no traces of coal were found.

Fossils,

Beds possibly newer.

No rocks of the age of those above described, were found, on the traverse of the same mountainous range of country by the Hope-Nicola trail, nor were boulders referable to them observed; so that it is improbable that they characterize any important area in that region. Still further north-westward, however, at a distance of sixty-two miles, near Boston Bar, and also nearly in the general line of strike of the rocks of the mountains, rocks of this age are again seen. From the vicinity of the mouth of Anderson River and Boston Bar, they were found to extend—though probably not without interruption—in a long, narrow trough, nearly coinciding in the main with the Fraser River, with a general bearing of about N. 70° W., to the vicinity of Lillooet and Fountain, a distance of about eighty miles. Beyond these localities, they have not yet been traced. The southern part of this line of Mesozoic rocks includes those on the main waggon road, which were first examined, and named from the locality of their greatest development the Jackass Mountain series.

Cretaceous areas further north.

The southern extremity of the trough, is found in the mountains immediately behind Boston Bar (Section No. 3), on the eastern bank of the Fraser. The position of the western edge of the Mesozoic trough, I believe to be about a mile and a-quarter from Boston Bar, in a north-east direction. The trail leading to the Coldwater River then passes over these rocks, eastward, for a distance of about three miles,

Synclinal behind Boston Bar.

the width of the trough at right angles to its direction being about two and a-quarter miles. The rocks seem here to be embraced in a simple synclinal fold, tightly compressed, with a general strike of N. 40° W., in which they do not differ much from that of the gneissic rocks to the eastward, and the slaty rocks of the Anderson River and Boston Bar series to the west. The dips observed, vary from 70° and 80° to vertical, and the thickness of the series cannot be much less than 5,000 feet. The lowest rocks seen, were hard bluish sandstones, or quartzites, with layers of rough conglomerate, also much indurated. The remainder of the series is built up of similar sandstones and conglomerates, with some greyish softer sandstones, and blackish hard shales or argillites. In one place, a fine-grained greyish igneous rock, with small black acicular crystals, which are probably of hornblende, appears to form a member of the series. The only fossil procured was found near the western margin of the area, and is an imperfect impression of a ribbed lamellibranchiate shell like a *Pleuromya.* The section seen in the ascent of the hill behind Boston Bar, and immediately east of the summit, would almost convey the impression, that the rocks above described rest conformably on those of the typical Anderson River and Boston Bar series. This appearance is probably, however, caused only by the tight folding of all the beds, and is contradicted by other and better sections.

Thickness of series.

Exposures at thirty-sixth mile-post.

About eleven miles beyond Boston Bar, near the thirty-sixth mile-post, on the waggon road, a cliff, with slope of talus, rising nearly 400 feet above the road on the east side, is found to be composed of similar Mesozoic rocks to those above described, while to the west of the road, low hills sloping toward the Fraser are formed of rocks of the Anderson River and Boston Bar series. The distance concealed in the hollow, which the road here followed, is about 300 feet only. The overlying series here dips N. 54° E., at an average angle of 35°. It is composed of greyish and blackish hard sandstones, which in some instances might be called quartzites. These hold occasional pebbly layers, and are associated with dark, sandy argillites. By careful search, a few fossils were found. These are *Belemnites impressus*, Gabb, *Syncyclonema Meekiana*, Wh., and an *Arca* possibly identical with a *Carterioni*, D'Orb. The underlying series is here composed of greyish, probably in part felspathic, schists, with hard, blackish argillite rocks, and thin bands of cherty quartzite, like that found in many parts of the Lower Cache Creek division of the preliminary classification. These beds strike S. 81° E., N. 81° W., and are nearly vertical.

Fossils.

Exposures at Jackass mountain.

The rocks of Jackass Mountain, near the fortieth and forty-second mile-posts on the waggon road, and forming the northern continuation of these above mentioned, are described by Mr. Selwyn in the Report of Progress for 1871-72.* They were subsequently correlated with the Mesozoic rocks of Tatlayoco Lake on lithological grounds,† but fossiliferous zones confirming this correlation were found only during the past season. Most of the fossils were obtained in a rock-cutting at the side of the road on the northern slope of the mountain. They include, according to Mr. Whiteaves, *Syncyclonema Meekiana* Wh., *Ancyloceras percostatus* Gabb., *Crioceras latus* Gabb., *Pleuromya* (n. sp. allied to *P. papyracea)* Gabb, an *Arca*, the same with that found at the thirty-sixth mile-post, and a badly preserved cast of a *Cuculæa*. Fossils.

North of Lytton, the eastern bank of the Fraser was followed as far as Forster's Bar, where the direct trail to Fountain was taken. The Mesozoic rocks throughout appear to lie in a trough of highly crystalline strata, gneisses, and schists, with great masses of diorite, or hornblendic granite without bedding. The Mesozoic rocks occur sometimes on both banks of the river, but often only on one side. Those exposures near the trail were the only ones examined, and do not require very detailed description. Cretaceous north of Lytton.

About a mile from Lytton, grey sandstones and shales with some conglomerate, like the beds of Jackass Mountain, occur. They dip eastward at angles of 50° and 60°. No further exposures of these rocks are found till a small stream about five miles from Lytton is crossed. The trail, on the north side of this, has been cut out in rather soft and earthy black shales, associated with sandstones softer than those before seen. These rocks rest at high angles, and the dip is séveral times reversed, indicating a repetition of beds. They are seen at intervals for about a mile along the trail, when they are followed by coarse conglomerates and sandstones which weather reddish and appear to overlie them, but are soon replaced in the section by granitic and other crystalline rocks. In their general strike, these beds follow the course of the river. They resemble those in which dicotyledonous leaves were found on the Skagit, and here also obscure plant remains were procured in the shaly beds. These, with those from the before mentioned locality on the Skagit River, were submitted to Principal Dawson, who has kindly furnished the following note concerning them. Though closely related to the rocks holding the molluscan fossils before enumerated, in neither case was their precise stratigraphical relation to them made out.— Plant remains.

"The specimens consist of a few fragments of dark coloured arenaceons shale and sandstone, full of obscure vegetable fragments. Among these the only recognizable forms represent three species, Note by Principal Dawson.

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*p. 60.

†Report of Progress 1875-76, p. 253.

of which two are dicotyledonous leaves, one of them apparently rounded the other of oval form, and a flabellate leaf with radiating venation becoming very close and wavy or sub-reticulated toward the margin. The two dicotyledonous leaves being mere fragments not showing the margins or fine venation, it would be impossible to refer them to their genera. The flabellate leaf, which may when perfect have been about an inch in length, of broadly cuneate form and lobed at the extremity, seems more to resemble a leaf of a taxine conifer allied to *Salisburya* than anything else. No deduction as to age can be drawn from these fossils, except that they are not likely to be older than Upper Mesozoic or Cretaceous."

Rocks near Fountain and Lilloet.

Some beds are quite carbonaceous, and a slight change in the conditions of deposit might suffice to render this a coal-bearing horizon, in some other locality. The lenticular area included between the direct trail from Forster's Bar to Fountain, and the Fraser, appears to be occupied almost exclusively by rocks of the Jackass Mountain series. The general form seems to be that of a synclinal trough, interrupted northward by a transverse anticlinal, the line of which the Fraser follows for a short distance, where it turns abruptly westward at Fountain. The rocks are not well exposed on the trail above alluded to, till quite near Fountain. Argillites, with volcanic rocks which might be called porphyrites, are seen in a few places, the latter, doubtless, belonging to the series to be described as occurring north of Fountain. Near Fountain, and on the road between that place and Lillooet Ferry (see Section No. 5), the rocks are well shown in many exposures, and rise in the centre of the synclinal to form high and rugged mountains. A few specimens of *Syncyclonema Meekiana* Wh. were found in one place, but fossils appear to be very rare. The rocks are sandstones, argillites and conglomerates. The latter are greenish or greyish, with well-rounded pebbles of granite and granitoid rocks, a few of poryhyrite-like rocks, and many of blackish and pale greenish-grey cherty quartzite. The sandstones are grey, various shades of greyish-green, or blackish, those of the last-mentioned tint being generally fine and passing to black and banded hard argillites. The sandstones often hold scattered pebbles. In composition few are truly siliceous sandstones, and many of them consist largely of felspar and felspathic materials, and resemble in this respect those described as *felspathic-sandstones* on the Nechacco.* The materials may here not improbably have been derived from the waste of neighbouring masses of granitic rock.

Scarcity of fossils.

Sandstones and argillites.

At the edge of the Fraser at Lillooet Ferry, the rocks are hard

*Report of Progress 1876-77, p. 73.

blackish argillites, almost cherty in the lower layers. They are much disturbed by small faults and traversed by intrusions of igneous material, and hold thin layers of highly calcareous argillite or limestone. These rocks might almost pass for the representatives of the Anderson River and Boston Bar group, but the impression received at the time of their examination was, that they form the lower member of the series above described.

Possible representatives of Porphyrite series.

On the east side of Fountain Creek, on the waggon road, grey sandstones, with some associated shaly beds, which are occasionally carbonaceous, like some of those seen near Lytton, are found. These are without doubt a part of the Jackass Mountain series, and dip southward at an angle of about 20°. They are followed by rocks of volcanic origin, of which the relations with this series and attitudes are obscure. They are in appearance older than the volcanic products of almost any portion of the Tertiary in this region, and resemble most the rocks of Tatlayoco Lake and the Iltasyouco, which in a former report were named the Porphyrite series. If this identification be correct, these rocks doubtless underlie all those above described, but positive evidence of this is still wanting at this place. The rocks are displayed in the vicinity of the road for about five and a-half miles beyond Fountain Creek, when they are overlapped by the Tertiary volcanic series. They are generally decidedly felspathic in composition, and for the most part fragmental, forming agglomerates of fine or coarse-grain, which in some instances appear to approach in structure the felspathic sandstones of the Jackass Mountain series. Most of the rocks might be broadly characterized as porphyrites, and generally contain porphyritically imbedded felspar crystals, without silica. In a few cases, besides the volcanic fragments, small pieces of dark cherty rock have been included. The colours are generally greyish, but just beyond the Fountain Creek, cliffs showing a great mass of red-weathering brecciated material, nearly white on fresh fracture and fine-grained, occurs. This appears to be felspathic in composition, but may have been partly altered by heated waters or otherwise, as it fuses with extreme difficulty, even in fine splinters.

Rocks opposite Ashcroft.

Mesozoic rocks, probably referable to nearly the same horizon as these last described, or in part to that of those of Jackass Mountain, were again found occupying a small area on the Thompson, below its junction with the Bonaparte. Opposite Ashcroft, these rocks were first found near the brow of the hill forming the side of the Thomson Valley, dipping toward the river, or N. 69 W., at an angle of 20°, with great regularity. They are blackish shales, often arenaceous, and passing to felspathic sandstones in places. The rock next seen—and apparently overlying the last—is a pale-grey rhyolite.

These are followed by felspathic sandstones, with some shaly beds, and a considerable thickness of bluish-grey petrosilex. Blackish and reddish beds, probably overlying these, were seen from a distance in the bank of the river, dipping at an angle of about 30°; no fossils were discovered. Further down the river, these rocks are replaced by great masses of volcanic material intercalated with limestones, and apparently forming a portion of the series which includes the thick Carboniferous limestones described in a former report.* This region was, however, visited late in the season, and not fully examined. It merits a close investigation, as it promises to yield some facts of importance, in connection with the general sequence of the formations.

Further examination required.

TERTIARY

Method of mapping the Tertiary.

Rocks of this age, cover a large portion of the district under examination. Their distribution, in so far as it has been ascertained, is shown on the accompanying map, in referring to which, however, it must be borne in mind that the dividing lines between formations were definitely determined only where crossed by the routes travelled, and that their continuation across the intermediate regions is more or less conjectural. This is more especially the case with the Tertiary, as it rests as a comparatively thin unconformable series, on the older rocks, and may, in many places, be worn into much more complicated outlines than those indicated.

General character of the series.

The Tertiary rocks, in this part of the Province, do not form such extensive unbroken sheets as they do further north, a fact due to the probably more mountainous and rugged nature of the country at the time of their deposition, and also to extensive and severe disturbance and denundation subsequent to that time. They are for the most part igneous rocks, but include thick masses of argillaceous and arenaceous beds, with lignites and coals. The igneous rocks are often fragmental, and in general much less basic in character than those of the northern parts of the Province. It is by no means improbable, that the Tertiary rocks of this part of British Columbia may eventually admit of separation into several distinct series representing different stages in the Cainozoic period, but palæontological evidence of this is yet wanting. The economic importance of the Tertiary, lies in the fact that it includes valuable seams of coal and lignite. The localities where these occur are here described, with a few other sections of more than ordinary interest.

On the west side of the North Thompson, above Kamloops, Tertiary

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

rocks are extensively developed. They appear also on the east side in detached portions, and one of these outliers, on the Indian Reserve, forty-three and a-half miles up the river, contains seams of coal. The area of this outlier, in so far as it can be defined by the sections on the east bank of the river, is not great. It rests on the older crystalline rocks, forming a ridge about 600 feet high along the base of the tier of mountains which, rising to a height of 2,000 to 3,000 feet above the river, here forms the border of the valley. The length of the ridge is about two and a-half miles, and it is where the little stream called Coal Brook cuts through it, that the Tertiary rocks are exposed, by the removal of the thick covering of boulder-clay and drift, which elsewhere shrouds it. The beds appear to form a synclinal, nearly parallel in its main direction with the trough of the valley. Tertiary outlier at the Indian Reserve

The following section, in descending order, includes nearly all the beds seen in the brook channel. Some layers were measured, others estimated by the eye only.— Section at Indian Reserve

		FEET	IN.
1. Sandstone, soft	at least	2	0
2. Carbonaceous shale		0	6
3. Shale and sandstone		3	0
4. *Coal*, shaly	about	1	3
5. Hard clay		0	6
6. Soft shale		1	3
7. Grey, fine shale, with fossil leaves		2	0
8. Coarse and fine-grained sandstone		15	0
9. Hard, fine, grey clays		1	0
10. Concealed		10	0
11. Sandstone		2	0
12. Grey shales		3	0
13. Sandstone		2	0
14. Soft grey shale		1	5
15. *Coal*		1	2
16. Shale		0	2
17. Sandstones and shaly sandstones		9	0
18. *Coal*	irregular	1	5
19. Black shale	irregular	0	8
20. Grey, crumbling sandstone		4	0
21. Carbonaceous shale	1 inch to	0	4
22. Rusty, nodular sandstone		1	8
23. Soft sandstone in thin layers		8	0
24. Concealed	15 feet to	20	0
25. Sandstone		4	0
26. Black shales		0	6
27. Sandstone		0	10
28. Shales, more or less carbonaceous, with a little coal		4	0
29. Ironstone, nodular		0	3
30. Thin-bedded clays, greyish and brownish		2	8

		FEET	IN.
31.	Grey sandstone, generally coarse and rather soft	10	4
32.	*Coal*, shaly	0	2
33.	Brownish sandy clays	6	9
34.	Thin-bedded sandy clays, rather hard..........about	20	0
35.	Coarse, pebbly sandstone ....about	8	0
36.	Brownish-grey sandy clay, at base.		
		148	1

At the base, the beds dip at an angle of 12°, further up at 15°, and again begin to dip at a lower angle at the summit. The direction of dip varies from N. 56° E. to N. 26° E. The lowest beds are first met with in ascending the brook. Beyond the highest represented in the above detailed section, a considerable gap occurs, in which the banks show no exposures. When next seen, the beds are poorly exposed, but one bank shows about twenty feet of sandstones and shales like those before met with, and includes two small seams of coal, the lower seven inches, the upper nine inches in thickness. These beds are doubtless the highest found in this locality.

Highest beds seen.

Character of the deposit.

It would appear, however, that in the sections, but a small portion of the entire thickness of Tertiary beds represented at this place, is seen. Their general character is much like that of those of other localities in the southern part of the Province, the sandstones holding, perhaps, more coarse pebbly material than usual. Notwithstanding this, however, there is no appearance of tumultuous deposit, and the coal seams, though thin, show considerable regularity. The coal-bearing character of the formation appears to persist throughout the section, and a further examination by boring may at some time become desirable. The best locality for a bore-hole would probably be in the valley of the brook, at the lowest beds of the section.

A sample of the coal analyzed by Dr. B. J. Harrington, proves it to be a fuel of good quality. It may be called a true coal, and cokes when rapidly heated.*

Sections on Kamloops Lake

The sections on Kamloops Lake, and in its vicinity, offer a very perplexing problem. As already stated, rocks of Tertiary age, chiefly of igneous origin, are found overlying a series of much greater antiquity, which is also mainly composed of contemporaneous volcanic materials. The Tertiary rocks seem to have been deposited on an uneven surface; they vary much in composition and thickness when followed horizontally, and are connected with a great mass of highly altered rocks, which have apparently formed the basal portion of a vent or group of vents. Even since Tertiary times the whole series

*Report of Progress, 1876-77, p. 468.

has suffered violent flexure and faulting. The complete working out of these sections, would require a much longer time than I have been able to bestow on them, and even to detail the observations made during my examination of the lake shores, would occupy an unwarrantably large part of the present report.

Section No. 7.

A section—partly diagramatic, and based for the most part on the exposures on the north shore of Kamloops Lake (Section No. 7)—has been drawn, in which the observed or inferred relations of the rocks are represented. A short description of this, with notes on a few salient features, must for the present suffice.

Junction of Tertiary with older rocks.

Following the north shore from Savona's Ferry eastward, the rocks seen are supposed to belong to the old underlying series, to within about a mile of Copper Creek. These underlying rocks are hard dark-coloured breccias of volcanic materials, with some beds of ordinary argillite, much hardened. Their upper surface is not regular, but confusedly broken, and mixed, as it were, with the lowest bed of the overlying series. The overlying material is tufaceous and arenaceous, and studded irregularly with fragments, either angular or more or less perfectly rounded. In some places it might be called a breccia, in others a true conglomerate, its very varied materials contrasting with the uniform character of those of the older underlying breccia. The fragments represent portions of the rocks immediately below, rounded masses of hard grey limestone, and pieces of Tertiary sandstones and shaly beds which had previously become consolidated. The well-rounded conglomerates resemble those seen on Three-mile Creek, and south of Savona's, on the south shore of the lake; and on the north bank of the Nicola, near the Coldwater. Northward, rocks like these are found on the lower part of Hat Creek.

Decomposed serpentinous rocks.

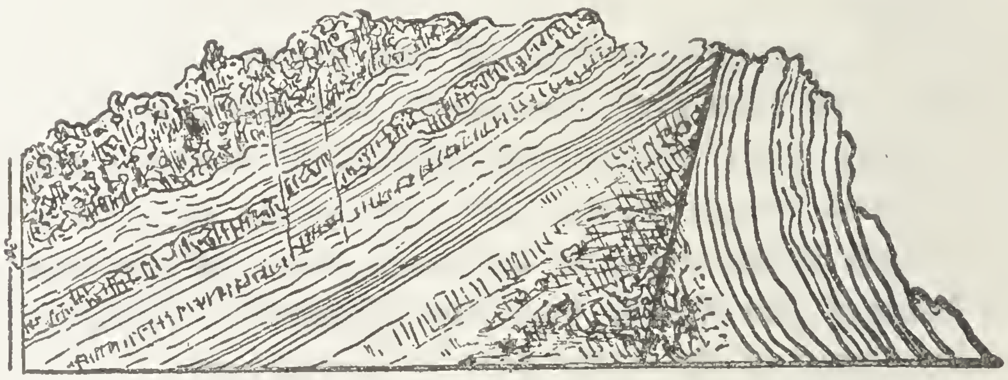
At Copper Creek, and probably overlying a considerable thickness of the conglomerates above described, occurs a series of remarkably brilliantly colored beds, in which reddish and pale green layers are interstratified. The red-colored rock is either rather hard, in flaggy layers, or massive, soft and of coarser grain. It is a sedimentary rock composed of volcanic materials, of which the iron has become peroxidised. The green, which from a distance resembles clay, is found to be produced by the decomposition of a hard, dark-green rock, which still remains in balls and irregular masses in the decomposed product. The least altered portions appear to be doleritic, and contain olivine in great quantity, which in more altered specimens becomes serpentine. The felspar of the more felspathic portions eventually becomes completely decomposed, a soft kaolinized and serpentinous material resulting. The whole section is traversed by veins and seams of calcite, and occasional copper stains were seen. The Indians

Copper ore and native copper.

were formerly in the habit of obtaining native copper in this vicinity, though probably in small quantity. I was not able to ascertain the precise locality, but Mr. J. W. McKay, of the Hudson Bay Company, subsequently informed me that he had found little veins on Copper Creek containing grains of native copper; and I was also shown, by Mr. H. Moreton, specimens of copper ore (bornite) from the same place.

Brilliantly coloured beds.

The bedded rocks are next interrupted by a grey, highly crystalline, but much decomposed trachyte, which may be an intrusive mass, but rather resembles a projecting portion of an older series. In the bay to the east of this, the brilliantly coloured rocks above described again appear, covering a considerable area in nearly horizontal beds, but cut into a complicated system of little hills and ridges, which are separated by narrow intervening valleys, like some portions of the 'bad lands' east of the Rocky Mountains. The colours here displayed pass from sap-green to pea-green, red, brown and purple. These rocks appear to dip eastward below a great mass of volcanic materials which are, for the most part, breccias, or agglomerates, but are much disturbed and not always well shown along the shore.



FLEXURE AND FAULT AFFECTING TERTIARY AGGLOMERATES AND TUFFS.
RED POINT. KAMLOOPS LAKE.

Thin-bedded tuffs.

Many of these breccia beds are soft and crumbling and weather into yellowish banks in the hills above. They appear to lie, in the main, in a synclinal, and at Red Point are found dipping north-westward at an angle of 30°. Forty or fifty feet in thickness of very regularly stratified sedimentary materials, interbedded with crumbling agglomerate in thin layers, here occur. A great part of the material of these beds is brownish and tufaceous in character, with only a few thin layers, paler in colour, of ordinary water-leached clays. These beds may represent an upper portion not recognized in the former exposures, of the brilliantly coloured series, or may be a modified extension of it. They are affected at Red Point by a sharp flexure, at which the strata have broken and been faulted.

A distance of between one and two miles from this place is occupied for the most part by agglomerates, which are not well shown. The western edge is then found of an area of very hard highly crystalline diorites, which, with considerable regularity in character, occupy a stretch of over four miles of the lake shore, including the prominent Battle Bluff. These rocks are grey or greenish-grey in general tint, are much divided by jointage planes which run in all directions, and have evidently been subjected to excessive disturbance even subsequent to their consolidation. They are traversed by veins, which hold some magnetic iron ore, in associatlon with epidote and copper ores. The iron ore is found, however, much more abundantly in their continuation in Cherry Bluff on the south shore of the lake. To the east, near the mouth of Tranquille River, the dioritic mass above described is directly overlain by a thick bed of columnar basalt, which dips eastward, first at an angle of 20°, but soon becomes more nearly horizontal. This is followed by a series, not seen on the shore, but found some distance up the Tranquille, which represents the lower beds seen to the westward, and like them is chiefly built up of agglomerates, generally rather soft, and often holding very large masses, in some cases over four feet in diameter. There is also much rusty tufaceous rock, which on weathering crumbles down completely, forming sloping banks like clay. The fragments in the agglomerates, are sometimes of a species of tachylite, occasionally amygdaloidal, and here and there associated with much chalcedony. There are many dykes, which run in all bearings. Overlying these, at the east end of Kamloops Lake, are well bedded volcanic sediments, with some ordinary water-formed clays. The beds have become nearly horizontal, and form a rampart-like slope facing the lake on the north side. Some fossil plants have been obtained in this section.

Beds surrounding the Battle Bluff diorite mass.

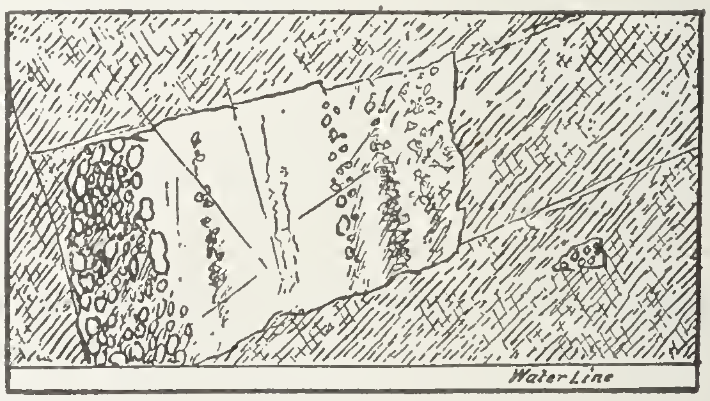
From its relation to the other beds, and general character, the extensive dioritic mass above described would seem to mark the position of a centre of Tertiary volcanic activity. Inland, it appears to be bounded by a range of mountains, in which volcanic beds are seen dipping away from this central region. On the south side of the lake it forms as above mentioned the rock of Cherry Bluff. The metalliferous deposits and crystalline epidote of its veins may probably have been produced during the last stages in decay of the volcano. A portion, perhaps even the greater part of this dioritic area may belong to the underlying pre-Tertiary volcanic series, but if so, the whole has been so completely metamorphosed, that all traces of bedding or other structure have become lost.

Probable vent.

On the south shore of the lake, near its east end, are interesting exposures of igneous rocks interbedded with others of ordinary argillite, which are generally considerably hardened, and sometimes hold obscure plant remains. At about two miles from the mouth of the Thompson, a fault brings these against a series of yellowish and brownish tufaceous sandstones, which form very regular beds, and are shown in a cliff to a thickness of 100 feet or more. They are interbedded with some ordinary sandstones, and both classes of rocks hold occasional stems or fragments of plants. In one place, a little vein about a quarter of an inch thick of much hardened bitumen was observed to traverse them.

Magnetic Iron Ore.

Near the west end of Cherry Bluff, in the dioritic rock above described, somewhat extensive deposits of magnetic iron ore are found. The mass of the rock is everywhere shattered, and many of the cracks and interspaces are filled with the ore, which forms veins from the thickness of a sheet of paper up to three feet or more. The larger masses are generally not continuous for any great distance, but occur toward the intersection of smaller veins in an irregular manner. The iron ore is closely associated with epidote, and often mixed with radiating crystalline masses of that mineral. The country rock is also more or less completely altered, and charged with epidote in the vicinity of the joints and veins. Between the west end of Cherry Bluff and the mouth of Cherry Bluff Creek, the beach is strewn with fragments of the magnetite. The ore, according to an analysis by Dr. Harrington, is of excellent quality, containing 66·83 per cent. of metallic iron, with very little phosphorous or sulphur.



FRAGMENT INCLUDED IN TERTIARY VOLCANIC ROCKS.

Fragment included in volcanic rocks.

Two miles east of the mouth of Three-mile Creek, in a low cliff, a remarkable instance of the amount of disturbance which the rocks of the region have suffered, and the general complexity of rock structure in this neighbourhood, is found. A rather coarse-grained massive igneous rock, apparently a dolerite, here includes a large foreign fragment, measuring about eight feet wide by ten or twelve in length. This is now bounded on several sides by joints or small faults, which traverse the enclosing rock in various directions. As though to prevent the supposition, however, that the mass has been faulted into its present place, a second smaller fragment of the same material, a few inches in diameter, lies near it, quite distinctly enclosed in the mass of the first mentioned rock. The enclosed mass is of limestone, the bedding planes of which are now nearly vertical in position. On one side, (whether originally the upper or lower surface of the mass can not now be known,) the limestone becomes a conglomerate, in which there scarcely remains enough calcareous matter to hold the rounded pebbles together. The pebbles are also of igneous rocks, not very dissimilar in general aspect from those of the enclosing Tertiary material.

Origin of the fragment.

The fragment would appear to have been derived from a bed somewhat like that described on the South Thompson as overlying the massive limestones there found (p. 80). The pebbles contained in it must have been broken from igneous rocks which may have been nearly contemporaneous, rounded, and included in the limestone at the time of its deposit.

Outcrops of conglomerate.

Conglomerates and breccias, like those seen near Copper Creek, are also found on the south side of the lake. About three miles up Three-mile Creek they form an imposing escarpment on the west side of the valley, rising about 2,000 feet above it. These exposures appear to deserve careful examination.

On the plateau south of Savona's Ferry, similar conglomerates, containing for the most part well-rounded pebbles which are occasionally a foot in diameter, forms, in association with igneous rocks of Tertiary age, a thin coating on the older volcanic series already many times referred to. The pebbles are either like the rocks immediately underlying, or are granitic.

Agglomerate with volcanic bombs.

About three miles S. 65° W. from the town of Kamloops, a coarse volcanic agglomerate occurs, forming the summit and some part of the slopes of a prominent hill. In this are many obsidian-like fragments,—probably tachylite—resembling those of the rocks on the Tranquille and elsewhere. There is here, however, much quartz and calcite with zeolitic minerals, in the interstices of the fragments and in small veins. One well-preserved volcanic bomb was also found, with others not so perfect. It was ovoid in shape, measuring about nine inches by six inches in its longest and shortest diameters. On being struck with the hammer it proved to be still hollow, and contained a beautiful moss-like coating of quartz, the fibres of which are built up of small crystals closely aggregated. The main escarpment of the Tertiary runs from this place toward the north end of Stump Lake.

The Tertiary series of the vicinity of Kamloops Lake appears to have been deposited on a very uneven surface of older rocks, forming

General arrangement of series.

the basin of a great lake or system of lakes, of which a portion of the shore-line was in the vicinity of the present eastern end of Kamloops Lake, for a considerable time in the earlier part of the period. The large size of the pebbles, and their rough arrangement in the conglomerates, seems to imply the action of heavy waves upon a beach. It would be hazardous to estimate the thickness of these Tertiary rocks, but it must be at least several thousand feet in some places. The lowest beds recognised appear to be conglomerates and agglomerates, above which beds of compartively well-stratified materials, chiefly volcanic in origin, are found. These are probably at least several hundred feet thick, and include the brigthly coloured beds of Copper Creek. Capping these, is a second great mass of agglomerates, with intercalated basalts and other allied volcanic products. No coal seams were observed in this region, and if they exist they must be situated in beds of strictly aqueous origin underlying all those above-mentioned. Such beds may occur in what were the lower parts of the pre-Tertiary surface.

Exposures on Hat Creek.

A locality of some interest in connection with the Tertiary is found on Hat Creek, about a mile above its abrupt bend at the eastern entrance to Marble Cañon. The exposures here extend for about 500 yards along the stream but are not continuous, and the arrangement of the beds is somewhat complicated by the fact that considerable land-slips have occurred in some parts of the banks. These have formed hollows beyond the margin of the bank, in two of which pools now lie. A great thickness of lignite coal, however, occurs here, associated with sandy or clayey, yellowish, greyish or purplish beds, which are generally rather incoherent. The stream nearly follows the strike of the beds, so that the same deposit of lignite is seen in a number of places. The lowest good exposure shows over thirteen feet of lignite, neither the top nor the base of the bed being seen. The lignite is pure throughout, with the exception of a few lenticular or more or less irregular masses formed by silicified or calcified stumps. In following up the stream, lignite of the same kind is frequently seen, and continues to show occasional masses of fossil wood of the kinds above described, but is without shale. Some portions of the wood have been changed to ironstone of good quality, which might be of value if the lignite bed were being worked. At the highest good exposure the beds are dipping into the western bank of the brook at an angle of 30°, and are probably undisturbed. The bank was here scarped down, and the section carefully examined. The result may be stated as follows, in descending order.—

Ironstone.

	FEET	IN.
1. Greyish, and brownish shales, and sandy clays, with lignite in seams a few inches thick...........about	20	0
2. Lignite, with shaly and lenticular layers of siliceous matter, ironstone and shale. Lignite of fair quality forms about two-thirds of the whole, and contains much crumbling amber........................	26	0
3. Lignite, with little or no shale or other impurity. Below very compact, rather softer in the upper layers..	42	0
	88	0

Great thickness of lignite.

The bottom of this enormous lignite bed was not seen, the measurement going only to the water of the brook, beneath which it is concealed. The appearance is as though the vegetable material forming the deposit had grown where it is now found, but no data are available for the precise definition of the outline of the region which it underlies. Basaltic fragments are quite numerous in the vicinity of the lignite outcrop, but no volcanic rocks occur in place.

Analysis.

An analysis of the lignite by Dr. B. J. Harrington gave the following result, and proves it to be of good quality. Though now somewhat remote from travelled routes, it may some day be of importance.—

Water..	8·60
Volatile combustible matter..............................	35·51
Fixed carbon...	46·84
Ash..	9·05

Lower part of Hat Creek. Conglomerates and sandstones.

The Tertiary rocks of the lower part of Hat Creek belong to the same area with those just described, but no lignite coal was found in them. For three and a-half miles below the bend of the creek at the entrance of Marble Cañon, the left bank is occupied by limestones, when the base of the Tertiary is found to overlap them, and to consist of a peculiar calcareous conglomerate, composed chiefly of limestone pebbles, with cherty quartzite, etc., the whole cohering firmly, and weathering reddish. To these succeed rocks of more ordinary type, sandstones and conglomerates, the materials of which are for the most part derived from the cherty quartzites of the Cache Creek group. The cement is calcareous, and the usual colors of the rocks greenish-grey, grey or brown. The conglomerates are sometimes lenticular, but on the whole the beds are extremely regular; shales seldom occur, nor were any tufaceous or other beds of volcanic origin observed. The beds dip in most places at angles of 30° to 50°, and are repeated several times between the points above-mentioned and the eastern edge of the formation, near the mouth of Hat Creek. (see Section No. 5.)

The thickness of the entire series is about 3,800 feet. Many of the sandstones resemble those associated with the coal at the mouth of the Coldwater, it is possible that careful search might bring to light coal seams here also, or at least plant-bearing beds. Some parts of this series would probably afford good building stones, though those layers subject to rapid decomposition would require to be carefully avoided.

The absence of volcanic rocks in the Tertiary sections of Hat Creek is the more remarkable that immediately opposite the mouth of Hat Creek, on the east side of the Bonaparte, a great thickness of Tertiary rocks is shown, and found to be composed entirely of igneous products, which are for the most part agglomerates. These may either overlie the Hat Creek series, or in part replace it.

Rocks of the Nicola and Coldwater

The fact of the occurrence of coal on the Nicola, at its junction with the Coldwater, has been known for some years, and the locality is briefly described in the last Report of Progress (p. 127). The sections can now be described in somewhat greater detail, having been made the subject of careful examination in connexion with a measured section of the Tertiary rocks by the course of the Nicola, from the Coldwater to Spence's Bridge.

Iron mountain.

A considerable area depressed below the average level of the plateau, occurs at the conflux of the Nicola and Coldwater rivers, the cause of which is to be found in the comparatively soft rocks with which the coals are associated. In the south-eastern angle formed by the two rivers, Iron Mountain—already referred to in another connexion—forms a prominent object. The greater part of the mass of this mountain is made up of much-altered volcanic rocks, among which brecciated materials abound. These are rather uncharacteristic and might with equal propriety be referred to the Tertiary, or older underlying volcanic series shown on Kamloops Lake. I am inclined, however, to place them, though with some doubt, in the former category, the more so that the summit shows the remnants of a covering of volcanie rocks of much newer aspect. In this case it would represent the locality of a centre of igneous eruption somewhat like that described on Kamloops Lake. Veins of specular iron ore traverse the summit of the mountain. Several were seen of a few inches in thickness, but my guide not being properly informed, we were unable to discover the precise locality of a vein several feet in width, which occurs. The ore appears to be rich, and of good quality, judging from loose masses which were found, though in the rather inaccesible position in which it is at present known, it is probably, of no economic value.

Specular Iron ore.

If the view of the structure of Iron Mountain above given be correct, the coal-bearing sandstones and associated rocks of the valley below doubtless pass beneath it, though probably in a state so fractured and disturbed as to render the coal seams valueless. The angle on the opposite or west side of the Coldwater, includes the exposures of the coal seams, while to the south and west the higher hilly region is composed entirely of volcanic rocks which are of Tertiary age, and without doubt overlie the coal-bearing series.

Section of the Main Coal seam.

About two miles from the point of junction of the Nicola and Coldwater, on the left bank of the latter, near a little foot-bridge which crosses it, an outcrop of coal occurs from which several tons have been taken at various times. The original opening being almost in the bed of the Coldwater, has since been quite filled up, but a second shallow pit on the outcrop, a few feet up the bank, was cleared of rubbish and deepened so as to exhibit a complete section of the seam, and its associated beds, which may be described as follows in descending order.—

		FEET	IN.
1.	Sandstone.		
2.	Shale	0	10
3.	*Coal*, good, with occasional silicified stumps, somewhat laminated, cleat in two directions	4	0
4.	Sand (not continuous)	0	0¼
5.	*Coal*, weathered, but probably of good quality	0	9
6.	Soft sandstone	0	0½
9.	*Coal*	0	6
10.	Soft grey sandstone......six inches to	0	7
11.	*Coal*	1	4½
12.	*Coal*, soft	0	2
13.	*Coal*, shaly	0	9½
14.	Hard, fine-grained sandstone, grey, with some obscure plant impressions. Variable but generally about	0	4
15.	*Coal*, laminated	0	3½
16.	Shale with obscure plants and remains of insects	0	9
17.	Sandstone.		
		10	5¼

Thickness of workable seam.

It may thus be said that we have here in a single seam, with very little impurity, five feet three inches of coal of good quality, while if that below the seven inch sandstone be included, the total thickness of workable coal is six feet seven and a-half inches. The occurrence of silicified stumps in the seam, while the surrounding vegetable matter has been changed to coal without any trace of silicification, is remarkable, but not unparalleled. It may probably have depended on their difference of state as compared with that of the peaty matter around them. These silicified stumps are black and hard, but easily separable from the coal. No well preserved fossil plants were found here or

Silicified stumps.

Fossil insects.

elsewhere in this region, but in one of the beds below the coal, as shown in the above section, insect remains occur, which are described by Mr. S. H. Scudder in an appendix to this report. The shales holding these are also charged with comminuted vegetable matter, and rather rough in texture, owing to which the harder portions only of the insects have been preserved.

Second section of main seam.

Underlying this coal seam, about 200 feet in thickness of strata are represented by occasional exposures of sandstone, which may be supposed to make up at least the greater part of the mass. The beds at the exposure above described dip N. 49° E. < 27°. Overlying it are massive sandstones, which form the bank of the Coldwater at this place, and are continuously exposed for a distance corresponding to an actual thickness of 210 feet. A line drawn in a bearing of N. 3° W. from the outcrop above described is the chord to an arc formed by a bend of the Coldwater, and in 1,600 feet, reaches the river bank at a spot where the same seam again crops out. The dip has gradually changed in the intervening distance, till it is here found to be about S. 61° E. < 15°. The coal and its associated beds are already considerably changed in aspect, showing the rather inconstant nature of these Tertiary measures. A comparison of the following section with that first given will illustrate this.—

		FEET	IN.
1.	Sandstone.....at least	10	0
2.	Grey Shale.....	2	0
3.	*Coal*.....	1	5
4.	*Coal*, with shaly partings.....	1	6
5.	*Coal*.....	2	0
6.	Soft brown shale.....	0	1
7.	Yellowish sandy shale.....	0	8½
8.	*Coal*, with occasional thin lenticular shaly partings.....	0	11
9.	Shale.....	0	6
10.	*Coal*.....	0	8
11.	*Coal*, with about ⅓ of shaly partings.....	0	11
12.	Fine-grained grey sandstone, equivalent to No. 14 in former section, the insect bed, etc., being absent.....about	0	4
13.	Yellowish sandstone, rather soft.....at least	10	0
		31	0½

Exposures in Coal Gully.

A mile and a-half from the first mentioned coal exposure, in a direction of about N. 60° W., is the mouth of Coal Gully, a little ravine, dry in summer, which runs up the face of the gently swelling hill to the south (see Section No. 8.) In this the best series of exposures of the coal bearing-rocks is found, and three or four distinct coal seams exposed. In the lower portion of the gully sandstones only are shown, and these are sometimes curiously weathered. They are supposed to form a gentle synclinal, and above them the rocks composing the following section lie, dipping at an average angle of about 20° to the south. The section is in descending order, ending below at the sandstones just alluded to.—

		FEET	IN.
1.	Soft yellowish sandstones, in thin beds, at the top of the hill.	32	0
2.	*Coal*, laminated, rather soft	15	4
3.	Sandstones, rather soft, with some shale	89	0
4.	*Coal*	5	4
5.	Sandstones, with a considerable thickness of shaly beds at the base	141	0
6.	*Coal* ... about	3	0
7.	Sandstones, generally in thin beds	136	0
8.	*Coal* ... about	2	5
9.	Sandstones		
		424	1

The lowest coal is poorly exposed, but with little doubt occupies the position here given to it. It may include some shale. The seam numbered (6) in the section was at one time opened out, and worked on a small scale. The shales have now fallen, concealing most of the outcrop. In one place a thickness of about three feet, as given in the section, was seen. The coal is much weathered, soft and crumbling, but is said to have been of good quality when worked into, and to have thickened. The coal numbered (4) has shale both immediately above and below it. It is much decomposed at the surface but appears to be free from shale, or nearly so, for the thickness given, and includes many small spots of fossil resin or amber. The highest seam appears to have the thickness given to it in the section, but is very badly weathered, and crumbling. There may be some small shaly intercalations which could hardly be detected in the condition of its outcrop. Many particles of amber are scattered through it. All the seams above mentioned are for convenience called coals, but to the upper ones the term lignite, or brown coal would be more applicable. Number (6) is the coal most closely resembling that of the first-described locality, but the exposures in the two places were not strictly correlated.

Character of the coal seams.

An analysis of the upper seam (2) by Dr. B. J. Harrington, gave the following result:—

Analysis of the upper seam.

Water	5.78
Volatile combustible matter	27.65
Fixed carbon	52.69
Ash	13.88

The percentage of fixed carbon is high for a lignite, but as a fuel this does not compare favourably with the lower seams.*

* For analyses of these see Report of Progress 1876-77, p. 465.

Disturbance of strata.

The coal-bearing rocks have been considerably disturbed both by flexure and faulting in this area, which, with the generally drift-covered character of the surface, renders it difficult to trace the seams from point to point. The locality on the bank of the Coldwater is probably the best adapted for working in the first instance, on a small scale, and much information would doubtless be gained as work progressed. To the metamorphism accompanying the disturbance above alluded to, the exceptionally good character of some of the coals may be due, a great proportion of their more volatile matter having been driven off.

Composition of the sandstones.

The sandstones associated with the coals are generally composed for the most part of siliceous materials, of which a large proportion is often nearly pure quartz, like that derived from decomposing granite. Pebbles occasionally appear in some abundance, though no great thickness of conglomerate, properly so called, is found. The sandstones are generally of about the texture of ordinary loaf-sugar, and of pale tints of grey or yellowish-grey. If any doubt were entertained as to the inferior position of these coal-bearing rocks as compared with the volcanic series of the Lower Nicola, this should be dispelled by the absence of any volcanic constituents in the sandstones, or materials such as might result from the weathering of pre-existing little-altered volcanic rocks. Decidedly argillaceous or shaly beds are also quite inconspicuous in the sections at this place.

Area of the coal-measures.

It is impossible from present data to estimate accurately the area of the portion of the coal-bearing series represented by these sections. In one direction they may be considered as practically bounded by the base of Iron Mountain. About a mile south-eastward from the mouth of Coal Gulley they are, I believe, cut off by a fault with extensive downthrow westward, which appears to have a course of about S. 18° E., and evidence of which was again found some miles up the Coldwater. South-east of this fault rocks of volcanic origin only, appear, and the sandstones and coals are probably out of reach beneath them. The question of the continuity of the coal-bearing series below the igneous rocks of the Lower Nicola is considered further on. For some miles up Guichon's Creek, (joining the Nicola four and a-half miles below the Coldwater,) rocks like the softer upper portion of the section above given, have a considerable spread, but are poorly shown. Specimens of lignite have been obtained from a locality near here, which was not visited. In following up the Coldwater, Tertiary rocks continue to appear for about twenty-three miles. They seem to be folded in a rather irregular manner, so that it would be difficult to state their average strike. Rocks of volcanic origin greatly preponderate, and among these breccias or agglomerates of varying texture are

Rocks on the Coldwater.

most abundant. Compact rocks with porphyritic felspar, which have doubtless been originally igneous flows, are also found. In the bank of a stream joining the river near the fifty-seventh mile-post from Hope, ordinary siliceous sandstones, like those at the junction of the Coldwater and Nicola, are met with, and were found to contain streaks of coaly matter. Near this is a bed of conglomerate, with rounded pebbles of varied origin, among which some almost certainly represent portions of the series seen on Nicola Lake, which thus appears to have been fully metamorphosed before the conglomerate was formed. It graduates upward into a volcanic breccia. In other beds of fine breccia, composed chiefly of volcanic fragments, particles of coal were observed, rendering it probable that coal seams may occur in underlying beds in this vicinity. I have, indeed, been informed that a coal bed has been seen near here. This may probably be in the bed of the river, which was very full at the time of my visit. The rocks are much disturbed and faulted, but the adhesion and blending of the ordinary sedimentary rocks and those of volcanic origin is perfectly demonstrated.

Reported coal seam.

Seven miles further up the Coldwater, beds of hard greyish-green sandstone, holding small coaly fragments, occur. They appear to rest upon and to be overlain by volcanic material.

Rocks of the Lower Nicola.

Volcanic rocks of Tertiary age, like those found in association with the coal-bearing sandstones at the junction of the Nicola and Coldwater, and for some distance up the latter stream, also extend northwestward on the Nicola River to its junction with the Thompson. A paced survey was made from the mouth of the Nicola to the Coldwater, a distance by traverse of nearly forty miles, for the purpose of ascertaining whether sandstones like those containing the coals appeared again in any part of the Nicola Valley nearer the Thompson, up which the waggon road and projected railway route passes. No sandstones precisely like those of the coal-bearing part of the series were, however, discovered, and it has even proved impossible with the information collected to unravel the complexities of the structure produced by the folding and faulting of the volcanic rocks combined with their original irregularity, so far as to determine with any precision the probable depth from the surface of the coal-bearing horizon, if indeed it still continues to maintain its character on the lower part of the river. The anticlinal and synclinal axes are sinuous in direction, and while frequently for some distance nearly following the line of the valley, are found to bend suddenly across it in other places. Rocks of a well marked tufaceous character were known to occur, and it was thought that these might be used as a fixed horizon, but it was found that they characterize at least two zones, and partake of the irregularity of other parts of the series.

General lithological character.

These Tertiary igneous beds very often lie at angles nearly as high as thirty degrees, but seldom have a greater inclination than this. Without entering into details as to the lithological character of the rocks, it may be stated that they consist for the most part of felspathic materials, true basalts not often occurring. Trachytic tuffs and tufaceous agglomerates, in colour generally pale grey or greenish, are abundant, and occasionally arranged in thin beds by water action. Rocks which may broadly be called porphyrites, of grey, greenish, reddish or purplish tints, form a great part of the series. Some of these have evidently been igneous flows, but many have a more or less roughly brecciated character. Rhyolites or quartz-trachytes are rare, basalts occur in a few localities, and an imperfect obsidian was noted in one instance only.

Probable equivalency of horisons.

Though the result of the examination of this valley proved thus unsatisfactory in regard to the definition, with any precision, of the possible position of the coal-bearing portion of the series on its lower part; it appears probable that the trachytic agglomerate seen by the road side about a mile below the bridge over Guichon's Creek, does not lie at a very great distance above the coal-bearing base of the formation, which appears to run up the east bank of the creek. It is also probable, that agglomerates of about the same horizon again come out on the road near Pulpit Rock, two and a-half miles above Smith's, or eleven and a-half miles down the river from the first mentioned locality. They are here dipping southward, and the tributary valleys on the north side of the Nicola for some miles below this, would appear to be worth searching for sandstones such as those holding the coals. The overlap of the Tertiary on the older rocks in the vicinity of Spence's Bridge on the Thompson, might also be examined for any trace of underlying truly water-formed beds. A spot on the south side of the river, five and a-quarter miles above the bridge which crosses the Nicola at its mouth, and nearly opposite a small stream which comes in from the north side, was noted as the best near the Thompson in which to test the lower strata by boring, but their broken and irregular character would seem to render this mode of proceeding undesirable unless some more certain data can, in the first instance, be obtained.

Rocks of Upper Salmon River.

Volcanic rocks of Tertiary date, cover a large area on the upper part of the course of the Salmon River. They are best shown in a series of bold cliffs which occur on the left bank of the river, about nine miles above the road at Grande Prairie, where they consist of alternating layers of compact, red-weathering basalt, with reddish amygdaloid, and a grey, fine-grained material, which may have been a volcanic mud or ash rock. Irregular cavities in this, hold well-crystalized chabasite, in nearly transparent and colourless rhombohedrons. Stilbite is also occasionally found. The igneous rocks here rest directly on an unconformably underlying schistose series, which is locally much altered by dykes. No sandstones or other ordinary sedimentary beds here occur at the base of the Tertiary, and further down the river valley, where a great thickness of coarse agglomerates is cut through, the underlying schistose rocks are again found immediately beneath the volcanic rocks.

On the west side of Okanagan Lake, nearly opposite the Mission, and in association with basalts and porphyrites of Tertiary age, a remarkable conglomerate was found. The material is a fine greyish trachyte-tuff, resembling mortar in appearance, and is charged with angular or more or less perfectly rounded fragments of highly siliceous granitic rocks. On Mission Creek, about three-fourths of a mile below the Mining Camp, a cliff estimated at 350 feet in height, is built up of overlapped flows of basalt, each from twelve to fifteen feet in thickness, and all wonderfully regular. Twenty-four such layers were counted, and there are probably eight or ten more in the face of the hill. The material is much alike throughout, and many layers are finely columnar. The whole mass dips away from the stream at an angle of about 15°, and is seen to be underlain by thirty feet or more of yellowish sandstone, of ordinary sedimentary origin. Conglomerate. Superposed flows of basalt.

On the plateau to the west of the Okanagan Valley, twenty miles north of Osoyoos Lake, a synclinal fold of considerable extent brings a great thickness of Tertiary rocks into view. The lowest beds recognized are tuffs and agglomerates. These are followed—as shown in Section No. 9—by nearly or quite 3,000 feet in thickness of well-bedded sandstones and shales. These, however, interlock with the underlying beds, and differ from the sedimentary rocks usually found at the base of the Tertiary, containing throughout much tufaceous material, and passing even, in some cases, into fine-grained agglomerates. In many layers, imperfectly preserved plant-fragments are found, but no coal was seen. In most places the plants are extremely obscure, but deciduous leaves and a fragment of a coniferous twig were recognized. Overlying all these, in the centre of the synclinal, is 250 feet or more of a grey, volcanic rock, which forms a bold escarpment to the south. It is a trachyte, in some places distinctly porphyritic, and with scattered hornblende crystals. Other portions are tufaceous, composed of fine particles, or becoming even brecciated. The whole is regularly bedded, and similar in colour. Mingling of sedimentary and volcanic materials.

The Tertiary rocks, as developed near the Forks of the Similkameen River, are of great interest, having yielded, besides numerous well-preserved plants, insect remains, fresh water molluscs and a few fish- Beds near Vermilion Forks.

scales—the latter being, I believe, the first tokens of vertebrate life yet found in rocks of this age in British Columbia.

Nine-mile Creek.

At the Nine-mile Creek, on the south Fork of the Similkameen, where crossed by the trail, a bank shows a small section of hard laminated clays, with layers of softer arenaceous clay. Plants are pretty abundant here, and well-preserved, and a few insects were obtained; but the section is not such as to allow any general observations on the relation of these to the volcanic rocks with which most of this region is covered.

Rocks on South Similkameen.

At three and a-half miles above the Forks, on the South Similkameen, at a locality in which gold-washing has been carried on at intervals for some years, pretty extensive exposures of sedimentary Tertiary beds exist, and coal has been reported. The lowest beds seen are sandstones, which appear a short distance down stream from the mining cabins. About half a mile above the cabins, low cliffs of Tertiary rocks margin the river on its south-east side, while the opposite bank shows the same in slides and broken cliffs. The stream nearly follows the strike, and the lignite, which has been referred to as coal, occurs on the north-west bank, in moved ground, and partly concealed by the water. It is in large blocks, and appears to be of fair quality, though in some layers a little shaly, and always tending to split up along the bedding-planes on becoming dry. The thickness could not be determined, but must be at least several feet. Above the lignite are coarse, hard sandstones, and a great thickness of bedded clays generally more or less arenaceous, and comparatively little consolidated, often carbonaceous, and purplish, with much selenite in veins and cracks, and a yellow, sulphur-like deposit. There are many little points of amber through all the layers and in the lignite.

Fossil plants.

Most of the beds are too soft to preserve fossils in a state fit for recognition, but in one layer hardened by siliceous matter, many perfectly preserved plants were found. This bed represents, indeed, the accumulation in a shallow pool of the Tertiary period, in which large equisetums were growing, and into which floated the dead leaves from some neighbouring forest. These fossils are noticed in Appendix B.

Vermilion cliff.

About three miles up the Tulameen, or North Fork of the Similkameen, from Vermilion Forks, is a bold cliff on the left bank of the river, composed of Tertiary rocks of very singular aspect. The Indians had often told me of this place as yielding red paint, and it is from this circumstance the name Vermilion Forks has arisen. I was induced to give half a day to an examination of the locality, by finding in the river at the Forks fragments of siliceous material holding shells of Limnæa, which it was rightly conjectured might be derived from it.

The cliff is nearly 200 feet in height, and shows about 150 feet in thickness of the strata. The beds dip at an angle of about 15° to the north-westward, and the individual layers are pretty uniform in thickness, and maintain their parallelism with considerable regularity. They are brilliantly coloured, the tints alternating, and varying from bright red through brick-red to various shades of yellow and rich brown. Thin layers which are exceptionally bright in colour, have been excavated by the natives for the red and yellow ochres.

Combustion of lignite.

The coloration of the cliff has been produced by the combustion of a bed of coal or lignite somewhere in its lower part, in the manner frequently found in the Tertiary bad-lands east of the Rocky Mountains, and also observed at Quesnel, in British Columbia.* On a closer examination of this section, however, it appears that the beds have originally differed in character from those usually found, and it becomes apparent that they have been laid down in the bed of a lake, into which very copious mineral springs have issued. The deposit of the springs has been chiefly siliceous, but there is much calcareous matter, and the water probably also contained iron, and other substances, all of which are now mingled with greater or less quantities of ordinary sediment. The resulting accumulations, with the alteration superposed by the comparatively recent combustion of the lignite, render the section at first sight a rather difficult geological problem, but I believe the above to be the correct explanation of it.

Deposits of Tertiary mineral springs.

Character of siliceous deposits.

The rocks as they now appear consist broadly of sandstones, shaly argillites and siliceous layers, with some siliceous limestones toward the base of the section, in thin beds. The beds more directly resulting from the siliceous deposit of the springs are very varied in character. Black chert-like layers occur, but generally do not continue far horizontally. Other beds, similar in texture, are mottled with red, due to the oxidation of iron, and traversed by tube-like white or grey markings, which on close inspection are seen to be silicified grass stems, which have been included in the mass. One of these materials, microscopically examined proved to consist of dull amorphous silica through which cloudy flecks were scattered, and occasional larger opaque patches, coloured with iron oxide. The base also held minute crystals of calcite, irregularly distributed, in obtuse rhombohedrons, perfectly formed, and almost resembling cubes. The mass must have been deposited originally in a gelatinous state, about the stems of growing grass; and the spaces formed by these are now filled with milky chalcedony, turning to crystalline quartz toward the centre of each. The stems have in great part decayed away before the final

* Report of Progress 1875-76, p. 257.

consolidation of the mass, and have collapsed irregularly in the tubes, though still showing the structure of cellular tissues and spiral vessels under the microscope. In other layers, a grey porous material is not uncommon, and in many cases appears to be almost entirely made up of silicified vegetable fragments, of which the forms can scarcely be defined. Some beds are pale yellow or grey in colour, formed of superposed laminæ nearly as thin as paper, but feeling harsh to the touch. Nearly all contain enough calcareous matter to effervesce readily.

Lignite bed.

The position of the bed of lignite or coal which has caused the alteration, is now concealed by slides at the base of the cliff, but near the summit a bed of lignite still remains visible, and appears to be of fair quality, though much decomposed at its outcrop. Measured from the top downward, it presents the following section.—

	FEET	IN.
1. Lignite, horizontally laminated, much weathered......	4	6
2. Shaly parting..................................	0	3
3. Lignite	2	3
	7	0

The regular bedding of the adjacent rocks, renders it not improbable that the associated lignites may preserve their character over a considerable area.

Fresh-water molluscs.

The limestone layers already referred to, alternate near the base of the cliff with some of the harder siliceous bands. Both weather red on exposure, and in the former were found a number of well preserved and silicified fresh-water shells, belonging to the genera *Limnæa* and *Physa* and *Sphærium*. In some cases the shells are filled with clear chalcedony, or crusted internally with crystalline quartz.

Anticlinal and fault.

On the opposite side of the river, about 100 yards further up stream, similar beds are found, but little, if at all affected by the metamorphism due to the combustion above referred to. The exposure is here, however, much smaller than the first. It is traversed by a fault, and becomes concealed by yellowish boulder-clay a few paces further up the river. The fault runs about S. 65° E., and is nearly vertical, but probably does not cause any very extensive displacement, or seriously interrupt the general anticlinal fold, the axis of which the river here nearly follows. The beds on both sides of the fault dip about S. 10° W. at angles of 30° to 45°. Those seen beyond the fault are not represented in the section in the cliff, but it appears probable that they are those immediately below the lowest beds there exposed. They include a layer of lignite about a foot thick, which rests in black, rather earthy, carbonaceous clays, and is overlain by fifteen feet or more of very thinly bedded, almost paper-like, yellow-grey siliceous shales. They appear on first sight to lie in beds each an inch or two thick, but split up readily into thin leaves. These, and the darker shales below them, hold remains of plants—chiefly coniferous twigs and leaves—and fossil insects, which, though not very abundant, are in good preservation. They are described in an appendix to this report by Mr. S. H. Scudder. The impressions of the annulated bodies of leeches are common in some layers. In the dark shales, the fish-scales before mentioned were found. The beds as a whole are well suited for the preservation of delicate organisms, and conveniently exposed for work in collecting. Fossil insects and plants.

The lignite bed just described, with its associated carbonaceous or bituminous shales, is probably that to which the metamorphism of the first-described section is due. More coaly matter may occur in still deeper layers, but these, being below the level of the water of the river, could scarcely burn under any circumstances.

The general resemblance of these beds to those seen on the South Fork is close, though little trace of siliceous deposit occurs in the latter. They may probably represent different portions of the bed of a single ancient great lake, of which they preserve for us an incomplete, but extremely interesting record.

Lignite is said by Mr. George Gibbs to occur much further up the South Similkameen, above the Pasayten or Passyton. It is associated with micaceous sandstone, formed doubtless of material from neighbouring decomposing granitic masses. Lignite.

Glaciation and Superficial Deposits.

In my two previous reports on British Columbia, many facts bearing on the mode of glaciation and character of the superficial deposits of the regions described, have been given. It is everywhere evident that action during the glacial period has been influential, to a great degree, in giving the surface of the country its present form and appearance, and this chiefly in the following ways.—The wearing down of the rocky surface by glaciers and perhaps also by floating ice, possibly proceeding in some instances to the actual excavation of rock-basins now holding lakes. The transport and wide distribution of *débris* or 'drift' resulting in the deposition of the boulder-clay, the production of moraines, and eventually in supplying the material for the terraces and benches which fringe the valleys. The great accumulations of loose material formed at this time are also responsible, though less directly, for changes in the drainage system of the country by the blocking up of pre-glacial river valleys, leading to the diversion of Consequences of glaciation.

streams or the formation of lakes. From an economic point of view, the geology of the glacial period has some features of special interest. It has determined the character of the soil, and must also be taken into account in the investigation of the superficial deposits in which gold placers are worked.

Recapitulation of facts previously published.

In a paper read before the Geological Society* I have collected the evidence obtained in the districts already reported on, adding facts from other parts of the Province, the results of my own observations and those of others. Many new points of interest have since appeared. It is here proposed to refer to these in a connected manner, placing them in juxtaposition with the general conclusions previously arrived at. These may be quoted from the paper above referred to, and are as follows.—

"The character of the rock-striation and fluting on the south-eastern peninsula of Vancouver Island shows that at one time a great glacier swept over it from north to south. The glacier must have filled the

Strait of Georgia glacier.

Strait of Georgia, with a breadth, in some places, of over fifty miles, and a thickness of ice near Victoria of considerably over 600 feet. Traces of the glacier are also found on San Juan Island and the coast of the mainland. The deposits immediately overlying the glaciated rocks, besides hard material locally developed and probably representing *moraine profonde,* consist of sandy clays and sands, which have been arranged in water, and in some places contain marine shells. These, or at least their lower beds, were probably formed at the foot of the glacier when retreating, the sea standing considerably higher than at present.†

"Observations in the northern part of the Strait of Georgia, and the fiords opening into it—where the sources of the great glacier must have been—show ice action to a height of over 3,000 feet on the mountain sides. The fiords north of the Strait of Georgia show similar traces. Terraces along the coast of the mainland are very seldom seen, and have never been observed at great elevations.

North-to-south glaciation.

"In the interior plateau of British Columbia there is a system of glaciation from north to south, of which traces have been observed at several localities above 3,000 feet. Subsequent glaciation, radiating from the mountain ranges, is also found.

Superficial deposits.

"The superficial deposits of the interior may be classified as unmodified and modified. The former, representing the boulder-clay, hold many water rounded stones, with some glacier-marked, and occurs at

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* Quart. Journ. Geol. Soc., vol. XXXIV, p. 89.

† Additional details in regard to the southward continuation of the Strait of Georgia glacier. and the drift deposits of Washington Territory, may be found in an article in the Canadian Naturalist, New Series, Vol. VIII, No. 7.

heights up to over 5,000 feet. The latter characterize nearly all localities below 3,000 feet, and are most extensively developed in the northern low country, where they appear as a fine white silt or loess. Terraces.

"The interior is marked with shore-lines and terraces from the present sea level up to 5,270 feet, at which height a well marked beach of rolled stones occurs on Il-ga-chuz Mountain.

"Moraines occur in great numbers. Some of the moraine-like accumulations may have been formed in connexion with the north-to-south glaciation. Most of those now seen, however, mark stages in the retreat of glaciers towards the various mountain ranges. The material of the moraines resembles that of the boulder-clay, but with water-rounded stones even more abundant. Moraines.

"The sequence of events in the interior region has been—Glaciation from north to south, with deposit of boulder-clay; formation of terraces by lowering of water-surface, accompanied or followed by a warm period; short advance of glaciers from the mountains contemporaneously with formation of lower terraces; retreat of glaciers to their present limits. Glaciation of Vancouver Island may have occurred during both the first and second cold periods, or during the second only. Sequence of events.

"If the north-to-south glaciation has been produced by glacier-ice, it must have been either (*a*) by the action of a great northern ice-cap (against which grave difficulties appear), or (*b*) by the accumulation of ice on the country itself, especially on the mountains to the north. In either case it is probable that the glacier filled the central plateau, and, besides passing southward, pressed seaward through the gaps and fiords of the Coast Range. The boulder-clay must have been formed along the front of the glacier during its withdrawal, in water, either that of the sea, or of a great lake produced by the blocking by local glaciers of the whole of the valleys leading from the plateau, to a depth of over 5,000 feet. Nature of the glaciation.

"If general submergence to over 5,000 feet be admitted, the Japan Current would flow strongly through Behring's Strait, and over part of Alaska, while arctic ice-laden water, passing south across the region of the Great Plains, would also enter the Central Plateau of British Columbia, accounting for the north-to-south glaciation and simultaneous formation of the boulder-clay."

The exploration of the season of 1877, while tending to confirm the general conclusions already arrived at, and succinctly stated in the above extract, has added materially to the facts heretofore at disposal in illustration of them, and has extended the area to which they apply over the southern portion of the Province. Observations in 1877.

General Glaciation.

North-to-south glaciation.

Rock striation and polishing due to ice, and referable to action during the period of general north-to-south glaciation above noted, has been observed in a number of additional localities, from which it would appear that the ice pressed forward over the southern part of the country to, or even beyond the line of the 49th parallel, notwithstanding the generally mountainous character of that part of the region. One of the most striking instances of this general glaciation, and, at the same time, that which carries it up to the greatest height hitherto observed in British Columbia, is that of Iron Mountain, at the confluence of the Coldwater and Nicola Rivers. This has already been noticed (p. 32), and need here only be referred to. The summit of this mountain rises to an elevation of 5,280 feet above the sea, or 3,500 feet above the valleys at its base. It has been heavily glaciated, and its projecting rocky masses worn into ridges parallel to the direction of ice movement, still preserve striated and polished surfaces, both horizontal and vertical. The indicated direction of motion is about S. 29° W. or N. 29° E., probably the former. If not due to the general system of glaciation, the markings here can only have been caused by ice descending from the higher mountains of the Coast Range toward the Interior Plateau of the Province. Though this latter movement is known to have occurred about the close of the glacial period, and in some cases to have been very important, it cannot, I think, be invoked to account for the facts here. The main outlines of the topography of the region have been described on a former page, from which it will appear that the Coast Range is neither high enough or so near, as to supply a body of ice sufficiently great to envelop and over-ride mountains of the height of Iron Mountain; and, indeed, all traces of the glaciation radiant from the present mountain systems has been found in the lower parts of the valleys leading from them. On the question, whether it is to glacier ice as such, or to floating ice that the north-to-south glaciation should be attributed, a few remarks are offered further on.

Iron Mountain.

Plateau south of Kamloops.

In the vicinity of the trail leading to Nicola, about nine miles south of Kamloops, and on the summit of the plateau already described on page 27, glaciation was observed in several places, at an elevation of 3,212 feet above the sea. This place is far removed from any mountain ranges capable of giving rise to extensive glaciers, being situated in the very centre of the Interior Plateau. The rocks are generally ice-shaped; and not infrequently polished, more rarely distinctly striated, and were not observed in any place to be fluted. The striæ examined vary in direction from S. 6° E. to S. 27° E., and in themselves, with the form of the rocks show evidence of a southward direction of movement.

Stump Lake.

In the valley of Stump Lake, at an elevation of about 2,300 feet, the rocks near the upper end of the lake were observed to be glaciated, with an indicated direction of S. 5° W. This also may be due to the period of general glaciation. On the plateau between Stump Lake and Douglas Lake, and north of the upper part of the course of the Nicola River, other instances of glaciation belonging to this system are found in a number of places. Here, as in the case of the plateau south of Kamloops, the rocks are more frequently polished than distinctly striated. The general direction of striation is, however, in some cases clearly shown to be S. 9° E. The altitude is 3,623 feet.

Plateau near Chain Lake.

Still another good instance of this general glaciation is found on the granite rocks of the plateau to the west of Chain Lake, referred to on page 44. Here, as in other cases, the circumstances entirely preclude the supposition of local glaciation, as the portion of the plateau on which glaciation was observed, is fully up to its average elevation, and this is only surpassed by a few insignificant hills at some distance. Well-formed surfaces are still beautifully polished, and show striation varying in direction from S. 20° E. to S. 28° E., but no deep grooving. The elevation is 4,075 feet.

North-to-south glaciation in other localities.

Glacier-ice has extended so far along the lines of the larger valleys from the main mountain ranges, that where these lie nearly north and south, it becomes impossible to separate with certainty the traces of the general from a later and more local glaciation. On the western side of Okanagan Lake, on the slopes of the hills, glacially striated rocks were observed in several places. The ice seems to have moved from north to south, and may possibly have been that of the first period. Similar traces occur in at least one place in the parallel valley followed by the road, a few miles north of the Mission. The summit of Okanagan Mountain, south of the Mission, on the east side of the lake, is evidently glaciated, though the granite rocks, superficially roughened by the weather, have not preserved actual striæ. This must be attributed, with little doubt, to the period of north to south general glaciation.

On the hills west of Osoyoos Lake, near the 49th parallel, glaciation running S. 13° W. was found. This, however, is at no very great elevation, and being parallel to the direction of a wide hollow among the hills, cannot be regarded as certainly referable to the general glaciation, especially as in a lateral valley, leading into Osoyoos Lake, glacial striæ with a course of S. 40° E. were found. These appear to indicate a local mass of glacier-ice descending—though, perhaps, for a short period only—from the low mountains of this region.

The remarkable valley of Okanagan and Osoyoos Lake has already been described (p. 52). It must almost certainly have been subject to ice-action during the period of general glaciation, but to what extent the features now seen may be due to this time, and in how far to a subsequent period, when as a long narrow arm of the sea, or of a great lake, it carried southward ice produced by glaciers nearer the mountains, it is now difficult to ascertain. Glaciation was observed in several places, but always without distinct grooving, the surfaces being polished, with only slight striation. The rocks of the sides of the valley are often, as viewed from a distance, distinctly *moutonnée*, those on the lower parts of the slopes showing flat outlines, while those higher up are more abruptly rounded.

Rocks, polished and striated parallel to the river valley, were noted on the Thompson nearly opposite Ashcroft. The river here runs nearly due south.

Local Glaciation.

Some of the more prominent examples of glaciation which may be classed as local, may now be given.

Local glaciation on Shuswap Lake.

On the south-east side of Seymour Arm, Shuswap Lake, glaciation was seen in several places above Cinnemousun Narrows, running south-westward parallel to the main valley. The markings are in horizontal lines on vertical or nearly vertical rock-faces, and resemble the work of glaciers. On the north side of the Salmon Arm, glacial striation, so heavy and regular that it might almost be called grooving, was found on a rock which inclines about 20° beyond vertical. The flat surface preserving the marks is not, however, due to glaciation, being in its origin a cleavage-plane, with a bearing parallel to that of the lake shore at the place, and also with the course of the ice. Glaciated stones are very numerous on some points of the lake shore near here. They are generally somewhat worn, but may easily be detected when wet with rain.

South Thompson and Kamloops Lake.

On the South Thompson, below the Shuswap Lakes, glaciation was observed in several places, generally, if not in all cases, parallel to the valley. Further down the valley, where it is occupied by Kamloops Lake, heavy and regular glaciation, forming smooth rounded rock-surfaces, occurs on the south shore of the lake near its east end. The direction of motion appears to have been from east to west. The projecting front of Battle Bluff, on the north shore of the lake, still preserves its glacial polish and striation on a vertical surface. The traces in both localities resemble those of glacier ice, but it is difficult indeed to account for its having pushed so far westward in this valley.

On the summits of the hills crossed on the southern trail to Cherry Creek, with an elevation of about 3,524 feet, the rock surfaces are found to be ice-polished, though striation is very faint, and appears to have been of secondary importance. The only direction clearly observed was S. 70° E. or N. 70° W.

Skagit and Whipsaw Creek

On the eastern branch of the Skagit River, rocks several hundred feet above the stream, in the mountain slopes, were observed to be ice-shaped, and though not preserving striation, their form would indicate the motion of the ice to have been parallel to to that of the valley. Near Powder Camp, on Whipsaw Creek, glaciation running N. 45° E., or parallel to the valley at this place, was found. Similar striation was again observed a few miles further down the Creek. Near Keremeoos, on the Similkameen, glaciation going S. 35° E., or down the valley, is also seen.

Nicola Valley.

In the Nicola Valley, eighteen miles above Spence's Bridge, glaciation was observed in one place. The striæ are on a surface which inclines toward the river at an angle of about 45°. The scratches cross at small angles and indicate, with little doubt, a movement of ice up the valley. The general direction is here S. 4° W. Many rock masses twenty to fifty feet above the present level of the river, show water-rounded surfaces, but this is quite distinct in appearance from these.

On Nicola Lake, a surface of fine green agglomerate was noted to be polished and irregularly scratched, as though by ice. The striæ, however, descend obliquely toward the lake, and may have an origin quite local.

Superficial Deposits.

Two classes of deposits.

The superficial deposits due to the glacial period are everywhere important in the region under consideration, and are concerned to a very great degree in giving it its present appearance. They may be spoken of as unmodified and modified, the former class including the boulder-clay, the latter the various deposits lying over it, and especially the material of the terraces or benches. The distinction between these two classes of deposits is, however, not so well marked in this southern part of the country as in the north, for the action of the weather, in denudation, has here been much more effectual, and has often modified, or in some instances almost entirely removed the terraces, spreading their material in the flat-bottomed valleys, or forming wide fans projecting into them. This applies specially to the central, dry plateau region, which may at first sight appear remarkable. It is nevertheless true, that with a rainfall very much less than in the north, the action on the surface of the country has been far greater. The extremely dry soil does not maintain a sufficiently dense protective coat of vegetation, the sod is not continuous and and strong on the open hillsides, and there is no great mantle of forest

Rapid denudation.

with densely-matted roots. In the southern country a comparatively light fall of rain, or the sudden melting of snow on the higher hills, may cause an amount of denudation, and the transport of material to lower levels, which it might take many years to effect in the north. This sudden action also, in a mountainous country, leads to the removal of rock masses of large size, and in such abundance that great caution must be observed in attributing to glaciers deposits of rudely-mingled materials, often including not only stones, but finer detrital matter, but which do not require for their explanation any circumstances different from those observed at present.

Boulder-clay.

Examples of the boulder-clay occur principally either on the higher portions of the plateau above the limit of most of the benches, or the banks of streams and rivers in the lower valleys, which have cut through the superficial materials to where it rests in the bottoms of these hollows. In the latter the best exposures are usually found.

Section on Coal Brook.

On Coal Brook, about a mile above the trail, on the northern part of the Indian Reserve on the North Thompson, a good typical boulder-clay is shown in a bank about fifty feet high, and in numerous smaller exposures. The matrix is a very hard, bluish, sandy clay, through which stones of all sizes are scattered in every position. These are chiefly of the rocks of the neighbourhood, but include numerous fragments of granite not seen at this spot. Many of the stones are heavily scored, and a few are very large; one, a mass of coarse granite, was found to be eleven feet four inches long, by eleven feet wide, and six feet four inches deep, the last dimension not fully shown. Notwithstanding the rough, or even tumultuous aspect of the deposit, traces of bedding are distinctly seen here and there, and near the top of the section a bed of clean-washed gravel about two feet thick occurs. Above this, the boulder-clay, with all its usual characters, resumes for a thickness of three or four feet, and is again covered by horizontally-stratified and false-bedded gravels which form the upper ten feet or so of the bank.

Kamloops and Nicola region.

In road-cuttings behind Kamloops the white silts rest on a deposit which, with little doubt, represents the boulder-clay. The matrix is greyish-blue, rather sandy than argillaceous, and packed with stones which are of all sizes and are not arranged in horizontal layers. Some of these are apparently glaciated, but most are merely more or less completely rounded. There are also in the deposit, frequent obscure traces of bedding which occasionally become distinct. The left bank of the Coldwater, a few miles above the Nicola Valley, shows remarkable sections of drift, which in some places must be over 100 feet thick. Cliffs which appear white from a distance, rise almost vertically above the river, or have been broken down by slides in places, to form a sloping talus. The greater part of the material here seems to be a true boulder-clay, the pale matrix being charged with gravel and boulders of varied origin and all sizes. The brownish, earthy boulder-clay seen in Spi-oos Creek, south of the Nicola, has already been alluded to. It is packed with large, distinctly-glaciated stones.

In the progress of hydraulic mining, which has been practised on a small scale at Cherry Creek, interesting sections of the lower part of the drift deposits in that region, lying within the western border of the mountains of the Gold Range, have been formed. From these it would appear that the gold in paying quantity occurs in pre-glacial gravels, in the bottom of the valley of the stream. This accords with the position of the rich gravels of the Cariboo district, which, in most cases, would also appear to date from a time anterior to the glacial period. In a place where work had been abandoned at the time of my visit in July 1877, the bank shows forty or fifty feet of detrital deposits, resting on the somewhat water-worn, but on the whole rather rough surface of the slaty rocks. Immediately on the rock lies a clean, rough, bouldery wash, above which is a thick or thin layer of find hard sandy material, which shows current-bedding often twisted in a remarkable way, and holds occasional large stones or boulders, some of which are pretty distinctly glaciated. A few clean-washed gravelly beds are intercalated with this sandy layer, but are very irregular in thickness, and generally lenticular. Above this is a considerable thickness of stiff, stony clay, probably true boulder-clay. The stones in this are generally rounded and water-worn, and traces of bedding, which occasionally become quite distinct, occur, and conform more or less to the slope of the side of the valley. Above this are other layers, not very dissimilar in appearance, but less compact, and conforming quite evidently to the side of the valley. These are probably due to the wash of the boulder-clay down the slopes of the valley subsequent to the glacial period. The surface of the underlying rock, in this place, after sloping gradually up to a height of about ten feet above the water of Cherry Creek, falls slightly as it passes under the bank, leading to the belief that a former channel of the stream may be found here. This is also the case in the locality next quoted, which lies a short distance further up the Creek, and if such old channels can be found and followed, this district, as an alluvial gold-mining region, may have considerable permanence. The Christian and Schneider claim is at present the best on the creek. The stratum here resting on the rock and constituting the 'pay dirt,' is a mass of boulders and stones from five to eight feet thick, clayey and much compacted. On this rests the stony clay with traces of stratification, which has just been described, but without the intermediation of the irregular sandy deposits. (see cut on p. 159).

Sections on Cherry Creek.

Gold in pre-glacial gravels.

Probable old river-channel.

Material of terraces.

Of the deposits of the terraces due to the glacial period, varying much locally, no particulars need be given, nor would it be of any interest to describe those of the terraces and flats formed by modern river action, in the lower parts of the valleys. One deposit, however, which probably dates from the latter part of the glacial period, from its uniformity in character and persistance over great areas, deserves mention. This is a white silt, resembling in most respects that which has been described in the northern part of the Province, but geographically separated from that deposit, and here characteristic of a less altitude.

White silt.

The drift materials shown in sections on many parts of the Thompson further down than Savona's Ferry, are markedly finer than those seen on the corresponding part of the Fraser River, but the white silts can scarcely be said to be typically developed here. They are better shown in several places on Kamloops Lake, where, however, they still hold—as they do on a larger scale on the Lower Thompson—gravelly intercalations. At the mouth of Cherry Bluff Creek, cliffs worn into columnar forms, show well stratified and rounded gravels, hard packed, for a thickness of twenty feet or more. Above these is about fifteen feet thick of typical white silt, finely bedded in horizontal layers, (some of which hold flattened calcareous nodules,) and the whole so compact as to stand in vertical faces. On the east side of the valley of Tranquille River, a mile or two from the lake, beds of rolled gravel similar to those just described are seen in cliffs over 100 feet high, which toward the top become interstratified with beds of white silt, of the usual character. The white silt deposits imply the former existence of a tranquil body of water, which must have filled the entire valley now occupied by Kamloops Lake and the Thompson to a considerable depth. The intercalation of gravelly layers—which are at times small in horizontal extent, and lenticular in section—would seem to show that on certain parts of the border of the lake, streams debouched, which at intervals, when in flood, brought down gravel and spread it for a limited distance over the bottom. In conformity with this supposition the thick masses of stratified gravel in association with white silt, are here found at the mouths of the Tranquille River and Cherry Bluff Creek, the valleys of which must always have carried streams of some size.

Cherry Bluff Creek.

Tranquille River.

Intercalated gravels.

Near the town of Kamloops the white silts are found, as above mentioned, resting on the boulder-clay. Gravelly layers occur about the junction of the two deposits, but whether the surface of the boulder clay has been denuded extensively before the deposition of the silts was not ascertained. The upward limit of the main mass of the white silt deposit, is found with an irregular undulating surface in the hills behind the town, at an elevation of about 550 feet above the Thompson River, or 1,680 feet above the sea. Material of the character of the silts occurs still higher than this, but not in any great thickness. On the North Thompson, white silts occur in occasional banks at least as far up as the Barrière River, in the vicinity of which they were seen in one place in an exposure of 100 feet in height. The turbidity of this river is due to material not dissimilar from the silts, and may probably be in great part derived from banks of this deposit yet further up, though a portion may be due to actual disintegration of rocks now in progress, and the glacier streams at its sources in the mountains.

Summit of white silt deposit.

In the valley of the South Thompson, the silt formation is most characteristically represented, forming, as before stated, broad terraces or benches along the sides of the valley, with other surfaces gently sloping toward its axis, where the river has formed for itself a deep subsidiary channel. In some places,—as above Kamloops, on the south side of the valley—the edge of the whole silt bench has been cut by little streams descending at times from its summit, into complicated and ragged edges. The eroded faces are always very steep, and occasionally vertical, and in the sunlight have a peculiar glossy shimmer, due to the great abundance of minute particles of mica, which, when the bank is wet, become arranged parallel to its surface, and on drying adhere in that position. The bedding is generally almost or quite horizontal, and layers of a few inches in thickness succeed one another with great regularity. The deposit is remarkably fine throughout, and no boulders or stones so large as to imply the action of ice were seen. A short distance below Little Shuswap Lake, the silts appear in a bank about sixty feet above the river, but beyond this point are not again met with, nor were they recognized on any part of the shores of the Great Shuswap Lake.

White silts on S. Thompson.

Limit of white silts.

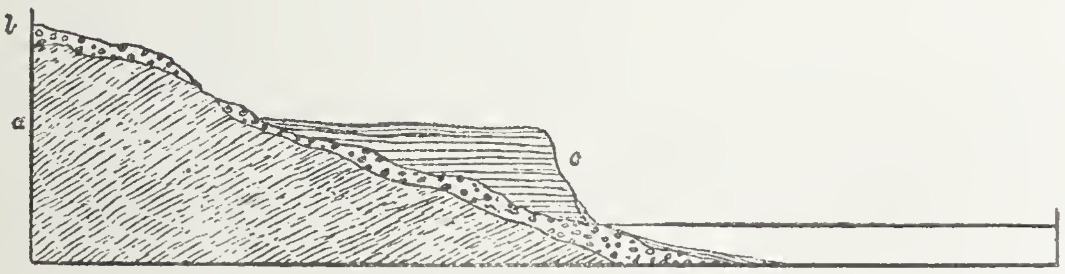

Diagram of Drift Deposits.—Okanagan Lake.

a. Crystalline rocks. *b.* Boulder-clay. *c.* White silt.

In the Spallumsheen Valley, are found deposits resembling the white silts in some respects, but coarser and not so pale in colour. In descending the west side of Okanagan Lake, they seem to be better characterized, and near the Mission are unmistakeable. The shores of

Spallumsheen and Okanagan Valleys.

the southern part of the lake are bordered by a high terrace of this material, the average elevation of the surface of which must be about 200 feet above the lake, or at an absolute elevation of 1,277 feet. Near the head of Du Chien Lake, the deposit is represented by hard, fine sands, but it was not noticed in the vicinity of Osoyoos Lake. On the Similkameen, small patches adhere to the mountain sides, in places at least as far up as Keremeoos.

Some banks on the Lower Nicola appear to hold a proportion of white silt, but so much mingled with stony *débris* from the sides of the valley—which is here narrow—that its true character is masked.

General character of the deposit.

It would thus appear that both in the Okanagan Valley and that of the Thompson and its main tributaries, a deposit characteristically pale-coloured, and composed of fine-bedded silt, occupies a conspicuous place, with an average maximum elevation of about 1,500 feet. The material requires, to account for its deposition, either the tranquil water of a lake, or that of wide inlets with little current. Water standing at the elevation above indicated, would flood not only the valleys of the North and South Thompson Rivers, but open free communication by way of the Shuswap Lakes, between the valleys of the Thompson and Okanagan. As we have already seen, however, the true white silt stops short of the head of Okanagan Lake, and at the lower end of Little Shuswap Lake, and it is difficult to assign a reason why the same deposit should not be found fringing the shores of Shuswap Lake. At the present time, turbid streams flowing into Shuswap Lake, deposit the whole of their suspended matter long before reaching its outlet, and the North Thompson, muddy by reason of its uninterruptedly rapid course, after mingling with the South River and entering Kamloops Lake, flows out perfectly clear at its lower end. It may be suggested that the current in the upper parts of of the valleys was so strong as to prevent the deposition of the silt, but apart from the difficulty of supposing such a great body of water as the valley must have held at this time to be in rapid motion, there is no sudden widening of the valleys where the silts begin to appear, which might have caused such a current to decrease in velocity; nor can other cause be assigned why the material in this case should not have been swept out of the whole length of the valley. At the same time it is evident that the silts, if not derived locally from the borders of the extended lake, could not have been deposited so regularly along a great part of its course unless a current carried the material onward. A lake with absolutely tranquil water or very gentle current would enable the streams entering at the heads of the arms to throw down at once the whole of their burden. It is, perhaps, on the whole, most probable that the basin of Shuswap Lake, with other valleys in the

Mode of its formation.

vicinity of the mountains, were occupied by glacier-ice, from which the water flowed down the long valleys, while the abrasion of the rocky bed of the glacier supplied in large quantity the material for the silt deposits. It must be remembered, however, that while the occasional inclusion of ice-borne stones confirms this view in the northern part of the Province, on the Nechacco and elsewhere, that no such proof has been obtained with regard to the white silts of this region.

Terraces of different kinds

In the plateau region, or that portion of the southern part of British Columbia lying east of the Coast Ranges, terraces are exhibited on a scale scarcely equalled elsewhere. They border the river valleys, and expanding beyond them at higher levels, are found attached to the flanks of the mountains to a great height, though none have yet been found in the district now in question to equal the elevation of that on Il-ga-chuz Mountain in the north—5,270 feet. It is of course important to distinguish between terraces or benches which have been produced by rivers gradually deepening their channels in the unconsolidated materials of the drift, and those marking the former levels of extensive sheets of water which must have depended for their existence on physical conditions far different from the present. Terraces of the former class should be found to slope more or less uniformly downward in the direction of the stream, while those of the latter should be horizontal, or very nearly so, over great areas. In the field, however, it is generally impossible to make sufficiently accurate observations to establish the horizontality or otherwise of the benches, and one must be guided to a great extent by the local circumstances in forming a judgment as to the cause of any particular series of terraces.

The higher terraces, can, however, be due to nothing else than a general submergence of the country. We know that the water must have stood at every lower level as it gradually descended, and it is therefore perhaps not much to be regretted, that in the case of some of the lower terraces it becomes impossible to determine whether they belong to this period of retreat or not.

Terraces of Iron Mountain.

The general appearance and high terraced slopes of Iron Mountain, at the mouth of the Coldwater, have already been described, (p. 32), as has also its heavily glaciated summit, (p. 136,) with an elevation of 5,280 feet. Five of the best-marked terraces on its southern slope were found to have the following elevations, the barometer readings on which they depend having been corrected by comparison with the nearest in time of those taken at the Meteorological Station at Spence's Bridge, by Mr. Murray:—

2,386	3,063	3,392	3,611	3,715	FEET.

The last mentioned is the highest observed, and is quite narrow. Above this, the drift covering becomes thinner, but rolled stones, some of them certainly from a distance, occur to the very summit.

Terraces on Okanagan Mountain.

The elevation of the white silt terrace bordering Okanagan Lake has already been stated as about 1,277 feet. Leaving this, to ascend Okanagan Mountain, south of the Mission, a great series of higher terraces is passed over. The heights of six were noted as follows:—*

1,862	2,042	2,141	2,645	2,800	2,839	FEET.

On the northern slope of the same mountain, six principal terraces were again observed, the heights being:—

1,451	1,579	1,962	2,452	2,553	2,879	FEET.

Benches occur, however, at many other intermediate heights, and those in one place narrow and apparently unimportant, become in another broad and well marked, making it difficult, without a resort to actual instrumental levelling, to correlate the various observations.

Terraces and drift material in Nicola Valley.

A hill on the east side of McDonald's River, near Nicola Lake, was observed to be terraced at several different levels, up to an estimated height of 800 feet above the lake, or about 2,600 feet above the sea. These terraces, which are not deeply impressed, must mark stages in the retreat of water once filling the lake valley to a high level. The Nicola Valley, a few miles below the lake, has its slopes heavily banked up with drift in some places, and this material is also arranged in terraces along the hills, with greater or less regularity. The stones and boulders found in these terraces are not those of the surrounding formations, nearly three-fourths being of pale granites, diorites, etc., like those of the Coast Range, and probably indicating that the glaciers, pushing eastward from the range, at one time reached this point. Where abrupt bluffs or cliffs of rock occur, however, the fragments are, locally, principally derived from them, probably by degradation since the glacial period. The fans of some small streams are in great part composed of the foreign material, showing that the drift, and not rocks of the higher parts of the hills, has contributed chiefly to their formation.

Coldwater River.

On the Coldwater, near the first bridge, a terrace fringes the west side of the valley at a height estimated at 200 feet above the river, or 2,955 feet above the sea. This can scarcely be a river-terrace. On Whipsaw Creek, Similkameen River, a terrace, also estimated at 200 feet above the stream, occurs near Powder Camp. Its elevation above the sea is 3,845 feet. Between Powder Camp and Nine-mile Creek

* Heights corrected as above.

some of the more prominent benches were found to have the following elevations above the sea:—

2,956	3,078	3,237	3,252	FEET.

Some of these may be due to river action, though their appearance and the position they occupy does not favour this view.

The trail, when some distance north of the South Similkameen, above its junction with the north fork, passes over several broad terrace-flats certainly not due to river action. Of these, the two best marked are elevated 2,683 and 2,632 feet above the sea. Near the junction of the north and south forks, a terrace-flat standing about 300 feet above the river, has an elevation of about 2,264 feet above the sea. This is probably not due to river work; but below it, in the triangular area between the two rivers, a number of terraces are found, some of them quite broad, but evidently due to the action of the river when at a higher level, and in some instances still preserving old river channels on their surfaces. Similkameen Valley.

The drift material of the Similkameen has travelled eastward, or down the valley, as is shown by the fact that boulders from the granitic area below Vermilion Forks, continue abundant and large at all levels on the benches, after the granitic outcrops have been left behind. Further down the Similkameen, remnants of terraces are visible in many places. They are, perhaps, best shown in a grassy hill above Keremeoos, where they reach an elevation of 1,000 feet, at least, above the bottom of the valley, or about 2,300 above the sea. Between the Similkameen and Osoyoos Lake, a broad terrace-flat has a height of 1,400 feet above the sea. North of Osoyoos Lake, in the same valley, several flat terraces, at a level of about 1,360 feet, were noted.

On the north side of Mission Creek, Okanagan Lake, broad terraces were observed at the following heights:— Okanagan Lake and vicinity.

1,395	1,414	1,453	FEET.

Further north, the bench separating Okanagan and Long Lakes, in a gap in the hills which usually lie between them, has an elevation of 1,380 feet. The extensive flat near the Cherry Creek mines has an elevation of about 2,256 feet. In the valley connecting the head of Okanagan Lake with the Elbow of Salmon River, the widest bench has an elevation of 1,430 feet, while a second, 100 to 130 feet higher, is seen above.

In a wide valley followed for some distance by the trail between Okanagan and Vermilion Forks, a rather irregular bouldery bench with an elevation of 3,713 feet occurs. It is on the rim of the valley and far above the level of the stream. Above Kamloops, a terrace at a height of 2,855 feet was noted. The trail between Guichon's Creek and Kamloops Lake passes over wide terrace-flats at an elevation of 3,116 feet.

Terraces on eastern slope of Coast Range.

The terraces so far quoted are examples of those found in the region east of the Coast Range, where the surface of the country is almost everywhere deeply covered with drift deposits. In the valleys of streams draining westward from the mountains, there is a remarkable absence of detrital deposits, (p. 48), and though a few terraces occur, the valleys are much contracted, and in a region so mountainous that it is generally difficult to decide precisely what significance attaches to them. Not only may some of them be merely river-terraces, but others may simulate beach-terraces, but owe their origin solely to the damming up of valleys by glacier ice or moraines. At the summit between the Coldwater and Coquihalla a terrace with an elevation of 3,286 feet is found. On the Skagit, a rough but broad and well-marked bench is crossed by the trail at an elevation of 1,997 feet. On the Uz-tlī-hoos, tributary to the Anderson River, narrow but well-marked benches occur at 3,087 and 3,582 feet.

Terraces on the Fraser near Yale.

Notwithstanding the scarcity of drift materials on the eastern side of the Coast Ranges, and the uncertainties above alluded to, the evidence goes far to prove that a general submergence of the country on both sides of the range has occurred. "In travelling up the Fraser valley through the Coast Range, one has the widest opening anywhere existing through these mountains at one's back; yet, step by step, the terraces can be followed from near the sea-level, to the highest water-marks observed. At Yale, on the outer border of the range, 160 feet above the sea, are terraces with narrow treads, composed chiefly of angular *débris*, but forming well-marked horizontal lines on the mountain-slopes. One of these, barometrically measured by my friend Mr. A. Bowman, was found to have an elevation of 800 feet above Yale. The highest perfectly distinct line was estimated to reach 1,500 feet. It may be open to question whether these benches may not be remnants of lateral moraines of an old great glacier which has filled the valley. They look, however, like shore-lines caused by the accumulation and horizontal arrangement below the water-line of *débris* from the mountain-slopes."

Boston Bar and northward.

"Following the gorge or cañon of the river through the Coast Range, besides lower terraces from 100 to 200 feet above the stream, everywhere visible, occasional fragments of benches bearing a close resemblance to those at Yale, may be seen perched far up on the mountain-sides. About a mile above the Stoyoma River of the Admiralty map (twenty-five miles above Yale) some of these were estimated to be as much as

2,000 feet above the water, or about 2,450 feet above the sea. At Boston Bar, terraces estimated at about the same height were seen. Near Lytton the Thompson River joins the Fraser, the valleys become wider, and the terraces well-defined and broad. One, barometrically measured, is 1,680 feet above the sea; others stand at estimated heights of from 1,780 to 1,880 feet. Further up the Thompson a terrace, again barometrically measured, was found at 1,600 feet, and a second, well defined, estimated at 1,900 feet. These are no doubt the same as the two last mentioned. On the Bonaparte River (tributary to the Thompson), four miles north of Cache Creek, a terrace estimated at 2,820 feet occurs, and further on, at Maiden Creek, one barometrically measured at 2,680 feet. On entering the Thompson valley the material of the terraces becomes much finer and more argillaceous than on the lower Fraser. In some places several hundred feet of nearly horizontal clay beds are exposed in transverse ravines, and seem to form the material of the terraces running along the sides of the valley. The lower terraces, which are always the best-preserved, are seen in many places to spread quite widely, and their deposits (shown in sections both parallel and transverse to the valley) to lie in beds nearly horizontal, or with a slight sag towards the centre. Individual gravel beds can sometimes be traced in the banks for a mile or more."*

On the Thompson and Bonaparte.

The estimates of heights given in the above extract lay no claim to accuracy, and are not like those given on previous pages based on comparison with a fixed barometric station. They are instanced for the purpose of extending the general facts in regard to terraces to the main valleys of the Fraser and Thompson, and to show the apparent continuity of the phenomenon throughout this, the main gap through the Coast Range.

Moraines not common.

Comparatively few instances of distinct morainic accumulations were observed in the district under examination. The subaërial agencies which have led to the degradation of the older terraces appear in most cases to have destroyed the characteristic features of moraines, which must certainly have been formed in the valleys carrying glacier ice.

Moraines at Shuswap Lake.

At low water, the outlet of Little Shuswap Lake is obstructed by several large boulders, and on examining these they are found to be merely the highest of a mass of similar fragments across which the river flows out. These are too far from the slopes of the neighbouring mountains to be accounted for on the supposition that they have rolled down from them into the place in which they now are, and are with very little doubt the remnants of an extensive moraine, to which is due in great part or entirely the existence of the lake.

* Quart. Journ. Geol. Soc., Vol. XXXIV, pp. 111-112.

Nicola Valley

The accumulation of granitic and syenitic rocks about the west or lower end of Nicola Lake, has the appearance of being the residuum of a moraine, or at least marks the limit in extension, for a considerable period, of the glaciers of the Coast Mountains in this region. On the Thompson River, near the 'eighty-nine mile stable,' about twenty-four miles from Lytton, another somewhat similar and probably morainic accumulation of granitic rocks is found. This no doubt has the same significance as the last mentioned.

Osprey Lake.

A short distance westward from Osprey Lake, a very distinct straight moraine runs across the valley, broken in one place by the passage of the stream. Benches giving evidence of contemporaneous water action, also occur. The elevation is 3,162 feet.

Moraines near Clinton.

In the valley followed by the road between Clinton and Kelley's Lake, some distinct moraines, due to local glaciation, are seen. They occur near the junction of a large branch valley; down this a glacier has passed, abutting on the slope of the main valley opposite, and spreading out laterally in the hollow. Three tiers of mounds are clearly seen, left by one side of the great glacier as it gradually retreated. Shallow pools lie between the mounds. The mouth of the tributary valley now shows a low terrace, which must have been formed by water since the period of glaciation to which the moraines are due.

Remarkable erratic.

The most remarkable erratic noted, is one which rests on the glaciated surface of a small rounded rocky hill which stands in the centre of the valley, near Coldstream. (see Plate 5.) This boulder is twenty-two feet long, sixteen and a half wide, and eighteen feet high. It is yellowish, highly calcareous and interstratified with layers of felspathic and quartzose materials, all the beds being much contorted. The rock on which the erratic stands is quite different in appearance from it.

General conclusions, and possible modes of glaciation.

In attempting to cover with any general theory the traces of the last great period of cold, generally known as the glacial period, in a district the physical features of which are so well marked and so varied as those of that now under discussion, much difficulty is felt, owing to the great number of possible combinations of circumstance. The earliest recognized traces of the period of cold, are doubtless the markings on the surface of the plateau, or high lands in connexion with it, which indicate the southward passage of massive ice. These, by the observations above detailed, have now been found in different parts of the interior plateau for a distance of over 300 miles, and traced up, on Iron Mountain, to a height of 5,280 feet. Erratics and drift material, with evidence of water action, occur to a like elevation. When compared with the ice-markings found in the lower valleys, and

Character of high-level glaciation.

PLATE V.—ERRATIC IN THE COLDSTREAM VALLEY, B. C.

to those of the south-eastern extremity of Vancouver Island, known to be due to glaciers, those of the higher parts of the interior plateau are less definite. The rocks are frequently well polished, with striæ faintly marked, and varying several degrees in direction. Heavy grooving or fluting like that frequently observed where true glaciers have been at work, is seldom or never seen, the nearest approach to it being on the summits of Tsa-whuz* and Iron Mountains.

Theories accounting for the facts.

As elsewhere more fully shown,† it is necessary, to account for the formation of the boulder-clay, with its water-worn stones, and for the highest terraces, to suppose that water has stood above the higher summits of the Interior Plateau, reaching an elevation of at least 5,270 feet above the present sea level. It then becomes a question whether, at this period of submergence of the plateau, the striation of the rocks, even of its higher parts, also occurred; or whether, to explain this, it is necessary to suppose a previous condition, in which the whole interior of the Province was buried in a confluent glacier-sheet. We have evidence of the extension of glaciers down the lines of the main valleys from the mountain systems, which involves the covering with glacier-ice of a great portion of the plateau, under either hypothesis; also evidence of the existence, locally, of glaciers on the higher parts of the plateau itself, and some evidence of the movement of glacier-ice from the interior, through the gorges in the Coast Range toward the sea. These facts, taken in connexion with our knowledge of the immense glaciers of the coast at this period, seem to render it not improbable that such a great confluent glacier as that supposed did indeed, at an early stage of glacial time, cover the interior of the Province. Leaving out of consideration the minor valleys, and taking the average elevation of the plateau, as before given, it will be evident that the supposed glacier-sheet, merely to cover the highest known glaciated points, need not have been much more than 2,000 feet in thickness, and it is probable that in the greater part of its extent its movement was very sluggish, and that only in the neighbourhood of those gaps through which its excess of material was forced, was well-marked grooving and fluting of rock caused. The greatest southern efflux was doubtless by the valley and surrounding comparatively low country of the Okanagan, while by the valleys of the Fraser, and other gaps in the Coast Ranges, it must also have discharged. For the cause of its movement we must look chiefly to its own mass, and the pressure of the ice from the regions of greatest precipitation, which must have been to the north of the fifty-fourth parallel.

Probable great glacier.

Its thickness and movement.

* Report of Progress, 1875-76, p. 261.

† Quart. Journ. Geol. Soc., Vol. XXXIV, p. 89.

Hypothesis of an arctic current.

It is well to remember, however, that the hypothesis of an arctic current bearing heavy polar ice through the Peace River gaps at the north, and thence southward down the region of the plateau, would serve almost equally well to account for its glaciation. Any theory of the cause of these traces of the earlier glaciation should at present be held tentatively, and subject to the result of further exploration.

Possible formation of a lake dammed by glaciers.

Regarding British Columbia by itself, it would appear that we may account for the action of water at great heights, the transport of erratics, formation of boulder-clay, and almost contemporaneous production of the higher terraces, under the supposition that a great inland lake was formed between the glacier-masses of the various mountain ranges when the ice began, under an increase of temperature, to retreat from the plateau. Such a lake it may be supposed gradually enlarged, the water level at the same time lowering, till by the decay of the ice blocking the various valleys it was at length drained. The damming in of the water at the height required involves, however, the co-ordination of so many circumstances that it appears to me improbable, while on the eastern slopes of the Rocky Mountains we seem to have clear proof of the invasion of waters which can not have been other than those of the sea to a height not far inferior to that required by the highest water-marks in British Columbia.* It is highly probable that this part of the Pacific coast stood at an elevation greater than at present in times immediately preceding the glacial.† It may have retained this altitude during the epoch of great confluent glaciers just referred to, but if I am right in attributing the flooding of the interior to the sea, we find a rapid subsidence of the land coincident with the decay of these vast glaciers. We may perhaps, with greatest probability, assign the clays and other deposits of the south-eastern portion of Vancouver Island, (which while holding marine shells and indicating a stage of the sea higher than now obtains, have evidently been laid down at the heel of the retreating great glacier of this region,) to the earlier stage of this subsidence, instead of to the close of that partial revival of glaciers which occurred afterwards.

Evidence of water at high-levels.

Second period of cold.

Of the second short advance of the glaciers on the plateau, from the mountains, the evidence is found in a region to the north of that treated of in the present report. It is detailed in the paper already more than once referred to, and nothing in addition has since been learned concerning it.

It may be supposed that the white silt deposit in its margin

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* Geology and Resources of the 49th Parallel, p. 258, Quart. Jour. Geol. Soc. Vol. XXXI. p. 618.

† Canadian Naturalist, New Series, Vol. VIII, p. 241.

toward the Gold Ranges, marks the degree of extension of the glaciers from these mountains at the time of its deposition. Its general level approximately shows that at which the water filling the valleys of the Interior Plateau stood at the same time. Whether this was in free connexion with the sea, or formed a great ramifying lake in the southern portion of the plateau, it appears to have found its outflow by the Okanagan Valley, while the gaps in the Coast Ranges may have been stopped by ice. At the last, it seems probable that the glaciers retreated with considerable rapidity, becoming extinct, or dwindling to nearly their present size, and leaving the upper portions of the valleys which penetrate the Gold Ranges almost free from *débris*, and ready to form the deep basins of the lakes which now generally occupy them.

Significance of the white silt.

Minerals of Economic Value.

It is proposed under this head, briefly to recapitulate the localities already mentioned as yielding minerals of economic value, or indications of such; also, to mention some additional localities and points in further explanation of those before noticed.

Gold.—This metal has seldom been found *in situ* in the region embraced in the present report, but occurs in remunerative quantities in placer deposits in a number of localities. These are generally found to lie on, or in the immediate vicinity of, certain black slaty rocks, from quartz veins traversing which the alluvial gold appears to be derived. In the search for gold placers, the extent and distribution of these slaty areas consequently becomes important, and though only a portion of the streams flowing over the slaty regions hold gold in paying quantity, a knowledge of their position may serve to deter too great expenditure of time in prospecting places probably barren, and turn attention to regions which promise better. These slaty rocks are those which have frequently been referred to as included under the Anderson River and Boston Bar series of the preliminary classification. Rocks undistinguishable in lithological character from those of the typical region, may, it is true, occur on other geological horizons in the district under review, but no clear evidence of this has yet been obtained. The rocks are generally black or very dark, slaty or schistose, often more or less markedly calcareous, and not infrequently micaceous or plumbaginous, more rarely chiastolitic. It is probably to the presence of a small quantity of organic matter in the sediments from which these rocks have been made, that their metalliferous character is due. Their fissile structure has subsequently rendered them easily permeable by waters, which have concentrated the minerals of economic value with quartz and

Gold found in regions of slaty rocks.

Character of the rocks.

other crystalline materials of secondary origin, in the veins. The rocks, in their more typical localities, appear to lie between those of the Cache Creek groups—Carboniferous—and the upper Mesozoic rocks already described as similar in age to the Shasta group of California. They seem to rest conformably on the former series, and even to blend with it, while the latter is built up on their upturned edges. They differ in appearance from the recognised Jurassic rocks of the Iltasyouco,* and have yielded no fossils, with the exception of the obscure impressions referred to on a former page (p. 66). While a portion of these rocks may represent Jurassic beds differing from those of the Iltasyouco region by reason of the want of volcanic materials, part at least would seem not improbably to represent the Triassic period, or even to pass downward into the Upper Palæozoic. They are not very markedly different from the slaty rocks of the continuation of the same mountainous belt in California, which are highly auriferous, and supposed to be at least in great part Triassic.

Age of the rocks still doubtful.

Gold on the Lower Fraser.

On the lower part of the Fraser River, embraced in the present report, no important gold-yielding bars or benches can now be mentioned, though this was the first region to attract the gold-miner to British Columbia, and yielded largely in the earlier days of the gold excitement. Here it would appear, as the result of enquiry, that the richest bars and those yielding the heaviest gold, were found precisely in that reach of the river which is occupied by the slaty rocks above mentioned. The rapid character of the river has, however, led to the distribution of the finer particles of gold throughout its entire course. No deposit of any great extent, as rich as those at first worked on the Fraser, is again likely to be found, as its valley is generally quite narrow, and the upper benches, as well as the bars near the level of the stream, have been well prospected. A considerable quantity of gold is, however, still obtained from the Fraser when the water is at a low stage, for the most part by Chinamen and Indians. It is also probable that many of the benches will eventually pay for working by the hydraulic method.†

Gold first found at Nicoamen.

From the Thompson, near Nicoamen, the first gold known to have been found in British Columbia was brought, (in 1857,) and this locality has continued to yield a considerable quantity of gold at the lowest stages of the water. The gold is in large particles, and is obtained by the Indians in crevices among and beneath the stones in the river. No rocks of the slaty series are known near this place, or for some distance above it, and it is not improbable that the gold may here be derived

* Report of Progress, 1876-77, p. 59.

† See also on the Fraser River, Report of Progress. 1871-71, p. 56. 1876-77, pp. 118, 141.

from some of the igneous rocks of the Tertiary. The occurrence of gold in rocks of igneous origin, in such quantities as to produce paying placer deposits, has lately been distinctly proved in several cases, in other parts of the world, and should be borne in mind.* Possible occurrence of gold in igneous rocks.

On the Nicola River, gold in thin scales has been found for about eighteen miles above its confluence with the Thompson. This district is also based entirely on volcanic rocks and the remarks made in connexion with Nicoamen may apply to it also. It is possible, however, that fine gold may in some instances have been carried far by the agency of ice and currents to which the distribution of material in the later portion of the glacial period is due. Gold on the Nicola.

Tranquille River, flowing into Kamloops Lake, was worked before 1862, and has afforded occupation to a varying number of miners every year since. Of late years it has fallen almost entirely into the hands of Chinamen, of whom an average number of twenty to thirty are usually at work. The placers on this stream at one time yielded largely, and the Chinamen are supposed to make over fifty dollars a month on it still, though it is impossible to ascertain this with any certainty. The gravels worked are those forming the banks or bed of the stream, or flats immediately adjacent to it. The flats are in a few places pretty extensive, but shallow. The bed rock is of the Tertiary volcanic series already described (p. 117) but it is probable that the gold has originally come from older rocks which may be exposed further up the stream, as it is in larger particles in the upper reaches. It has been found for a distance of eight miles in all from the mouth. Most of the gold is scaly, and mixed with it are particles of platinum, similar in shape and size to those of gold. Besides the gravels near the level of the present stream, an older series is exposed in banks about 100 feet high on its east side, and are interstratified toward the summit with the white silt deposit. The gravels are bedded, and the stones well rounded, reaching in some cases a diameter of six or eight inches. The deposit is evidently a remnant of a rough delta formed by the Tranquille when the water of the lake was at a higher level, in times immediately succeeding the glacial period. It should contain gold, but I could not learn that it had been found to do so in paying quantities. Placers of the Tranquille River. Platinum.

At Louis Creek, on the lower part of the North Thompson, gold in paying quantities has been discovered, and was at one time worked. Some gold has also been obtained, I was informed, in a small stream near the saw mill, on the west bank. The rocks of the North Gold on the North Thompson.

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* See especially R. Daintree on modes of occurrence of gold in Australia, Quart. Journ. Geol. Soc., Vol. XXXIV, p. 431.

Thompson are elsewhere described. They hold blackish schistose or slaty layers, though probably older than those of Boston Bar.

Coquihalla River.

The continuation southward of the slaty rocks of Boston Bar, on the Coquihalla, has already been described. Notwithstanding the similarity of the formation, however, little gold has been found on this river. Good prospects have been obtained on Ladner's Creek, and also on Pierre River, which is the next tributary below it. There is little gravel deposit in these valleys, and the streams are rapid and full of boulders.

Gold and platinum on the Similkameen.

Three and-a-half miles above Vermilion Forks, on the South Similkameen, gold mining has been carried on for several years, though never employing a large number of men. A few Chinamen were working here at the time of my visit in 1877. The gold is obtained in the gravel of the lowest terrace-flat, which never rises over about twenty feet above the river. This rests on the worn surface of the Tertiary clays and shales, which form the bed-rock, and have been reached in many places, but only when the river is at its lowest stage, thus restricting the season of profitable mining. The gold is generally found in coarse scales, and is mixed with a considerable proportion of platinum in similar sized particles. Of this latter metal Messrs. Allison & Hayes secured for me about an ounce, by requesting the Chinamen to save it. The gravels hold many coarse pebbles, large stones and even boulders. These are chiefly of greenish rocks like those of Whipsaw Creek, but also include Tertiary igneous rocks and granite. The source of the stones of the gravel should be that of the gold, and the evidence favours the belief that it is derived from the green series above referred to, or from the slaty rocks associated with these. It is remarkable, however, in this case, that no paying deposits of gold have been found on Whipsaw Creek itself.

The Tulameen, or North Fork of the Similkameen, though yielding abundant 'prospects' has never, I believe, afforded remunerative employment to a large number of miners.

Further down the Similkameen, gold has been found in a few places, notably in the vicinity of the Twenty-mile Creek, where it was worked for some years. In the cañon near the forty-ninth parallel a considerable quantity of gold was got in 1858-59-60. This region soon abandoned by the whites, was worked for years by Chinamen.

Placers on Rock Creek.

Rock Creek continues to afford profitable employment to a few men. "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."*

Gold in small quantities has been found on several streams flowing into the Okanagan Valley, but the only one of these which has proved of importance is Mission Creek. The locality worked is situated about seven miles from the mouth of the stream, where it is found issuing from a narrow rocky gorge, into a wider valley. Some years ago mining was carried on in the bed of the Creek, and very good pay got for a time, in a reach of about half a mile below the gorge above mentioned. Two or three ounces of gold were obtained *per diem* to the hand in some instances. No remunerative ground was found above the gorge or cañon. The mining now in progress is on the lowest bench, or river flat, the 'pay dirt' in the McDougall's claim (which was the best at the time of my visit in 1877) being a 'cement,' or gravel consolidated by calcareous matter, which is probably local in origin. This rests upon a 'bed rock' which the miners call a rotten slate, but which is really a dark colored bed of the Tertiary formation, which here overlaps the older rocks. The gravel of the flat rests on the Tertiary beds, which a little further from the cañon become yellowish, and paler in tint, but are all fine-grained clays or shales. Nodules of iron-stone derived from the Tertiary are abundant in the gravels, but were not observed in place. The pay dirt in the McDougall's Claim is about three feet thick, and has to be stripped of eight feet of useless gravel. It was wheeled in barrows to the river, about twenty yards, and washed in two lengths of boxes, though as all the gold is coarse, it is stopped for the most part at the first riffle.

Mission Creek.

Paying ground limited.

'Bed rock.'

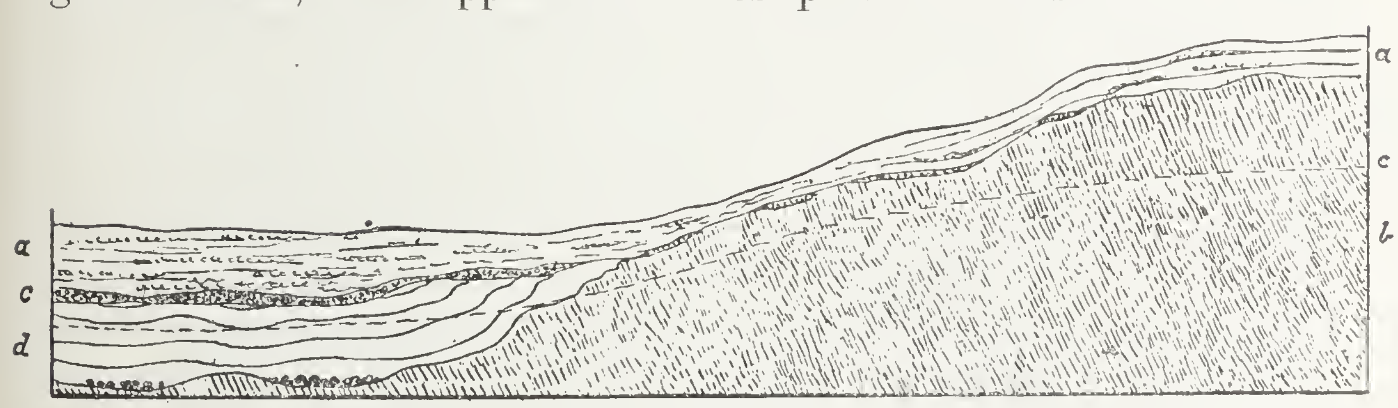

DIAGRAM REPRESENTING MODE OF OCCURRENCE OF GOLD. MISSION CREEK.

a. Recent gravels. *c.* Auriferous gravel.
b. Crystalline rocks. *d.* Tertiary deposits.
e. Line representing present bed of stream.

The rocks seen in the cañon are gneissic, of the character of those so extensively developed east of the south end of Okanagan Lake. About a quarter of a mile from the lower end of the cañon they are

* Report of Progress 1876-77, p. 143.

very regularly arranged, but lower down are cut by faults and traversed by quartz veins. At the lower end of the cañon the Tertiary deposits overlap these rocks, as above noted. Gold has been found in gravels resting on the surface of the old rocks, but in irregular pockets formed by the uneven hollows into which they are worn. It is not until these gravels are found spreading more widely, and in thicker masses over the Tertiary beds, that the richer gold deposits occur. The precise junction of the Tertiary with the underlying rocks was seen in one place. The latter were superficially decomposed and shattered, and passed upward into a clayey breccia which was soon followed by clays and shales. Had the lower bed of the Tertiary been a water-formed conglomerate, instead of having the character above described, it would probably form a rich gold-bearing horizon. Such water-worn materials marking the courses of streams of pre-Tertiary age must occur in many places throughout the gold-bearing districts, and though now difficult to find, may probably, if discovered, yield rich returns.

Possible Tertiary placers.

The richest deposits of Mission Creek have doubtless been already worked, but it is not impossible that some of them would pay for working again, at present prices, or that some of the higher benches might yield profitable returns by the hydraulic method.

Gold on Cherry Creek.

Cherry Creek, a tributary of the Shuswap River, has yielded a considerable quantity of gold, and still gives employment to a few white miners and a number of Chinamen. The portion of the creek which has proved remunerative is that part of the South Fork extending for about three and a-half miles above its junction with the North Fork. The actual valley of the stream is here a narrow depression about 225 feet in depth, which scores the bottom of a broadly rounded valley, beyond which the mountains rise. This valley must have existed and carried a stream similar to the present in pre-glacial times, and it appears highly probable that the pre-glacial stream occupied, at least in part, the actual river course now pursued by its successor. When the glacier-ice—which doubtless extended thus far from the axis of the Gold Range—retreated, leaving the valley blocked with moraine material and boulder-clay due to action at this time, or in that immediately following it, the stream again taking its way down the valley began anew to excavate its bed. The soft materials were rapidly removed, the stream at first changing its bed frequently, but at last subsiding into the deep narrow valley in which it now flows. In some places this would appear to be identical with the original valley, while in others it is probable that a new course has been cut out in the rocky floor of the wide valley, leaving the old channel yet buried with drift on one side of the present. The cañons with steep rocky sides may represent such places, in which the stream

Mode of formation of the valley and its deposits.

has abandoned the pre-glacial channel, and cut for itself a more direct course across some projecting rocky point.

DIAGRAM SHOWING POSSIBLE POSITION OF PRE-GLACIAL CHANNEL OF CHERRY CREEK.
a. Auriferous gravel. *b.* Boulder-clay and overlying drift.
c. Slaty rocks with water-worn surfaces.

Method of working.

Such is a theoretical account of the Cherry Creek Valley, which is, I believe, borne out by the facts, and if so becomes available as a valuable clue in tracing out the gold deposits. The nature of the clays and sands filling the valley has already been referred to on page 141. Gold was originally worked in the bed of the stream by wing-damming, and this mode is still followed; but at the time of my visit in 1877, the best paying claim was one owned by Messrs. Christian & Schneider, which was situated on a little bench, about thirty feet above the stream. The outer edge of this bench, and the slope between it and the creek, is composed of rock, in following the surface of which under the bank, it is found to be covered with from five to eight feet of rough, bouldery gravel, which constitutes the 'pay dirt.' The rocky surface is also found to be smothly water-worn, and to slope away beneath the bank, and is soon buried under a great thickness of the stony clays. It would appear that the course of the pre-glacial stream was here to one side of the present, an idea confirmed by the fact that the bed-rock is found to slope away under the bank in the same manner in two other places at an extreme distance of about 300 yards. It is by no means improbable that this channel may leave the present, and running round to the left of the little hill at the cañon which separates the upper from the lower workings, may again join the present valley. If such a fact can be proved for this or any other similarly circumstanced part of the stream, a considerable area of 'deep diggings' would at once be defined.

Probable old channel.

Yield.

The claim above-mentioned was yielding, I was told at the time of my visit, about $10 a hand for each working day. The bank overlying the 'pay dirt' was being removed by the hydraulic method. During the autumn of 1877 a nugget worth $130, besides two others worth $90 and $40 respectively, were obtained in this claim.

Quality of the gold.

The prevalent rocks in this part of Cherry Creek are blackish slates and shales, which are traversed by many quartz veins, including those which held the silver mentioned on a subsequent page. The gold obtained here is worth from $15.60 to $16 per ounce, containing a considerable percentage of silver.

Scotch Creek.

Scotch Creek, flowing into Shuswap Lake from the north, has yielded some heavy gold, but no mining is now going on there.

Quartz with gold and silver.

About fifteen miles from Clinton, near the stream which flows from Kelley's Lake, Mr. F. W. Foster has discovered a quartz vein, a sample of which has yielded on analysis, in San Francisco:—Gold, 1·21 ounces; silver, 2·43 ounces to the ton, with $\frac{6}{8}$ of one per cent. of copper.

Specimens of pyritous quartz from the veins of the vicinity of Cinnemousun Narrows, mentioned on p. 100, have been examined by Dr. B. J. Harrington, but prove to hold little of value. Two samples yielded traces of gold, and one of them 0·088, the other 1·02 oz. of silver to the ton.

Localities of occurrence of coal and lignite

COAL AND LIGNITE.—The circumstances bearing on the character and extent of these beds, being precisely those affecting the strata as a whole, have been discussed at as great length as the present report admits, on previous pages. It will only be necessary here to mention the different localities, and refer to the page on which an account of each will be found. Coal and lignite are only known, within the area now in question, to occur in the Tertiary rocks, a circumstance which imparts to these later beds a peculiar interest.

Fuels which, without impropriety, may be called coal, have been found only on the North Thompson (p. 113), and near the junction of the Nicola and Coldwater Rivers (p. 122). Lignite coal occurs at the latter locality, at Guichon's or Ten-mile Creek (p. 126), on the North and South Similkameen (pp. 130, 132) and at Hat Creek (p. 120). It is also reported to occur on the Fraser, near Lillooet, on the Thompson not far below Kamloops Lake, and on the upper part of Kettle River.

Silver at Hope.

SILVER.—Of the deposits of this metal near Hope, few particulars in addition to those already given in the Report of Progress for 1876-77, p. 131, have been obtained, nor has any work lately been performed here, though attempts haue been made to sell the property. Mr. J. Fraser Torrance, however, states that the rocks in the vicinity of the vein, and forming the higher parts of Silver Peak, are conglomerates. These are probably of the Jackass Mountain series.

Silver ore of Cherry Creek.

The occurrence of rich silver ore at Cherry Creek has been known for some time, and an attempt to develop the deposit, made some years since, while resulting in a considerable expenditure, was not prosecuted far enough to test thoroughly its nature and extent. At the time of my visit, in the summer of 1877, it was impossible to tell the exact course of the lode. It crosses Cherry Creek obliquely, and, I was informed, had originally been traced for about seventy feet, chiefly in the bed of the stream. All the ore at first visible had, however, been excavated and a couple of small shafts sunk on the lode, from which ore was obtained, but which were subsequently invaded by the stream and completely filled with rubbish. The deepest shaft was said to be thirty feet, and it was abandoned on account of the disappearance of the lode, which first became very narrow, and then seemed to be completely pinched out. On the bank of the stream, on the presumed line of continuation ef the vein, an adit was begun, but driven for fifteen feet only. Small and rather irregular veins, which appear to hold rich ore are visible in this. The slaty rocks through which the lode runs are greyish and blackish-grey. They change their direction of dip rather suddenly near the mouth of the adit, a circumstance which may be connected with the pinching out of the vein at this place. On the opposite side of Cherry Creek, some yards further up stream, and in the direction which the lode may be presumed to follow, a mass of quartz traverses the slates, but appears to be quite barren of valuable minerals. Character of the deposit.

The accessibility of Cherry Creek, and the cheap rate at which supplies can be obtained there, as compared with Cariboo and other mining districts of the Province, should encourage further prospecting in this region, and especially the complete testing of the value and extent of the original locality above described. The ore is probably freibergite, with a little galena and blende, in a quartzose gangue. Fragments broken from a mass of the richer quality of the ore weighing about twenty pounds, so as to represent all parts of it, yielded to Dr. Harrington on assay at the rate of 658·43 ounces of silver to the ton. Richness of the ore.

Pellets of argentiferous galena found in the sluice-boxes on Cherry Creek, above the known lodes, assay at the rate of 220·93 ounces to the ton, and show the existence of lodes not yet discovered. Quartz veins are numerous in the surrounding district, and some of them were observed to contain galena which, judging from that above mentioned, should also be highly argentiferous. About two and a half miles up the north fork of Cherry Creek, a rather irregular mass of quartz, formed apparently by the intersection of several smaller veins, is found. From this, several tons have been blasted, and a sample assayed yielded, I am told, $300 worth of silver to the ton. This assay, however, represents a portion of the rock much richer than the average. Specimens collected by myself gave, on assay by Dr. Harrington:— Other argentiferous deposits.

	oz.
Silver	8·254
Gold	0·058

In the walls of the cañon below the first-described lode, a very well-defined vein is seen in the cliffs on both sides of the river. A vertical section of about 150 feet is thus made, showing the vein to be over ten feet thick in some places, and never very thin. It does not appear to be richly metalliferous, but holds some galena, with spathic iron and iron pyrites.

Small pellets of native silver have been found in gold placers on the Similkameen and on Mission Creek.

Iron.

IRON ORE occurs in considerable quantity in Cherry Bluff, Kamloops Lake (p. 118) and on Iron Mountain (p. 122). It is also reported to exist in a vein eight feet wide, in a ravine half a mile below Nicoamen, but this locality was not visited.

Localities of occurrence of copper.

COPPER—In small veins at Copper Creek (p. 116) and at Cherry Bluff, Kamloops Lake (p. 117). In schists at Copper Island (p. 98), and in traces in other localities on Shuswap Lake. Fragments of rich copper ore, and of native copper, have been found on the Thompson.* Pellets of native copper also occur occasionally in places on the Fraser, and have been found on the Similkameen. Near McDonald's Creek, running into Nicola Lake, fragments of rich copper ore were found, which did not appear to have travelled far.

Bismuth.

BISMUTH—In long, prismatic crystals of the sulphide, enclosed in thin veins of quartz, was found to occur on the north-east side of Little Shuswap Lake, a mile and three-quarters from its upper end.

Mica.

MICA—Occurs in large crystals, in veins in granite rocks in the vicinity of the North-east Arm of Shuswap Lake, and may possibly be found in deposits of commercial value.

Localities of occurrence of limestone.

LIMESTONE—While abundant in some localities, is altogether wanting over considerable areas, and from the rough character of the country, it cannot be carried far for ordinary purposes. It may be useful to enumerate the localities in which it was met with in the vicinity of roads, travelled routes and rivers.

About four miles above Hope, on the same side of the Fraser, a limestone bed occurs. Lime has been made from it, but it is reported to be of poor quality.

On the main waggon road, limestone occurs at a little more than six miles above Yale, but is siliceous and unfit for burning.† Three-

* Report of Progress, 1876-77, p. 148.

† Report of Progress, 1871-72, p. 63.

quarters of a mile beyond the thirty-ninth mile-post, a grey, laminated limestone is seen in the cutting at the side of the road. It is not over 100 feet thick, and probably considerably under this thickness, but appears to be pure and suitable for making lime. At a short distance above Spence's Bridge, massive limestones appear on the road, and continue for some miles on both sides of the river. They are often well exposed and of good quality. Similar limestones also occur in many places on the Bonaparte River. Marble Cañon is walled almost throughout its length by limestone, which also forms entire mountain masses between Clinton and the Fraser. On the North Thompson as already mentioned, (p. 82), limestones were observed in several places. Of these the nearest outcrop to Kamloops, is six and a-half miles off, opposite station picket 4,275 of the Railway location line of 1877. It is pure, and would make good lime. On the north bank of the South Thompson, ten miles above Kamloops, extensive exposures of good limestones are also found. (p. 80). Limestones appear on the shores of Great Shuswap Lake in a number of places, of which the most notable is about one and three-quarter miles south of Cinnemousun Narrows, on the west shore. It has been altered to a rather coarsely crystalline nearly white marble, and though often rather shaly in its bedding, has thick massive layers at intervals and is in the aggregate, of great thickness. The weathered surfaces along the shore are now uniformly grey, and curiously pitted. It is very pure in most places, would make excellent lime, and is well situated for shipment. Just north of the first rocky point on the west shore, at the mouth of the Shuswap or Spallumsheen River, a similar marble is found in great thickness. It is highly silicious in some places, but there are bands of considerable width which would make good lime. On the south-east shore of the western arm of Shuswap Lake, marble and limestone are found in numerous localities, and are in some instances suitable for burning, though it would be necessary to avoid the impure and silicious layers.

Limestone on Waggon Road.

Limestone near Kamloops.

Limestone on Shuswap Lake.

On the south side of the dry transverse valley which connects those of the Shuswap or Spallumsheen, and Salmon Rivers, a bed of white saccharoidal marble crops out. It appears to be pure, and would probably yield good lime. On the upper part of the Salmon River a small outcrop of limestone occurs. It is of poor quality.

At the lower end of Grande Prairie, before the bridge across Salmon River is reached, limestone occurs in a cutting at the side of the road. It is also seen in large masses in the hills on the opposite side of the valley. Between the head of Okanagan Lake, and the north end of Long Lake, limestone of good quality occurs in the immediate vicinity of the road in abundance. It is unnecessary to particularise localities. Five miles above Mr. Vernon's house, on Coldstream, limestone from

Limestone near head of Okanagan Lake.

which good lime has been made is found on both sides of Nelson's or Dutot's Creek. Similar limestone is again found south of the Camel's Hump, three miles from Bull Meadow, on the old trail to Cherry Creek.

Limestone at Nicola, Osoyoos Similkameen, etc.

The limestone at McDonald's Creek, on Nicola Lake has already been described. (p. 75). Part of the bed is quite pure and excellent lime has been made from it.

On the west side of Okanagan Lake, a few miles above the Mission, beds of limestone probably sufficiently pure to make good lime come out on the trail. Seven miles north of the north end of Osoyoos Lake, on the trail which follows the western bank of the valley, a whitish marble, probably averaging about fifteen feet in thickness is found. It appears to be suitable for burning. On the Similkameen thick limestone beds form a part of the altered series at the Twenty-mile Creek. (p. 85). Some layers are moderately pure. The colour varies from grey-blue to whitish and the texture is sometimes coarsely crystalline. On the Sumallow river—as described on page 69—limestone is found which is usually bluish and thin-bedded, but often becomes blotched with white, or even entirely converted into a white coarse crystalline marble.

Good building stone scarce.

Building Stone.—Wood being almost exclusively used in buildings of all kinds, the need of building stone is not yet much felt, but in the event of the construction of a railway large quantities of this material would be required in various localities. So much disturbance and crumpling of the rock masses has, however, occurred since their partial or complete induration, resulting in the shattering of all the beds, that the scarcity of homogeneous rocks suitable for building purposes, is truly surprising. These, however, occur in certain places, and a few notes may be useful. It should be borne in mind, however, as a general principle, that wherever it is admissible to substitute rubble masonry for ashler in the course of construction, the relative difference in favour of the former will be much greater than in most other districts.

Rocks of the Coast Range.

By whatever route a railway may traverse the Coast Range, there will be little difficulty in procuring any required quantity of granitic or dioritic rocks, of the usual grey or blackish tints characteristic of these in that region. It will only be necessary to chose those localities where the rocks are most favourably situated for quarrying, and most conveniently divided by planes of bedding or jointage. All rocks of this class are, however, hard, and expensive to dress, though in most cases very durable.

Rocks of the Interior Plateau.

In the Interior Plateau resource will probably be had to the igneous rocks of the Tertiary period, which are there widely spread. Some of these, especially the more porous basaltic varieties, may be worked easily, but as many of these rocks decompose very readily, it will be necessary in selecting them to examine the natural outcrops with care, in order to ascertain their quality in this respect.

Limestone and sandstone.

With few exceptions, the limestones noticed in foregoing pages are quite valueless as building stone, being generally traversed in all directions by flaws. Sandstone which might properly be called freestone can scarcely be said to exist in the district, except in the area of Tertiary coal-bearing rocks at the junction of the Nicola and Coldwater. In Coal Gulley the sandstone might easily be quarried, but for permanent work it would be necessary to reject certain layers which show a natural tendency to disintegration.

Building stones on Kamloops Lake and connected waters.

Kamloops Lake, with the lower part of the North Thompson, the South Thompson and Shuswap Lakes, forming parts of a single system of navigable waters, materials from any one locality may be taken to any other with comparative ease. On Kamloops Lake the only beds which I have seen which appear suitable for anything but the roughest masonry are, the columnar basalt described as occurring on the eastern flank of Battle Bluff, and the beds of tufaceous sandstone which form a bold cliff on the south side of the lake, nearly opposite Tranquille. Neither of these rocks has been quarried, however, and it is impossible to tell with certainty whether blocks of suitable size could be obtained free from flaws. On the South Thompson, the granitic rock already referred to (page 81) occurs at a distance of about twenty-five miles above Kamloops. It is situated at the water's edge, and might, I believe, be quarried in blocks of considerable size if desired. A similar material is again found on the north-west side of Little Shuswap Lake. On Great Shuswap Lake, besides granitic rocks, the beds of marble described as occurring south of Cinnemousun Narrows, and at the mouth of the Shuswap or Spallumsheen River, both appear capable of yielding large blocks, which, as compared with most of the rocks of the district, would be worked with ease. They are well situated for quarrying, with deep water alongside.

Brick clays.

With the exception of certain clayey beds in the Tertiary deposits, no clays suitable for the manufacture of bricks of good quality were observed in the district now reported on. The Tertiary clays are only locally exposed, occur in thin beds, and are besides frequently rather too hard to be easily disintegrated by the ordinary processes. Plastic bluish clays occur toward the base of the drift deposits, but are charged with stones and boulders to such an extent as to render them useless. The white silts, though so extensively spread, are in most places incoherent, and would generally yield a weak, porous brick. Some of the finer layers give a brick of considerable strength, but still unsuited for permanent structures in the rapid alternations of temperature, with severe winter frosts, which prevail in the interior region.

General Conclusions, and Remarks on the Rocks of British Columbia.

Difficulties met with in this region.

It is by the slow and laborious processes of accumulation of many observations, and the attempted coördination of these in every probable manner, alone, that the interrelation and foreign equivalency of the rock-formations of such a region as that portion of the Cordillera system included in the Province of British Columbia, can be ascertained. In a country in which the beds attributable to the later Tertiary are frequently, and over considerable areas, found tilted at angles of thirty degrees from their original horizontal position, as is the case in the southern part of the Province; a district easily accessible in all its parts, and correctly represented on maps of large scale, would be required to enable a geologist to ascertain satisfactorily the structural details of the older rocks. It is unnecessary to say that no facilities of the kind mentioned are available in British Columbia, and that, in consequence, the detailed examination of sections must be narrowly restricted, while it is endeavoured, by observations of an extended character, to trace the general distribution of certain well-defined groups. When it is remembered for how many years large geological parties have been occupied in the exploration of the corresponding region of the Pacific slope, where crossed further south by the Union and Central Pacific Railways, where the surface of the country is seldom forest-clad, and unincumbered with glacial deposits, and withal how many points, there still remain in doubt, it becomes scarcely necessary to enter further into the difficulties met with in arriving at a satisfactory classification of the rocks of British Columbia.

Tertiary rocks.

As compared with the Tertiary rocks of the parts of the Province described in earlier reports, those of its southern portion show some important differences. As above mentioned, they have, in most cases, been considerably flexed and disturbed, and it is seldom that nearly horizontal flows of igneous materials, at all comparable to those of the north, are found. There is, too, a difference in composition of the igneous rocks. Those of the north become felspathic and tufaceous in the vicinity of the ancient vents, but in the south a more acidic character is found to preponderate throughout, and true basalts are rare, and, so far as can be ascertained, probably most abundant in the the highest part of the series. While the major part of the Tertiary series appears to be represented by a great thickness of volcanic rocks, true water-formed sandstones and argillaceous beds, often holding coal and lignite, are frequently found at the base. Like those to the north, they adhere to the overlying volcanic products, and even become interbedded with them, as in the section north of Osoyoos Lake (p. 129). Volcanic materials arranged in water, and forming sometimes very fine-grained and well-bedded tufaceous sandstones, are often present in important thickness.

Possible differences in age.

Whether the lithological difference of various parts of the volcanic rocks of the Tertiary may indicate considerable diversity in age, it is at present impossible to say. But apart from the greater amount of disturbance which the southern portion of the series has suffered, there are other reasons for believing that the period of greatest volcanic activity in the Tertiary occurred progressively later toward the northwestern portion of the Interior Plateau. As mentioned, however, in a previous report, no instance of volcanic rocks of post-glacial age has anywhere been met with.

Plant and insect remains.

As remarked by Mr. S. H. Scudder, in his note on the fossil insects obtained from the Tertiary rocks of the southern part of the Province, it is notable that, of forty species now described by him, from three localities in British Columbia (Quesnel, Nicola and Similkameen), none are found in more than a single place, a fact indicating either a difference in age of the several deposits, or a very rich insect fauna.

The plants recognized in these beds are enumerated in another place, but these depend so much on the surroundings of each particular locality, that; in the absence of large collections, they offer comparatively little aid in tracing out the minor subdivisions of the Tertiary, especially as between places widely separated in latitude.

The rocks probably Miocene.

We may therefore probably err little in continuing to call the Tertiary deposits of the interior, as a whole, Miocene, and in correlating them with the beds attributed to the same period to the southward in the basin lying east of the Sierra Nevada.

No beds known to represent those included as Eocene, under any of the classifications employed in the Western States, have yet been found in British Columbia.

Cretaceous rocks.

Of the coal-bearing Upper Cretaceous rocks of Vancouver Island and the coast, no mention need be made in the present connexion. They have not been recognized in the region now under notice, though it is possible that some ef the strata now included in the Jackass Mountain series may eventually be found to be equivalent in age to the coal-measures of Nanaimo and Comox. The Cretaceous fossils so far obtained on the mainland appear to belong to a single well-marked horizon representing that best defined palæontologically in the Shasta

Fossils.

group of the Californian geologists.* Fossils of this age were first discovered in the rocks of Tatlayoco Lake in 1875, and it was then ventured to correlate these on lithological and stratigraphical grounds with those previously included in the Jackass Mountain group by Mr. Selwyn, but in which no fossils had at that time been found. This classification has been shown to be correct by the discovery in 1877 of the fossils referred to on a former page, from the typical localities of the Jackass Mountain rocks, and fossils of the same group have also been collected in rocks between Fountain and Lillooet, and in the upper part of the Skagit Valley. The last named place is about two hundred and twenty miles south-eastward from Tatlayoco Lake.

Composition of the series.

These rocks, in all the localities above mentioned, occupy an analagous position in the eastern ranges of the Coast or Cascade Mountains. They are closely folded together with the older rocks, on which they appear to rest quite uncomformably. Their material is usually arenaceous, but conglomerates are extensively developed in several parts of the series, and argillaceous beds are not altogether wanting. The sandstones may, for the most part, appropriately be styled quartzites, but often contain a large proportion of felspathic material derived in most cases from the degradation of neighbouring granitic rocks, but possibly in some instances in part due to contemporaneous volcanic activity. The quartzites are of greenish, greyish, and blackish tints, but seldom have the dense cherty character of those of the older rocks. The conditions indicated are littoral, and as no rocks of Cretaceous age have been found to the eastward of the line of deposits just referred to, over the entire area of the Interior Plateau and Gold

Shore line of the Pacific Cretaceous.

Ranges, it is evident that the eastern shore of the earlier Cretaceous sea nearly followed the line now marked by the north-eastern margin of the Coast Ranges, (which have been elevated subsequent to that time,) from the southern boundary of British Columbia at least as far north-westward as the vicinity of Tatlayoco Lake, in 52° north latitude. Beyond this point, it is probable that future investigation may enable us to trace the deposits of the Cretaceous sea north-eastward to the Peace River country, where they may have inosculated with those of the Great Plains. To the south, the evidence favours the belief that a pretty continuous land barrier separated the Cretaceous ocean of the west from that covering the present area of the Great Plains. The western margin of the Pacific of the Cretaceous period touched, as Clarence King has shown, the Blue Mountains of Oregon, and thence

* It may be stated, however, that during the field work of 1878, not yet reported on, fossils apparently of the same Shasta horizon have been found in rocks closely associated with the coals of Quatsino Sound, Vancouver Island.

trended south-westward to Mount Shasta, and from this, according to Whitney, still further southward, following the western slope of the Sierra Nevada, which had been upraised at a previous period.

Thickness of Tatlayoco or Jackass mountain group.

The thickness of the Tatlayoco or Jackass Mountain group is great. On Tatlayoco Lake it probably does not fall short of 7,000 feet; as shown near Lillooet and behind Boston Bar, it is represented by nearly 5,000 feet of rocks, and on the Skagit a measured section included 4,429 feet without comprising the entire group.

Palæozoic rocks.

In regard to those Palæozoic rocks of the Interior Plateau region which have been grouped under the general name of the Cache Creek series, the remarks as to their relation with the Victoria rocks and those of the Cascade and Rocky Mountains, made in the preceding report,* still hold in most points. In the region here reported on, however, characteristic fossils of Carboniferous age have now been obtained in the limestones in several additional localities, and the association of these with the peculiar cherty quartzites, and with contemporaneous volcanic products and serpentines, clearly ascertained in a number of places. These rocks are, however, often much disturbed and highly altered, in consequence of which neither the actual summit nor the base of the portion representing the Carboniferous period has been fixed. It therefore remains uncertain whether any part of these rocks, which have so far been spoken of as the Cache Creek group, may belong to horizons higher or lower than the true Carboniferous. The thickness of the entire series is unknown, but must be very great.

Cache Creek Carboniferous

Probable equivalency of Cache Creek and Cascade crystalline series.

The greatest difficulty in the way of satisfactorily correlating the rocks of the Cache Creek group as typically developed, with their supposed representatives in the disturbed region of the Coast or Cascade Ranges, is found in the comparatively unimportant part which quartzites hold in these mountains and the great preponderance of felspathic and dioritic rocks. There is no evidence whatever to show that the region of the Coast Ranges was land in Carboniferous time; the recognized Carboniferous rocks are nowhere of a littoral character in their vicinity, being composed of very fine material, and including, moreover, great beds of pure limestone. Neither are any fragments like the granitic and gneissic rocks, now so abundant in these mountains, found in the Cache Creek deposits. There is, therefore, every probability that rocks of that age were formed westward over the entire region now occupied by the Coast Ranges. There can be little doubt that the rocks of Victoria, as explained in the report already referred to, and elsewhere, are also of Carboniferous age. They are for the

Contemporaneous volcanic accumulations.

* Report of Progress, 1876-77.

most part built up of contemporaneous volcanic materials, felspathic, dioritic, etc., which, when they are most altered, closely correspond to the rocks of the Coast Ranges not alone in actual composition but in lithological character, becoming gneisses, and dioritic and micaceous schists. It is thus shown that intense volcanic activity prevailed in the region of Vancouver Island in Carboniferous time, and that to it the greater part of the thickness of the beds there representing that period is due. It is highly probable that such volcanoes followed nearly the present coast line, parallel to which the disturbances of every period have occurred, and it is not unreasonable to suppose that the very abundant introduction of easily metamorphosed volcanic material began westward, near the position of the present eastern margin of the Coast Ranges. Evidence of the interlocking of the quartzites with abundant felspathic and other volcanic material, is also found in working out the sections on the ground.

Composition of the Coast Ranges.

It is not intended to assert, however, that the whole mass of the Coast or Cascade Mountains is of Carboniferous age. The rocks described as Triassic are largely represented; and those of the Jurassic Porphyrite series of the Dean or Salmon River, and even—as above-mentioned—of the Lower Cretaceous, are important factors. It is also quite possible, and indeed probable, that older rocks are brought to the surface at least in some parts of the range, but none such have yet been recognised. It is clear, however, that neither the chemical composition, nor the crystalline character of the rocks of Victoria and the Coast Ranges, can be adduced in support of any theory assigning to them a great antiquity, and that the easy methods of mineralogical chronology must be exchanged for more laborious surveys in the field.

The Gold Ranges possibly older.

It has been supposed that the gneisses, mica-schists and similar rocks of the Gold Ranges bounding the Interior Plateau northeastward, have an origin similar to that above indicated for a part, at least, of the Coast Ranges. As stated, however, in a preceding section of this report, they have a somewhat different aspect from these, with an appearance of greater antiquity, and it is by no means improbable that the Cache Creek rocks may be found to rest unconformably upon them, though this has not yet been demonstrated. If so, they may form a portion of the oldest land of this part of the Cordillera system, representing the "Archæan" described by the U. S. geologists in Colorado and Utah. The rocks, as shown on the Shuswap Lakes, present, indeed, a striking resemblance to the Upper Archæan group, as defined by Clarence King. The precise relations of these and of the gold-bearing rocks of Cariboo and elsewhere, to them, constitutes one of the more interesting and important problems to be worked out in this field.

Overlying volcanic rocks. The Nicola series.

When it had been ascertained that extensive volcanic intercalations occurred in the Cache Creek series, it was natural to suppose that certain other very extensive volcanic deposits, evidently older than those of the Tertiary, different from the Porphyrite group, and apparently in some places closely associated and flexed together with the typical Cache Creek rocks, belonged also to that series. It has become necessary, however, to separate these, constituting a great formation, apparently of Triassic age, built up almost exclusively of volcanic products, which have frequently a characteristically green colour, and hold, toward the base, beds of grey, sub-crystalline limestone, intimately mingled in some places with volcanic material, and holding occasional beds of water-rounded detritus. These it is proposed to call the *Nicola Series*, from the very characteristic section of them exposed on the south side of Nicola Lake, where, also, the only determinable fossils so far obtained have been collected.

Evidence of their Triassic age.

The limestone of McDonald's River, Nicola Lake, was at first supposed to be Carboniferous, but the most diligent search failed to bring to light any characteristic forms of this age, and, on the contrary, resulted in the discovery of the scattered joints of a crinoidal column, closely allied to *Pentacrinites asteriscus* Meek., of the Jurassic of the Black Hills. It differs from this form, however, in some particulars, but in these it approaches to, and is probably conspecific with, a *Pentacrinites* doubtfully referred to, *P. asteriscus*, by Hall and Whitfield,* and procured from beds of Triassic age in the Pah-Ute Range of Nevada. Apart from other considerations, this might form a rather uncertain criterion of age, but in the same limestone a *Terebratula* also occurs which can be referred, with very little doubt, to the rather variable species *T. Humboldtensis*, which is also found in association with the crinoid above named, in the same locality in Nevada.

As a further evidence of the Triassic age of these green volcanic rocks, their association with the argillites holding *Monotis* on Whipsaw Creek, already noticed, may be referred to, and their unconformable superposition on the Carboniferous limestones exposed above Kamloops on the South Thompson. The calcareous beds there lying at the base of the great igneous flows, hold rolled fragments of the cherty concretions and veins, of the underlying *Fusulina*-limestone.

In the table, the relations and the equivalency of the rocks of British Columbia are shown in so far as at present known. The Rocky Mountain section on the forty-ninth parallel, is that detailed in my Boundary Commission Report.

* U. S. Geol. Exploration of the Fortieth Parallel, Vol. IV., p. 280.

<table>
<tr><td rowspan="3">Tertiary.</td><td>Pliocene.</td><td rowspan="3"></td><td colspan="2" rowspan="3"></td></tr>
<tr><td>Miocene.</td></tr>
<tr><td>Eocene.</td></tr>
<tr><td rowspan="8">Mesozoic.</td><td rowspan="4">Cretaceous.</td><td rowspan="4">Californian Section.</td><td colspan="2">Tejon Group.</td></tr>
<tr><td colspan="2">Martinez Group.</td></tr>
<tr><td colspan="2">Chico Group.</td></tr>
<tr><td colspan="2">Shasta Group.</td></tr>
<tr><td>Jurassic.</td><td rowspan="16">Section in the Area of the 40th Parallel Exploration.</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Triassic.</td><td>East of Wahsatch Mountains.</td><td>West of Wahsatch Mountains.</td></tr>
<tr><td rowspan="2">Red Beds.</td><td>Star Peak Group.</td></tr>
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<tr><td colspan="2">Upper Coal Measures.</td></tr>
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<tr><td rowspan="2">Cambrian.</td><td colspan="2">Pogonip.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="2"></td><td>Huronian.</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>Laurentian.</td></tr>
</table>

Section in the Rocky Mountains on the 49th Parallel.	Section in British Columbia, chiefly West of the Rocky Mountain Region.
	Not recognized; land probably at a high level.
	Volcanic rocks, sandstones, and argillites of the Interior Plateau, with lignite and coal — deposits of a fresh-water lake. Beds with marine fossils and lignite on the coast.
	Not recognized; region possibly a land area.
The Cretaceous has not been recognized in this part of the mountains, but is supposed by Dr. Hector, to appear further north, in broken folds among the higher peaks.	Coal-bearing series of Nanaimo Comox, &c., on the coast; not recognized in the Interior.
	Coal-bearing series of Queen Charlotte Islands. Tatlayoco Lake or Jackass Mountain Group of the Interior; sandstones and conglomerates. Coal-bearing series of Quatseno Sound.
	Porphyrite series of the Salmon or Dean River, composed chiefly of volcanic materials. Argillites and sandstones of Rock Island Gates, Peace River. (?)
Series H. and G. Dolomitic sandstones and limestones, with red beds.	Nicola series of the interior : rocks chiefly volcanic, but with limestones and argillites. Volcanic accumulations, argillites, &c., on Vancouver and Queen Charlotte Islands. Sooke series. (?) Monotis shales of Peace River.
	Anderson River and Boston Bar Argillites, Leech River rocks. Gold-bearing schists of Cariboo. (?)
Series F, E and D. Dolomitic sandstones, &c., overlying (E) amygdaloidal trap, and (D) massive bluish limestone.	Cache Creek Groups of the Interior; limestones and quartzites, with volcanic rocks and serpentine. Victoria Series of Vancouver Island; Volcanic rocks, in places gneissic, with limestones and argillites. Cascade Crystalline Series of the Coast Range, at least in part. Gneissic and dioritic rocks, with limestones, &c.
Series C. Quartzites and slaty rocks.	Not recognized.
Series B. Magnesian and cherty limestone.	Not recognized.
Series A. Impure dolomites and dolomitic quartzites.	Not recognized.
	Crystalline Rocks of Shuswap Lakes and the Gold Range. (?) [These may be found to represent the Cascade Crystalline Series.]

APPENDIX A.

—

THE FOSSIL INSECTS COLLECTED IN 1877, BY MR. G. M. DAWSON, IN THE INTERIOR OF BRITISH COLUMBIA.

BY SAMUEL H. SCUDDER.

The geological investigations of Mr. Dawson in British Columbia during the season of 1877 brought to light three new localities yielding fossil insects, all belonging to the Tertiaries. One of these localities is upon the Nicola River; another on the North Fork of the Similkameen River, three miles from its mouth; and the third on Nine-mile Creek, flowing into the Whipsaw Creek, a tributary of the Similkameen. The lithological character of the rocks in each of these localities is distinct from that of the others, as well as from that of Quesnel, as are also the insects entombed in them, so far as the small collections brought home testify. Seventeen species (1 Hym., 2 Dipt., 10 Col., 4 Hem.,) were obtained—seven from the first-named locality, six from the second, and four from the third; only fifteen of them, however, are represented by specimens worthy of description. The Nicola locality is remarkable for containing only Coleoptera (seven species); the other three species of Coleoptera come from Nine-mile Creek, which otherwise yields us only one species of Hemiptera. The Similkameen locality, on the other hand, affords us Hymenoptera, Diptera and Hemiptera, but no Coleoptera,—in all six species—and in this respect its ancient fauna resembles that of Quesnel, which has only yielded a single species of Coleoptera and many more of the orders mentioned from the Similkameen River than of any other. "There can be little doubt, however," Mr. Dawson informs me, since writing the above, "that the specimens from the North Similkameen and Nine-mile Creek represent deposits in different portions of a single lake. A silicifying spring, probably thermal, must however have entered the lake near the first-named place, as evidenced by the character of some of the beds, in which fragments of plants, with a few fresh-water shells, have been preserved."

That none of the insects about to be described at all resemble those previously received from the Tertiaries of British Columbia, is indicative either of the total distinctiveness of the beds of Quesnel, Nicola and Similkameen, of different surroundings, or else of very varied faunæ. In the same connection, it may be noticed that more than a single specimen of four of these fifteen described species has been found (in one instance five specimens), and in the case of the Quesnel insects four out of the twenty-five species are represented by duplicates. It is, therefore, highly probable that an extremely rich insect fauna will be found in the Tertiary rocks of British Columbia worthy of the special labors of field geologists.

The species described below present no features worthy of special remark, unless it be the Homoptera, represented by three large species, two of them indeed very large, and one of them recalling the gigantic Cercopida of Radoboj in Austria; while one of them, Planophlebia, is still further remarkable for the venation of the tegmina, in which the branched veins impinge upon the costal, instead of upon the apical or inner margin.

The number of described species of Tertiary insects from British Columbia is now forty.

HYMENOPTERA.

Bracon sp.—An insect of this sub-order (Nos. 69, 78), apparently belonging to Bracon or a closely allied genus, is so imperfectly preserved as not to allow of description; both the front wings are very imperfect; the whole of the body and fragments of the legs are preserved, showing that the insect was 4 mm. long, and the length of the front wing about 2·85 mm. It came from the Similkameen River.

DIPTERA.

Penthetria similkameena.—Five specimens (Nos. 76, 79, 80, 81, 82 *a. b.*, 83 *a. b.*), three of them with their reverses, represent very fairly a species of Penthetria—one of them certainly a male, and remarkably perfect. The body of this male is of nearly equal size throughout, scarcely thickened at the thorax. The male antennæ consist of ten joints, and they are moniliform, very gently and slightly decreasing in size to the tip, the apical joint smallest, all together a little longer than the height of the head. Legs of the male long and slender, all the femora of equal length (the middle pair perhaps a little shorter than the other), slightly thickened, especially on the apical half. All the tibiæ are very long, slender, equal, covered below with a dense clothing of very delicate and short hairs, and furnished above with a row (?) of very short, delicate, minute, recumbent spines, the apex devoid of spurs; the first pair is about as long as the fore femora; the second is considerably shorter than the middle femora, while the third pair is longer than the hind femora. The tarsi are scarcely shorter than their respective tibiæ; the first joint is nearly as long as the rest of the tarsus, excepting on the middle legs, where it only equals the two succeeding joints taken together; the remaining joints are subequal in length (on the middle legs, the second and third joints, are longer than the fourth and fifth), and the last is armed with a delicate pair of divergent claws. The whole body and the appendages are black. The wings are fuliginous, deepening in tone toward the front margin; they are nearly as long as the body, and about three times as long as broad. The first and second longitudinal veins are straight and approximate to the front margin, the latter striking it scarcely beyond the middle of the apical half of the wing, the former at about the middle of the third quarter; the third longitudinal vein diverges from the second at some distance before the middle of the wing, is connected by the middle transverse vein a little beyond the middle of the wing to the fourth longitudinal vein, and forks either at a little more (♂) or at a little less (♀) than one-third the distance from the cross vein to the apex of the wing,* the lower branch striking the tip, while the other, strongly curved, strikes the margin at about one-third (♂), or a little more than one-third (♀), the distance from the apex of the second to that of the lower branch of the third longitudinal vein; the fourth longitudinal vein is very nearly straight until it forks, considerably (♂) or a little (♀) nearer the middle transverse vein than the origin of the fork of the vein above; the branches part widely at base, the upper more arcuate than the lower; the fifth longitudinal vein forks as far from the base of the wing as the divergence of the second and third longitudinal veins, the upper branch being connected, just beyond its origin, with the fourth longitudinal vein, which is of the same length as the middle transverse vein, and lies as far within, as that without, the middle of the wing. In none of the specimens (owing to imperfect preservation) can the sixth longitudinal vein be traced beyond the basal transverse vein.

On account of the length and longitudinal direction of the upper branch of the third longitudinal vein, I have placed this insect in Penthetria rather than in Plecia, although this branch arises, especially in the male, at an unusual distance from the middle transverse vein.

Length of body, 11 mm.; breadth of thorax, 1·75 mm.; of abdomen, 1·2 mm.; length of femora: fore, 3·5 mm.; middle, 3·5 (?) mm.; hind, 3·5 mm.; of tibiæ: fore, 3·65 mm.; middle, 3·25 mm.; hind, 4 mm.; of tarsi: fore, 3 mm.; middle, 2·75 mm.; hind, 3·5 mm.; of first joint of tarsi: fore, 1·4 mm.;

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* The sexes in this genus differ in neuration, and as the wing attached to the body of the male differs from the other wings in the particular above mentioned, I look upon the others as belonging to females of the same species, and describe them accordingly.

middle, 1 mm.; hind, 1·5 mm.; length of wing, 10 mm.; breadth of same, 3·5 mm. All the measurements are taken from the male. Similkameen River.

COLEOPTERA.

Nebria paleomelas.—A nearly perfect elytron (No 58) with the humeral angle broken off represents a Carabid, probably related to Nebria. A species is indicated which is of about the size of *N. Sahlbergi* Fisch. The elytron is about two and a-half times longer than broad; the surface is nearly smooth, piceous, with nine striæ, which are rather deeply impressed, and a scutellar stria, which unites with the first longitudinal stria at about one-sixth the distance from the base, in such a way as to make it appear equally forked in passing toward the base, its outer fork striking close to the base of the second longitudinal stria; the fifth and sixth striæ are united to each other and to the united third and fourth striæ, near the apex, by a wavy continuation of the sixth, after it has bent toward the fifth in running parallel to the seventh, as it curves toward and runs to the tip of the elytron; the ninth stria, which forms the edge of the elytron as it is preserved, shows no appearance whatever of ocellate punctures, although under the microscope some of the central striæ show slight signs of faintly-indicated punctures near the middle of the elytron.

Length of elytron, 5·2 mm.; breadth, 1·8 mm. Nicola River, below main coal seam.

Cercyon? terrigena.—A single elytron with the base broken off (No. 57) appears to represent a species of Hydrophilidæ, and perhaps is most nearly related to Cercyon, but of this there is much doubt. The elytron is pretty well arched, equal nearly to the tip, then rapidly rounded off, indicating an ovate beetle with the shape of a Hydrobius or a shorter insect, and of about the size of *Helophorus lineatus* Say. Eight faintly impressed unimpunctured striæ are visible, the outer one, and to some extent the one next it, deeper; these two unite close to the tip, curving strongly apically; the next two curve slightly near their extremity, but are much shorter, not reaching the fourth stria from the suture, which, like the remaining three, pursues a straight course to the seventh stria. The surface between the striæ is nearly smooth, piceous.

Length of fragment, 2·4 mm.; breadth of elytron, 1·35 mm.; distance apart of the striæ, 0·15 mm. Nicola River, below main coal seam.

Trox Oustaleti.—A single elytron (No. 61), well-preserved, appears to represent a species of Trox, of about the size of *T. terrestris* Say, but with rather slender elytra. The elytron is subequal, narrowing rapidly and regularly at the tip, well arched, and was apparently still more arched originally, the middle portion having a flattened appearance, as if from pressure, with a narrow flattened outer margin; the surface is completely and uniformly covered with thirteen or fourteen equal, equidistant rows of frequent dull tubercles, as distant from one another in the rows, as each row from its neighbour, and obsolescent toward the apex and the base, especially towards the former. In certain places there is a very slight appearance of greater prominence to every fourth row, which would hardly be noticed, if its resemblance to modern species of Trox did not lead one to look for it; the extreme tip is broken. The colour is dark-brown, approaching black, but the whole central portion of a faded brown, nearly resembling the natural colour of the stone in which it is preserved.

Length of elytron, 4·25 mm.; breadth, 1·85 mm. Nine-mile Creek. Named after M. Emile Oustalet, whose researches on the Tertiary insects of Auvergne and Aix are well-known.

Buprestis tertiaria.—Three specimens (Nos. 48, 51, 52, 54) were obtained of this species, all of them elytra. One shows the two elytra crossed at the base, and a reverse of this shows the cast of the upper surface; the other two are single and perfect elytra, both exhibiting the upper surface, one in relief, the other as a cast, but they are not reverses. This and the two following species classed under Buprestis agree closely together, but do not seem to be plainly referable to any recent American genus, although approaching nearest Buprestis or Ancylocheira. They seem to be nearly related also to the Tertiary species from Sieblos, described by Heyden under the name of *B. senecta.* For the present I place them in Buprestis.

The elytra are very long and slender, nearly four times as long as broad, equal throughout the basal two-thirds, then gradually and very regularly tapering by the sloping of the outer edge, the tip a little produced and rounded, and about one-fourth as broad as the middle of the elytron. The surface is ornamented by ten rows of very distinct striæ with rather deeply-impressed punctæ; these striæ are a little sinuous near the base, and there is also a scutellar stria extending down nearly one-third of the elytron; the outer stria unites with the margin in the middle of the outer half of the elytron; the three inner and two other outer striæ extend to the apex, while the four interior striæ terminate—the inner pair a little beyond the termination of the outer stria, the outer pair still a little further toward the apex, thus allowing for the narrowing of the elytra; the surface between the striæ is much broken by slight transverse corrugations, giving, with the punctate striæ, a rough appearance to the elytra. This species differs from the two following by the great slenderness of the elytra, and the more delicate tapering of its tip.

Length of elytron, 6·5 mm.; breadth, 1·7 mm. Nicola River, below main coal seam.

Bupretis saxigena.—This species is represented by four specimens (Nos. 49, 50, 55, 56), besides the reverse and obverse of another (Nos. 47, 54). They are all elytra or fragments of elytra, sometimes preserved by pairs in natural connexion. It is very closely allied to the last, but differs from it in having the elytra less slender, the breadth being contained about three and a-half times in the length, and in the rather greater coarseness of the punctuation and transverse corrugation. The striæ are the same in number, but are, perhaps, a little more sinuous, and the scutellar stria is shorter, hardly extending so much as a quarter way down the inner margin; the other striæ terminate in much the same way as *B. tertiaria*, but the seventh stria (from the suture) frequently runs to, or very nearly to, the tip; the extreme tip is formed precisely as in *B. tertiaria*, but the sides of the elytra, running parallel throughout three-quarters of their length, taper toward the apex more abruptly than in the preceding species, though with the same regularity. This species stand midway between the other two, here described, in the form of the apical third of the elytra.

Length, 6·2 mm.; breadth, 1·7 mm. Nicola River, below main coal seam.

Buprestis sepulta.—A single specimen (No. 53), showing the greater part of both elytra in natural conjunction, must be separated from the two preceding by its still broader elytra, with more rapidly tapering apex. The elytra are slightly less than three and a-half times longer than broad, with sides parallel throughout three-quarters of their length, then suddenly tapering, the extreme tip shaped as in the other species, only more produced, so as to form more distinctly a kind of lobe, the outer margin being very slightly and roundly excised just before the produced tip. The surface is, perhaps, even rougher than in the other species, but the striæ appear to be less sinuous; the scutellar stria is destroyed in both elytra of the single specimen before me; the outer stria terminates as in *B. tertiaria*, but the inner pair of the middle series of striæ is here the longer, extending barely to the tip of the outer stria, while the outer pair is a little shorter; the produced tip of the elytra is a little shorter than in the preceding species, but similarly rounded apically.

Length of elytron, 6·7 mm.; breadth, 2 mm. Nicola River, below main coal seam.

Cryptohypnus? terrestris.—A single, very nearly perfect, elytron (No. 59), broken slightly at the base, which belongs, with little doubt, to the Elateridæ, is provisionally referred to this genus. The form of the elytron is as in *C. planatus* LeC., which is slightly larger than the fossil species. The surface is very minutely punctato-rugose, and the striæ are sharp and clearly defined. In nearly all Elateridæ, the fourth stria from the suture unites with the third rather than with the fifth, although it often runs independently to the tip. In Cryptohypnus there appears to be more latitude, nearly any of the striæ uniting with either of their neighbours; and in this species, the fourth unites with the fifth some distance before the tip, while the first three run to the extremity of the elytron, and the sixth, seventh and eighth, following the curve of the outer margin, terminate near the tip of the third stria.

Length of elytron, 5·5 mm.; breadth, 1·75 mm. Nicola River, below main coal seam.

From the same locality were brought the remains of another insect, consisting of the metasternal plates, one side complete, the other broken, and plainly belonging to the Elateridæ. The perfect side agrees so well with the same part in *Cryptohypnus planatus* LeC., that I refer it to the fossil species above described, which its size renders entirely admissible. It is, however, relatively longer than in *C. planatus*, the perfect half being about a third longer than broad, not including, of course, the side pieces, which are not preserved. The surface is densely and rather heavily punctate, more densely and perhaps less deeply next the coxal cavities; the median line (separating the two lateral halves of the whole metasternum) is very deeply impressed, but the furrow dies out anteriorly in the projection between the coxæ. Length of metasternum, 2·1 mm.

Elateridæ ? sp.—There is another elytron (No. 60), with the base nearly destroyed, which resembles in striation the Hydrophilidæ, but is far too elongated to belong to that family, resembling rather the Elateridæ. It is so imperfectly preserved that, perhaps, a nearer determination is impossible at present. There are eight rather faintly-impressed but distinct striæ, the outermost a little more distinct, especially toward the tip.

Width of elytron, 1·25 mm.; its apparent length, 4·5 mm. Nicola River, below main coal seam.

Gallerucella picea.—A pair of rather poorly preserved elytra, parted at the tip, and showing between and through them the outlines of the abdominal segments (No. 62) represents a species of Chrysomelidæ, which appears to be most nearly allied to the genus in which I have placed it, and to be about the form of, and a little smaller than, *G. maritima* LeC. The elytra are uniformly piceous throughout, showing no marks of lighter coloured borders; there are faint indications of one or two marginal impressed lines in their outer half, and the whole surface seems to have been very minutely punctate, more faintly and finely than in the existing species mentioned. The abdomen is very broadly and very regularly rounded, subovate, and at least five segments of similar length can be determined.

Breadth of the pair of elytra at base, 3·75 mm.; length of elytra, 5·5 mm.; breadth of abdomen, 3·25 mm.; length of penultimate segment, 0·4 mm. Nine-mile Creek.

Tenebrio primigenius.—A single, complete and well-preserved elytron (No. 63) represents a species of Tenebrionidæ, a little larger than, and somewhat resembling, *T. molitor* (Linn.), the beetle of the common meal-worm. It has been flattened by pressure, so as to show but little sign of having been arched, while, at the same time, the shape is fairly preserved. Wherever it differs in colour from the stone, it is piceous. The margins are very nearly parallel, approaching each other rather gradually and very regularly toward the tip; there are eight equidistant, pretty strongly impressed, rather coarse, longitudinal striæ, besides others next the outer margin, whose number cannot be determined, and a short scutellar stria, about as long as in *T. molitor*, but quite as distinct as the others; the surface between the striæ appears to be very minutely subrugulose, and shows, in favourable light, a faint transverse corrugation.

Length of elytron, 11 mm; breadth, 4·4 mm. Nine-mile Creek.

HEMIPTERA.

Hygrotrechus Ståli.—Two specimens, with the reverse of one, besides an immature specimen (Nos. 70, 71, 72, 73), represent this species, which is, perhaps, not a true Hygrotrechus, although certainly very closely allied to it. The thorax seems to be shorter than in Hygrotrechus, with the limits of the prosternum more visibly marked from above; the eyes do not appear to be so prominent, and the first antennal joint would seem, from the position of the others, to be shorter than in Hygrotrechus. The insect is about the same size as our *H. remigis* (Say). The head, as seen on a side view, is small and rounded; thorax minutely scabrous like the head, narrowing rather rapidly and uniformly, the posterior limit of the prosternum marked by a slight depression next the anterior coxæ, the whole thorax considerably longer than broad. Abdomen tapering, the apical angles of the sixth segment produced to a sharp but short spine, reaching the middle of the succeeding segment. Antennæ nearly (perhaps quite) as long as the head and thorax together. Fore femora equal, stout, as long as the thorax; fore tibiæ of the same length; middle and hind legs very slender; middle femora considerably more than twice as long as the fore femora, the tibiæ less than twice as long as the fore tibiæ;

hind femora nearly three times as long as the fore tibiæ; hind tibiæ a little more than twice as long as the fore femora; first joint of hind tarsi about one-fifth the length of the hind tibiæ. On one of the specimens, preserved on a dorsal view, a line is seen proceeding from either side of the thorax, directly in front of the middle coxæ, which passes toward and nearly to the middle of the hinder edge of the second abdominal segment with some distinctness, accompanied on the second and third segments by other lines which seem to indicate the veins of the tegmina, the first-mentioned line being the *sutura clavi;* but all trace of lines is lost beyond the third segment, as if the wings did not extend over more than half the abdomen; on the specimen preserved, on a side view, they appear to extend to the hind edge of the sixth abdominal segment. Attached to the posterior extremity of the abdomen is a pair of stout lappets, nearly straight, but curving slightly outward, equal, about twice as long as broad, rounded and very slightly produced at the tip.

In a specimen (No. 70) which I have considered an immature individual of this species, but which may possibly be a Metrobates, the middle and third femora are of equal length.

Length of body, 19·75 mm.; of head, 1·5 mm.; of thorax, 5 mm.; breadth of anterior extremity of thorax, 1·75 mm.; of posterior extremity, 3·5 mm.; of sixth abdominal segment, 2 mm.; length of fore femora, 5 mm.; of fore tibiæ, 5 mm.; of middle femora, 12·5 mm.; of middle tibiæ, 9 mm., of hind femora, 14 mm.; of hind tibiæ, 11·5 mm.; of first joint hind tarsi, 2·3 mm.; of abdominal lappets, 1·3 mm.; breadth of hind femora, 0·35 mm.; of hind tibiæ, 0·2 mm.; of hind tarsi, 0·15 mm. Similkameen River.

I name this interesting species after my lamented friend, Dr. C. Stål, of Stockholm, whose marvellous industry and keen insight into the structure of Hemiptera is known to all entomologists.

Cercopis Selwyni.—A pair of nearly perfect tegmina, reverses of each other (Nos. 64, 65), represent a species allied, but rather distantly, to the gigantic species of Cercopida described by Heer from Radoboj. It differs from them all in neuration, in the form of the costal border and of the apex. The portion of the wing below the straight *sutura clavis* is broken away. The basal half of the costal margin is strongly and rather uniformly arcuate, but more strongly close to the base; the apical half of the same is nearly straight; the apical margin is a little obliquely and roundly excised, gently convex, the tip roundly angulated. The costal vein parts from the common trunk close to the base and follows close to the margin, terminating at about one-third way to the tip; the radial vein is directed toward the middle of the outer half of the costal border, until it forks, a little before the middle of the wing, when both straight branches run subparallel toward the tip; the ulnar vein also forks once, half-way between the base and the fork of the radial vein, and its straight branches, with those of the radial vein, subdivide the outer half of the wing subequally, all being evanescent toward the apical margin; the *sutura clavi* reaches as far as these veins are visible.

Length of wing, 16.5 mm.; breadth of wing at tip of *sutura clavi*, 5 mm.; length of *sutura clavi*, 14 mm. Nine-mile Creek.

Cœlidia columbiana.—A pair of tegmina, in which most of the venation can be made out, with a crushed body and crumpled wings (No. 75), represent a species of Cœlidia or an allied genus, with rather broad tegmina. The veins of the tegmina are nearly parallel to the gently arcuate costal margin, are equidistant from one another, and are united by cross-veins near the middle of the apical half of the tegmina, the lower ulnar vein, which runs only a little below the middle of the wing, forking at this point; the upper of the apical areolets, however, is considerably shorter than the others; the two ulnar veins are united by a cross-vein in the middle of the basal half of the tegmina, while not far from the middle of the tegmina the ulnar and radial veins are similarly united. The tegmina do not taper apically, the extremity is rounded and obliquely docked, and the *sutura clavi* is short. The hind wings are provided with an unusual number of cross-veins.

Length of tegmina, 8 mm.; breadth, 3·25 mm. Similkameen River.

Planophlebia (πλάνος, φλέψ), nov. gen.

This name is proposed for a genus of Fulgoridæ apparently belonging to the Delphacidæ, but differing from all Homoptera I have seen in the remarkable trend of the principal veins of the tegmina, nearly all of which, and certainly all the branches of the radial, as well as most of the branches of the ulnar vein, terminate upon the costal margin, the costal areole being very brief, or less than one-third the length of the tegmina. The radial vein branches very near the base of the tegmina, and its lower branch again a very little way beyond, all three of the branches running in a straight course parallel to one another, and embracing at tip the middle third of the margin. The ulnar vein forks near the outer branching of the radial vein, the upper branch soon dividing again, the lower dividing beyond the middle of the tegmina, all the branches running parallel to those of the radial vein.

I know of no Homopteron the veins of whose tegmina trend as in this genus; indeed it appears to be quite abnormal in this particular. Nor can Mr. Uhler, to whom I submitted a drawing, find any form whose branched veins run toward the costal margin; but I have in vain attempted to believe that I have interchanged the two margins of the tegmina. In point of neuration, the tegmina approach most closely, as Mr. Uhler has pointed out to me, to those of *Amphiscepa bivittata* (Say), but even from this it differs widely.

Panophlebia gigantea.—The specimen (No. 77) is very fragmentary, consisting of an upper wing, of which the whole of the costal border as far as the tip, and the basal half of the inner margin, can be made out; but only three patches of the surface with its accompanying veins are preserved,—a piece next the base, crossing the wing; another near the middle, which crosses rather more than three-quarters of it from the costal margin backward; and a greatly broken patch at the upper half of the tip; but from these pieces nearly the whole of the neuration, as given in the generic description, can be determined. The costal vein appears to be forked close to the base, with branches running close and subparallel to each other. There are five branches of the ulnar vein, terminating above the middle of the apical margin of the tegmina, but below that the veins are wholly obliterated. The *sutura clavi* must be very brief (as we should, perhaps, expect it to be in a wing with so short a costal areole), since no sign of it appears on the basal patch; it must terminate before the branching of the ulnar vein. The tegmina are of very large size, the costal margin regularly and gently arched, the inner margin almost straight, and the apex very regularly convex, at least on the upper half.

Length of fragment, 23·75 mm.; estimated length of the tegmina, 25 mm.; breadth in middle, 9·5 mm. Similkameen River.

A few other insect-remains were found; one apparently of plant-lice, another possibly of Asilidæ, but all in too imperfect a state for any reasonable identification at present.

APPENDIX B.

LIST OF TERTIARY PLANTS FROM LOCALITIES IN THE SOUTHERN PART OF BRITISH COLUMBIA, WITH THE DESCRIPTION OF A NEW SPECIES OF EQUISETUM.

BY PRINCIPAL J. W. DAWSON, LL.D., F.R.S.

The following plants are from Coal Brook, on the Indian Reserve, North Thompson River:—

Populus subrotundatus—Lesq.

Populus arctica—Heer.

Populus latior—Heer.

Also a pinnate leaf like that of a *Sorbus*.

The following plants were collected in the vicinity of Vermilion Cliff, about three miles up the Tulameen, or north fork of the Similkameen:—

Taxodium distichum, Miocenicum—Heer.

Myrica partita—Lesq.

Also, a leaf similar to those which have elsewhere been assigned to the genus *Paliurus*.

On Nine-mile Creek and a second neighbouring locality referred to in the preceding report, specimens representing the following plants were obtained:—

Equisetum Similkamense—Sp. Nov.

Taxodium distichum Miocenicum—Heer.

Sequoia Langsdorfii—Heer.

Sequoia brevifolia (?)—Heer.

Glyptostrobus Europeus—Heer.

Thuja.

A pod of the genus *Leguminosites,* and like *L. arachioides*—Lesq.

Platanus—Sp.

Myrica, probably an undescribed species.

Populus latior (?)—Heer.

Populus arctica—Heer.

Corylus—Sp.

Betula Stevensoni—Lesq.

Juglans—Sp. allied to *J. rugosa*—Lesq.

Sapindus—Sp. allied to *S. angustifolius*—Lesq.

Carpinus grandis (?)—Ung.

Nelumbium—Sp.

It is hoped that the acquisition of larger collections of the Tertiary plants of British Columbia, may eventually render it desirable to publish a detailed report on the flora. In the meantime, the following species may be described:—

Equisetum Similkamense.

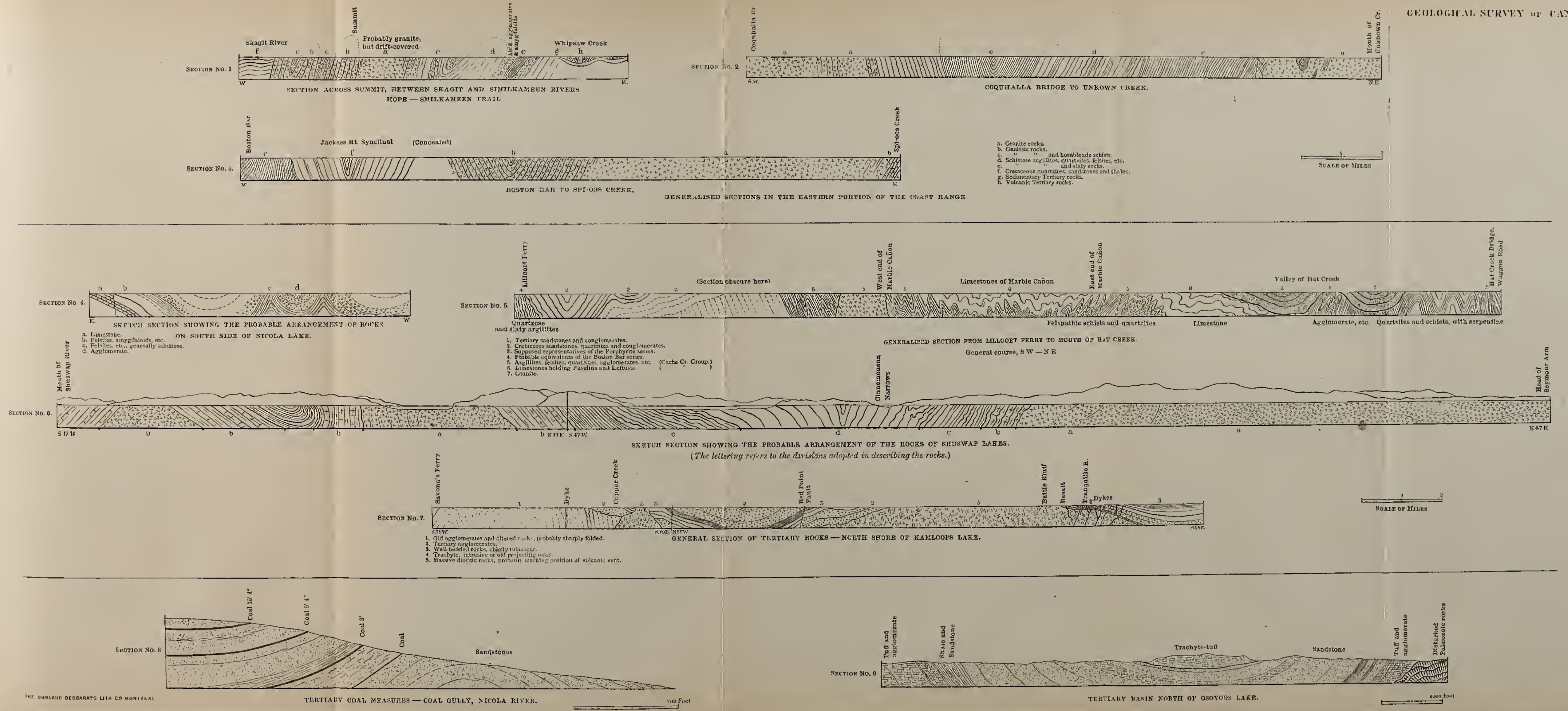
Stems naked or with remains of slender branchlets; ordinary diameter, fifteen millimetres, but some much larger; lacunæ and ribs, as many as sixty in large stems; wall thin, with small exterior lacunæ; nodes in some stems as close as one centimetre, but often further apart; sheaths, about six millimetres in length, with about thirty-five teeth, varying from a long and very acutely-pointed tapering form to a short form with somewhat obtuse tips, one-nerved.

Rhizomata, smooth, obscurely striate, with oval tubercles or bulbs in rows on the sides of branches; rootlets slender and branching.

The stems and roots of this fine species are very abundant, in a brown, laminated shale from the south fork of the Similkameen River. They are associated with grass-like plants and with coniferous and dicotyledonous leaves, probably blown or drifted into the pond or swamp in which the Equiseta were growing. The specimens of this plant are abundant and well-preserved, and very characteristic of the locality.

Of the described species known to me, *E. Winkleri* (Heer) and *E. Limosellum* (Heer), the variety with large, round sheaths, make the nearest approach to the present species.

The plants above referred to are no doubt Tertiary; and several of the species are identical with forms which according to Lesquereux have a wide distribution, as to time and space, in the Tertiary basins south of the United States boundary. The beds have been provisionally called Miocene (see p. 167 supra) and this would correspond with the indications of the flora; but there would be no improbability in the supposition that some of them may be upper or middle Eocene; beds holding similar plants having elswhere been referred to various portions of the Great Tertiary Series, and the stratigraphical evidence in British Columbia not being yet sufficiently complete to enable the exact relations of the beds in different localities to be understood.


Section No. 1
Skagit River
Summit
Probably granite, but drift-covered
Whipsaw Creek
SECTION ACROSS SUMMIT, BETWEEN SKAGIT AND SIMILKAMEEN RIVERS
HOPE — SMILKAMEEN TRAIL
Section No. 2.
Coquhalla Br.
Mouth of Unknown Cr.
COQUHALLA BRIDGE TO UNKOWN CREEK.
Section No. 3.
Boston Bar
Jackass Mt. Synclinal
(Concealed)
Spi-oos Creek
BOSTON BAR TO SPI-OOS CREEK.
GENERALISED SECTIONS IN THE EASTERN PORTION OF THE COAST RANGE.
a. Granite rocks.
b. Gneissic rocks.
c. " " and hornblende schists.
d. Schistose argillites, quartzites, felsites, etc.
e. " " and slaty rocks.
f. Cretaceous quartzites, sandstones and shales.
g. Sedimentary Tertiary rocks.
h. Volcanic Tertiary rocks.
Scale of Miles
Section No. 4.
SKETCH SECTION SHOWING THE PROBABLE ARRANGEMENT OF ROCKS ON SOUTH SIDE OF NICOLA LAKE.
a. Limestone.
b. Felsites, amygdaloids, etc.
c. Felsites, etc., generally schistose.
d. Agglomerate.
Section No. 5.
Lillooet Ferry
(Section obscure here)
West end of Marble Cañon
Limestones of Marble Cañon
East end of Marble Cañon
Valley of Hat Creek
Hat Creek Bridge, Waggon Road
Quartzose and slaty argillites
Felspathic schists and quartzites
Limestone
Agglomerate, etc.
Quartzites and schists, with serpentine
GENERALISED SECTION FROM LILLOOET FERRY TO MOUTH OF HAT CREEK.
General course, S W — N E
1. Tertiary sandstones and conglomerates.
2. Cretaceous sandstones, quartzites and conglomerates.
3. Supposed representatives of the Porphyrite series.
4. Probable equivalents of the Boston Bar series.
5. Argillites, felsites, quartzites, agglomerates, etc. (Cache Cr. Group.)
6. Limestones holding Fusulina and Loftusia. (" ")
7. Granite.
Section No. 6.
Mouth of Shuswap River
Cinnemousun Narrows
Head of Seymour Arm
SKETCH SECTION SHOWING THE PROBABLE ARRANGEMENT OF THE ROCKS OF SHUSWAP LAKES.
(The lettering refers to the divisions adopted in describing the rocks.)
Section No. 7.
Savona's Ferry
Dyke
Copper Creek
Red Point Fault
Battle Bluff
Basalt
Tranquille R.
Dykes
Scale of Miles
GENERAL SECTION OF TERTIARY ROCKS — NORTH SHORE OF KAMLOOPS LAKE.
1. Old agglomerates and altered rocks, probably sharply folded.
2. Tertiary agglomerates.
3. Well-bedded rocks, chiefly tufaceous.
4. Trachyte, intrusive or old projecting mass.
5. Massive dioritic rocks, probably marking position of volcanic vent.
Section No. 8
Coal 15' 4"
Coal 5' 4"
Coal 3'
Coal
Sandstones
TERTIARY COAL MEASURES — COAL GULLY, NICOLA RIVER.
500 Feet
Section No. 9
Tuff and agglomerate
Shale and Sandstone
Trachyte-tuff
Sandstone
Tuff and agglomerate
Disturbed Palæozoic rocks
TERTIARY BASIN NORTH OF OSOYOOS LAKE.
2000 Feet
THE BURLAND DESBARATS LITH CO MONTREAL

GEOLOGICAL SURVEY OF CANADA.

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

REPORT

ON AN

EXPLORATION OF THE EAST COAST

OF

HUDSON'S BAY

1877

BY

ROBERT BELL, M.D., C.M., F.G.S., C.E.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:
DAWSON BROTHERS.
1879

MONTREAL, May 9th, 1878.

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

Director of the Geological Survey.

SIR,—I beg to submit the following report on the results of the exploration of the eastern coast of Hudson's Bay (including James' Bay) which I was instructed to make during the season of 1877.

I have the honor to be,

Sir,

Your obedient servant,

ROBERT BELL.

Printed by Geo. E. Desbarats. From a Sketch by DR. BELL.

THE NORTH BLUFF, LITTLE WHALE RIVER, WITH HUDSON'S BAY CO.'S POST.

Overflows of Columnar Trap, resting on Dolomites and Quartzites.

REPORT

ON AN

EXPLORATION OF THE EAST COAST OF HUDSON'S BAY,

IN 1877,

BY

ROBERT BELL, M.D., C.M., F.G.S., C.E.

In order to commence operations, I proceeded from Montreal by the easiest route (namely that by way of Michipicoten on Lake Superior) to Moose Factory at the southern extremity of James' Bay. Thence I followed the eastern coast as far north as possible, allowing sufficient time to return to Moose Factory during the season of navigation. The Minister having sanctioned the suggestion that on my return to the post, I should if possible proceed by the Hudson's Bay Company's ship to London, England, with a view of gaining some reliable information respecting the navigation of Hudson's Bay and Strait, the directors and other officers of the Company readily agreed to allow me a passage by their vessel for which they proposed to make no charge. I may be here allowed to add that we were indebted to all the officers and employés of this Company with whom we met during the season, for rendering us any assistance in their power and for many acts of kindness and hospitality.

Route followed.

Ship to London.

Assistance from the Hudson's Bay Co.

No arrangements having been made for obtaining supplies on James' Bay, it became necessary to take along with us everything we might

Transport of supplies.

need for the whole season. Four canoes with an average of three men in each were required to transport this material from Michipicoten to Moose Factory. Leaving the former place on the 11th of June, we reached Moose Factory on the 30th of the same month, the journey having occupied nineteen days. The distance by the canoe route is 400 miles. Our loads, which amounted to between 6,000 and 7,000 pounds, and the four canoes to about 1,500 more, required to be carried on the men's backs twenty-seven times, past falls, chutes and the height of land, and the whole or the greater part of the load upwards of a dozen times more, making in all some forty portages or "demi charges." No accident of any consequence occurred on the trip, and the whole of our supplies were delivered at Moose in perfect condition.

In order to save expense, immediately on arriving at Moose Factory five of the party were paid off and sent back in one canoe to Michipicoten.

Survey of Abittibi River.

As it was considered very desirable to have a geological "traverse" made of the country between James' Bay and Abittibi Lake, to which the explorations of the Survey had already extended from the southward, Mr. A. S. Cochrane, one of my assistants, was instructed to make a track-survey of the Abittibi River to the lake of the same name, while I proceeded with the rest of the party to explore the east coast of James' and Hudson's Bays. Mr. Cochrane performed this duty successfully, and returned home in the month of September.

Boat and crew for coasting voyage.

Through the courtesy of S. K. Parson, Esq., the gentleman in charge of Moose Factory, I obtained the use of a schooner's jolly-boat for the coast journey. My crew consisted of four voyageurs from Lake Superior, and one assistant. Two Indian guides belonging to the country were tried in succession, each for a short time, but as they proved to be worse than useless, we were obliged to depend entirely upon ourselves both in going and returning; and having taken unceasing care to provide against every contingency, we met with no mishap whatever during the whole of the round trip.

Farthest point reached.

Starting from Moose Factory on the 7th of July, we worked northward till the 24th of August, when we turned to come south again. We reached the south-eastern extremity of Portland Promontory—the most conspicuous point or headland on the east coast of Hudson's Bay, and which having as yet no name, I propose to call Cape Dufferin, in honor of the Governor-General of the Dominion. This Cape is situated at about 600 miles from Moose Factory, or nearly two-thirds of the distance from that place to Hudson's Strait. While going northward, as we followed the coast closely the whole way from Rupert's House, our track was probably upwards of 800 miles in length. In returning we touched at many points and islands which we had not an opportunity of examining on the way up. Altogether, I think I have succeeded in obtaining a good general knowledge of the geology of the whole coast as far as we went.

Cape Jones, in about latitude 55° and directly opposite Cape Henrietta Maria, is considered the point at which we pass from James' Bay into Hudson's Bay, proper. From this point northward the geology became more interesting than it had been to the south, and I made a track-survey of the topography, as well as a careful record of the geology of the coast and islands to our turning point, a distance of nearly 300 miles from Cape Jones. In making this survey the distances were ascertained by means of Walker's patent ship log, the rate of speed of our boat, estimation of short distances by the eye, rough triangulation, and by observations for latitude, while the bearings were taken by compass, the variation of which was determined by numerous observations of the pole star.

Survey from Cape Jones northward.

Having made a *reconnaisance* of the coast from Moose Factory as far as the north shore of Rupert's Bay in 1875 (see report of the Geol. Survey for that year), the geological work of the present season only properly began where that of 1875 terminated. I may here recall the fact that during that season I made a track-survey of the route which we followed the present year from Michipicoten to Moose Factory, which proved to differ less than one per cent. from the correct distance as determined by the latitude and longtitude of each extremity. In passing over the same ground again the present season, a considerable improvement was accomplished in the topography of the large straggling sheet of water called Lake Mattagaming, and a survey was made of Brunswick Lake and River on the west side of the Missinaibi* branch of the Moose. These as well as our surveys of the Abittibi River and of the mouth of the Moose (to be noticed further on) will appear upon the map of the work of 1875. Many additional details which were noted in regard to the geology, cannot be given in the limits of this report, but a few of the more important facts require a passing notice. A narrow band of Huronian rocks crosses Crooked Lake at "the jog" near the middle. They consist of greenish silicious hornblendic and dioritic schists running N. 25° W., and dipping to the westward at an angle of 70°. From the Split-rock, or St. Peter's Portage, for a distance of about a mile down the Missinaibi River, felsites and mica schists are exposed which may belong to a narrow

Continuation of work of 1875.

New surveys.

Map.

Huronian rocks

* The name of this lake and of the river which flows from it to the main Moose River is frequently called Missinibi (Big Water) and it was so written in my report for 1875. Last year, however, I was informed by Mr. John Sanders, a native missionary in that region, and by Mr. Thomas Richards, in charge of the Hudson's Bay Company's post at Brunswick Lake, that the name meant Pictured Water, and that therefore the word should be written Missinaibi.

belt of the Huronian series. The only solid rocks found on the shores of Brunswick Lake and River consisted of Laurentian gneiss.

Lignite beds.

The existence of lignite on the Missinaibi River was referred to in my report for 1875, page 326. During the past season I found it *in situ* in several places on this river between the Long Portage and its junction with the Mattagami. The first or highest of these was in the west bank of Coal Brook, three quarters of a mile from its mouth. Coal Brook is a small discharge or channel which leaves the main river opposite the head of the fourth or River-side Portage, and rejoins it at five-and-a-half miles below Round Bay at the foot of Hell's Gates. This bed of lignite is about three feet thick, and is underlaid by soft sticky blue clay and overlaid by about seventy feet of drift-clay or "till," full of small pebbles and passing into gravel towards the top. Much of the lignite retains a distinct woody nature; some of the embedded trunks are two feet in diameter. When dry it makes a good fuel, but contains a little iron pyrites.

Coal Brook bed.

Lignite two miles above Woodpecker Island.

On the south-east side of the river, at nineteen miles below Coal Brook or two miles above Woodpecker Island, a horizontal seam of lignite was found in the midst of a bank of "till" 125 feet high. It is from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet thick, and is made up principally of sticks and rushes. Below the lignite are 80 feet of yellow-weathering grey clay, and above it 45 feet of blue clay. Both varieties of clay are full of pebbles, and they also hold some striated boulders of Laurentian gneiss, Huronian schists and unaltered Devonian limestone.

6 feet of lignite five miles from the last.

At three miles below Woodpecker Island, or nine miles above the mouth of the Opazatika (Poplar) River, another bed of lignite occurs in the bank on the same side. It is six feet thick but diminishes to the eastward, and is of a shaly character, being made up of lamminæ of moss and sticks. Immediately beneath the lignite is a layer, one foot thick, of irregularly mingled clay and spots of impure lignite. Next below this are 40 feet of unstratified drift full of small pebbles, under which are a few feet of stratified yellowish sand and gravel. Resting upon the lignite are five feet of hard lead-colored clay with seams and spots of a yellow color, and layers of red, grey, drab and buff. Above all and forming the top of the bank 65 feet high, are ten feet of hard drab clay with striated pebbles and small boulders and holding rather large valves of *Saxicava rugosa*, *Macoma calcarca* (*Tellina proxima*) and *Mya truncata*.

Smaller seams of lignite.

Small seams of lignite were seen in two places in the bank on the same side, at, and again half-a-mile below, the foot of a rapid which occurs about six miles above the Opazatika.

"Bubbling Water."

In the interval between one and two miles above this stream the whole bed of the river appears to be underlaid by lignite. When sounded with a heavy pole, it has an elastic feel and gives off large volumes of gas, which may also be seen at any time bubbling up spontaneously here and there all along this part of the river. This phenomenon has been observed by the Indians from time immemorial, and the locality has received the name of the "Bubbling Water." A box of specimens of the lignites of the above localities was brought to Montreal for examination. A number of rock-specimens for the museum were also obtained in different parts of the route from Michipicoten to Moose. I also collected a considerable number of fossils between the Long Portage of the Missinaibi Branch and Moose Factory. These have been examined by Mr. Whiteaves, who gives the following provisional list of the species, which shews that the formation from which they are derived is of Devonian age. In my report for 1875, page 316, Mr. Whiteaves gives a list of twelve species of Devonian fossils from similar rocks on the Mattagami branch of the Moose River.

Specimens.

Devonian fossils.

Provisional list of fossils collected between the Long Portage of the Missinaibi branch of the Moose River and Moose Factory.

PROTOZOA.

Stromatopora. (N. Sp.) Apparently undescribed, but possibly an extreme form of *S. concentrica*, Goldfuss. It differs materially from any of the species of *Stromatopora* from the Devonian Rocks of Ontario described by Dr. H. A. Nicholson.

CÆLENTERATA.

Favosites Winchelli, Rominger. Two specimens.

Favosites hemisphærica, Troost, *var. turbinata*. Of the usual turbinate form of this well marked variety, but with exceptionally small corallites.

Favosites polymorpha, Goldfuss. A portion of a branch.

Alveolites. Two species. One a massive form, perhaps identical with *A. vallorum* of Meek from the Mackenzie River; the other a branched, spreading species.

Cladopora cryptodens? Billings. One badly preserved example.

Syringopora Maclurei. Billings. A single specimen.

" *Hisingeri.* Billings. Two or three examples.

Aulopora? (Sp. undt.) Possibly the young state of a species of *Syringopora*.

Cyathophyllum (Heliophyllum) Halli, Edwards & Haime. One specimen.

" *(Acervularia) Davidsoni*, " " " "

Cystiphyllum. (Sp. undt.) A fragment, shewing only the internal and generic characters.

Diphyphyllum (Eridophyllum) Simcoense, Billings. A typical but rather small form of this species.

Phillipsastræa Vernueili, Edwards & Haime. Two characteristic fragments.

Zaphrentis cornicula? Nicholson. Apparently the same as a species of *Zaphrentis* figured and described under this name by Dr. Nicholson on page 75 of his second " Report upon the Palæontology of the Province of Ontario," but most likely distinct from the *Z. cornicula* of Lesuer, which, as Mr. Billings pointed out long ago, is probably a *Heliophyllum*. Dr. Rominger, who regards *Heliophyllum* as synonymous with *Cyathophyllum*, refers Lesuer's species to the latter genus.

POLYZOA.

Dictyonema. (Sp. undt.) A portion of a frond, showing the non-celluliferous side.

BRACHIOPODA.

Strophomena (Strophodonta) concava, Hall. A cast of a ventral valve.
" " *demissa*, Conrad. One imperfect specimen, but with both valves and most of the test preserved.
Streptorhynchus ? (Sp. undt.) A cast of a ventral valve.
Orthis Vanuxemi, Hall. " " " "
" N. Sp. A small species, with a shallow sinus in the dorsal valve. Abundant and tolerably perfect, but always with the outer layer of the test exfoliated.
Atrypa reticularis, Linnæus. Common.
Spirifera sculptilis ? Hall. Two detached valves, one dorsal, the other ventral. The hinge area is not visible, but in almost every other respect the specimens correspond with the description and figures of *S. sculptilis.*
Cyrtina Hamiltonensis, Hall. One nearly perfect example, with an unusually elongated foramen.
Rhynchonella pleiopleura, Conrad. Two specimens.

LAMELLIBRANCHIATA.

Leptodomus. (Sp. undt.) An immature left valve.
Conocardium trigonale, Conrad. Abundant.
Pterinca textilis, var. *arenaria*, Hall. A cast of a left valve.

GASTEROPODA.

Pleurotomaria. Two species. Too imperfect to be identified with any certainty.

CEPHALOPODA.

Orthoceras. Two species. One, which is marked with narrow, rather distant, longitudinal ridges, may be a cast of *O. profundum*, Hall. The other has a nearly central, moniliform siphuncle, and an apparently smooth surface.

CRUSTACEA.

Phacops rana ? Green. A cast of the head of a trilobite which appears to belong to this species.

The age of the rocks from which these fossils were collected is obviously Devonian and the horizon is probably nearly identical with that of the Corniferous formation of Ontario.

J. F. WHITEAVES.

Glacial phenomena.

Numerous additional observations were made in regard to the glacial phenomena on the route to Moose Factory. Although the striæ are generally well preserved and conspicuous on rock-surfaces which have been protected by a covering of earth or water, yet in

Printed by Geo. E. Desbarats. From a Sketch by Dr. Bell.

THE GREAT STONE "CONJURING HOUSE," MISSINAIBI RIVER,

Showing Post-glacial Denudation.

several places there are evidences that a considerable destruction of the solid rock has taken place since the glacial period. Probably the most remarkable of these locations is the Conjuring-house Rapid, where the river passes through a crooked gorge with rugged sides, excavated in the garnet-bearing micaceous gneiss, which here strikes N. 80° E. A curious angular pillar forty or fifty feet high stands perpendicularly in the middle of the rapid. Its proportions resemble, on a large scale, those of the Indian medicine-man's conjuring-house, from which circumstance it derives its name, and the Indians regard it with superstitious veneration. This gorge and pillar are represented in the sketch on the next page. Rock disintegration.

In the bed of the Moose River, near the north side and just below the forks, 46 miles from Moose Factory, a mastodon's jaw with one of the teeth was found by an Indian, who broke out the tooth with his axe and carried it to Moose Factory. Loose pieces of lignite are very abundant in the bed of the river at this locality, and it probably exists here *in situ* under the debris forming the bottom of the stream. Jaw of mastodon,

As mentioned in my report for 1875, marine shells were observed in the drift clays in various places all along the river from its mouth to Round Bay at the foot of the great Laurentian and Huronian plateau, 127 miles from Moose Factory, and elevated about 300 feet above the sea. Upwards of a dozen species were found at the mouth of the river, but the number diminishes in ascending the stream, and only two appear to persist to Round Bay, namely, *Saxicava rugosa* and *Macoma fragilis* (*Tellina grœnlandica*). Marine shells.

Soil of the Country between Lake Superior and James' Bay.

In my report for 1875, I gave a general account of the soil, &c., in the region between the great lakes and James' Bay. Following the canoe-route from Michipicoten to Moose Factory, the country is more or less rocky as far as Missinaibi Lake, yet even in this section the proportion of rock-surface to the whole area may be comparatively small. But after passing the "Swampy Grounds," north of Missinaibi Lake, the traveller cannot fail to be struck by the abundance and the general fertility of the soil exposed in the banks of the Missinaibi and Moose Rivers all the way to Moose Factory. It consists mostly of a brownish, somewhat gravelly loam or earth, resting upon "till," and sometimes upon stratified clays or the solid rock, which, however, is seldom seen, except at the principal rapids and falls. But in the central third of the section between Lake Superior and James' Bay, or from the Brunswick to the Long Portage, a light-colored clay usually forms the surface. I examined the country for a mile or two back from the river in several places for the special purpose of ascer- Soil. Rock-surface. Brownish loam. Light-colored clay.

taining the nature of the soil, and found it excellent in all cases, but tending to become more swampy in receeding from the river in the Devonian region below the Long Portage. Samples of the soil were collected in a few places for subsequent examination. In traversing such a great extent of almost unbroken wilderness, one is apt to forget the possible value of this vast region for agricultural purposes. But the examples of the farms at New Brunswick House and Moose Factory shew, upon a small scale, what might be extended over a great part of the country. I have no doubt that at some future time this territory will support a large population.

Agricultural value

Return Journey.

As already stated, Cape Dufferin was the most northern point which we reached on our voyage up the Eastmain coast. Turning southward on the 24th of August, we again reached Moose Factory on the 22nd of September, and learned that the Hudson's Bay Company's ship had sailed for London two weeks before our arrival, which was somewhat earlier than the usual date of leaving. While the necessary preparations for our return by Michipicoten were being made, I surveyed the mouth of Moose River and the vicinity of Moose Factory, and made daily observations for latitude at this post. Leaving Moose on Monday, October 1st, we reached Michipicoten on Monday the 22nd of the same month (having occupied just three weeks on the trip), and I arrived at Montreal on the 1st of November. Having thus briefly sketched our journeys in connection with the season's operations, I now propose to give a short account of the principal results in reference to the Eastmain coast. The great object of the expedition was of course to ascertain the nature and geographical distribution of the rock-formations in the region explored, and to determine the probability, or otherwise, of the existence of valuable minerals. But as already mentioned, I also made what topographical surveys were possible, and obtained, in addition, a large amount of information in regard to the soil and general contour of the country, the characters of the rivers and coasts, the climate, timber, and vegetation, fisheries, natural history and botany of the regions visited, the aboriginies, and, in fact, in regard to all matters which might, at any time, be of interest to the public.

Survey of mouth of Moose River.

Summary of results.

Geology of the Eastmain Coast.

Laurentian series.

Laurentian Gneiss.—From Rupert's Bay to Cape Jones the geology of the coast is comparatively uninteresting: The rocks consist of Laurentian gneiss with a belt of Huronian schists at Cape Hope, and another at the Paint Hills. The gneiss presents a great variety of characters in this distance, and although I noted descriptions of these for reference in many places, they may not be worth giving at length in the present report. The average strike at Rupert's Bay was west-north-westward, but in going towards Cape Jones it gradually changed to north-west and north-north-west. The following examples of the character of the gneiss (briefly stated) with the strike at a number of localities, arranged from south to north, may serve instead of a more extended description. The directions refer to the magnetic meridian:

Average strike.

Examples of character and strike.

	STRIKE.
1. On S. W. point of Sherrick's Mount Island, gneiss is composed of coarse white felspar and quartz with garnets, interstratified with silicious and micaceous beds; general appearance, light-colored	N. 70° W.
2. 30 miles northward of Rupert's River, very massive coarse greenish and yellowish holding twisted masses of a hard black micaceous character. On the large scale it has a striking barred appearance	N. 70° W.
3. 22 miles, bearing N. by E. from N. point of Sherrick's Mount Island (the interval being occupied by grey gneiss), it is hard, micaceous and hornblendic, with beds of white felspar and numerous disseminated crystals of the same minerals........................	N. 60° W.
4. The prevalance of felspar characterizes the gneiss all the way from the last locality to the mouth of the East-main (or Slude) River, where the strike is..........	W.
5. From 5 miles N. of Cape Hope to Paint Hills, 39 miles N. of it, grey and reddish grey.......................	Cortorted.
6. 11 miles N. of Paint Hills light pinkish grey massive gneiss	N. 60° W.
7. 40 miles S. of Big River (Fort George) grey finely-marbled gneiss, dips N. 70° E. < 25°........................	N. 20° W.
8. From Big River for 10 miles southward, the gneiss is usually contorted. Average strike about............	N. 45° W.
9. Governor's Island in mouth of Big River, grey gneiss dips S. 35° W. < 45°..................................	N. 55° W.
10. Esquimaux Point, 1½ mile N. W. of Fort George and near the last locality, grey gneiss dips S. 80° E. < 9°......	N. 10° W.
11. 14 miles N. of Governor's Island, reddish gneiss........	N. 55° W.
12. 18 miles N. of Governor's Island, reddish grey gneiss....	N. 50° W.
13. Islet 18¾ miles N. of Governor's Island; the lamination of grey gneiss is well marked. It holds black patches like embedded boulders..........................	N. 65° W.
14. 20 miles N. of Governor's Island, grey gneiss..........	N. 65° W.
15. 21½ " " " "	N. 70° W.
16. Wind-bound Point on N. side of North Fishing Creek and 36 miles N. of Governor's Island, grey and red.......	N. 70° W.
17. Extremity of Cape Jones, three varieties of gneiss; general strike	N. 33° W.

Huronian band of Cape Hope.

Huronian Bands.—On the extreme western point of Cape Hope (island), the rock consists of dark grey hornblendic schist with some lighter and more silicious belts. Most of the schist is divided into small lenticular forms, each surrounded by granular white calcspar, which also occurs in patches and short veins. The rock is cut by numerous straggling veins of mixed calcspar and quartz, intercalated with schist. Some of them are wide, but short. They run in various directions. No metallic ores were obtained in any of them.

Huronian band of the Paint Hills.

The Paint Hills occur on a point with several islands lying off it at a distance of about 39 miles north of Cape Hope. The most western or outermost hill on the point appears to be the highest. It has an elevation of about 150 feet above the sea. Here the rounded rocks are in some places, especially along the north-west side, stained reddish and brownish and resemble smooth oxidized surfaces of metallic iron. In some parts they weather to a green color. The rocks at the hills themselves consist of micaceous and hornblendic silicious schists with epidote in crystals and patches and epidosite in masses of varying size. The schists are full of disseminated specks of white iron pyrites which also occurs in small veins of white quartz. They also contain a good deal of white calcspar in the form of partings in the joints and cleavage-planes and also as isolated patches, which might be called granular crystalline limestone. The cleavage runs in two directions—S. 60° W. and S. 40° W., and dips to the north-westward.

Schist conglomerates.

On an islet half-a-mile north of the point, the rock is a dark grey mica-schist full of rounded pebbles of light grey fine grained granite, and of different varieties of silicious schists. The pebbles are mostly small, but some larger than the rest measured about eight inches in diameter. The cleavage runs east and west but the bedding strikes N. 10° W. This is clearly shown by a belt of large rounded pebbles and small boulders (the largest being two feet in diameter) closely crowded together; and also by a parallel band close by consisting of soft green schist, which cuts the cleavage of the schist-conglomerate like a vein. A vein of granite composed of reddish-white quartz and very large crystals of white felspar traverses the islet in the same direction. At about six miles northward of Paint Hills, the cleavage of a greenish schist, occurring on an islet, strikes N. 30° W., and dips to the north-eastward at an angle of 70°. The breadth of this Huronian band at right angles to its course may be two or three miles.

Islands off Paint Hills.

On the outermost islands, several miles to the south-eastward of the extremity of the point at the Paint Hills, the rocks consist of fine-grained dark greenish-grey hornblendic schist, with fine-grained silicious portions. Small veins of whitish granite also occur following the stratification which runs N. 30° W.

Printed by Geo. E. Desbarats. From a Sketch by DR. BELL.

VIEW OF EASTMAIN COAST, HUDSON'S BAY, LOOKING N. E., FROM A POINT TEN MILES S. W. OF LITTLE WHALE RIVER.

Columnar Trap resting on Dolomites, Quartzites, &c., all dipping under the Sea.

In the above interval of the coast between Rupert's Bay and Cape Jones, dykes of dark-colored heavy trap were observed in numerous places cutting the gneiss. They varied from a few feet up to 80 feet or more in width. In all cases where their direction was taken it was found to be due north and south (magnetic). I have elsewhere referred to the influence of trap dykes in shaping out the present natural features of the regions to the northward of the great lakes (See Reports of the Geol. Survey, 1870, page 331, and 1875, page 315), and I have little doubt that these north-and-south dykes had something to do with producing the coast-line along which they occur.

Trap Dykes.

Influence on topography.

General Character of the Coast.—The outline of the land from Rupert's Bay to Cape Jones is undulating and rather low. The coast is fringed with a great number of islands with long points and peninsulas of the mainland among them. The water between these islands and points and for some distance out to sea is shallow. The majority of the islands are rather low and composed of boulders and shingle with few or no trees, but the solid rock occurs upon a large proportion of them. No regularity can be detected in the general arrangement of these islands. They present a kind of labyrinth, which it would be very difficult to map with accuracy, and which is not unlike that of the northern shore of the Georgian Bay, Lake Huron, except that on the east coast of James' Bay the water is shallower and shews evidence of receding rapidly, and the islands are, as above stated, mostly covered by boulders and shingle.

From Rupert's Bay to Cape Jones.

From the neighbourhood of Cape Jones, all the way to Cape Dufferin, the coast is of a different character and the rocks are more varied and interesting. The general outline of the land is higher and more uneven and it rises gradually as we go north all the way to the head of Manitounuck Sound. Here it becomes bold, rugged and often precipitous, and maintains this character nearly to the point at which we turned back.

From Cape Jones to Cape Dufferin.

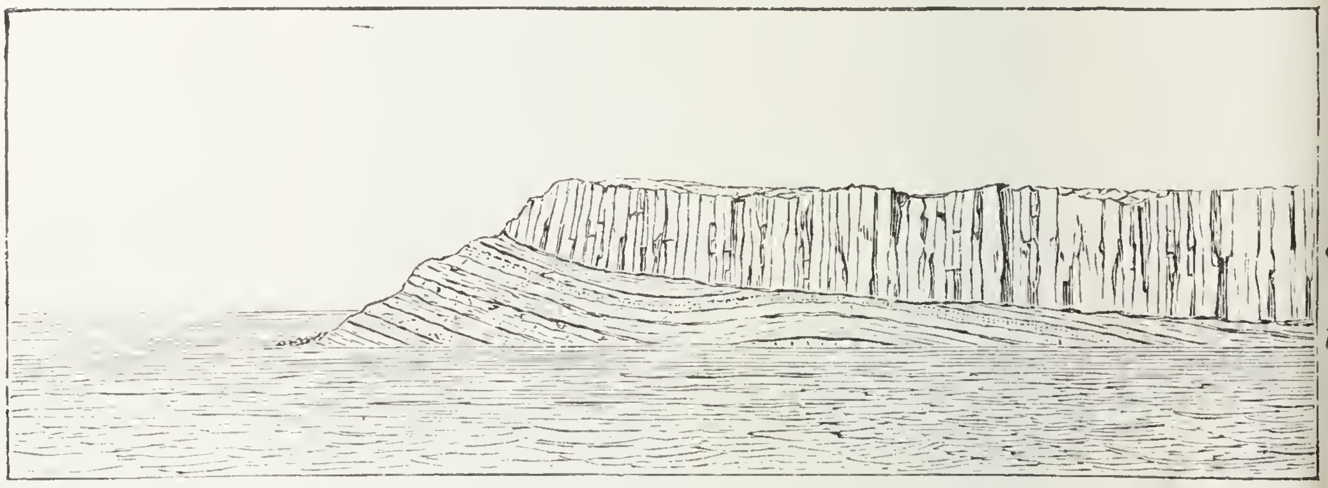
The islands along this part of the coast run in regular chains, nearly parallel with the shore, of which the principal are the Manitounuck, Nastapoka and Hopewell chains. Long Island, which begins a few miles north-east of Cape Jones, and measures about thirty miles from one extremity to the other, also lies parallel to the shore.

Chains of islands.

Manitounuck Group of unaltered rocks.—The rocks of these islands and of the main shore from Manitounuck Sound to a point north of Richmond Gulf, consist of an unaltered stratified series, in which I could detect no fossils, and which resemble the Nipigon rocks more closely than any other yet described in the Dominion. They might for convenience at present be called the Manitounuck group. They are made up mostly of limestones (generally silicious and argilla-

Manitounuck group of rocks.

ceous), sandstones and quartzites, shales, ironstones, amygdaloids and basalts. The strike corresponds with the general course of the shore and with the chains of islands. The dip is at a low angle (generally 4° or 5°) to seaward and consequently all the escarpments of the islands are on the side next the main shore, and those upon the latter all face inland. Many of the latter rise to a height of 700 feet or more above the level of the sea. At Little Whale River, a grey quartz conglomerate of great thickness occurs below these rocks; but the limestones, which are bluish-grey and generally silicious or argillaceous, are found in most localities at the base of the series. They usually occur in thick beds and contain cherty concretions having a concentric structure. The quartzites and sandstones come next in ascending order and also occur in massive beds. They vary in color from very light to very dark grey, and a few beds are reddish. Associated with the quartzites and overlying them is a series of cherts and shales mostly darkly colored. These are surmounted by a great thickness of amygdaloids of various kinds and by diorites of a basaltic character. The last mentioned rocks occur in patches on Long Island and as an almost continuous capping on top of the islands of the Manitounuck chain. From Manitounuck Sound to Richmond Gulf, the main shore consists of very massive beds of amygdaloid with the underlying basalts, shales, quartzites and limestones appearing in the cliffs at a greater or less distance inland.



SECTION NEAR SOUTH-WEST EXTREMITY OF LONG ISLAND.
a. Overflow of columnan trap. *b.* Ferruginous beds, slightly unconformable to trap.

Nastapoka and Hopewell Islands.

The Nastapoka and Hopewell chains of islands consist of quartzites and shales with ironstone bands capped by basaltic diorites in some places. The general run of all these rocks is interrupted by numerous very low transverse anticlinals. The effect of this structure, under the powerful glacial denudation to which the whole country has been subjected, has been to cut out the channels between the islands and to give to each of the latter a crescent-like form, the convexity of each island being towards the main shore. The gaps through which Little

Printed by Geo. E. Desbarats. From a Photograph by JAMES L. COTTER.

HILLS ON SOUTH SIDE OF LITTLE WHALE RIVER, EASTMAIN, HUDSON'S BAY.

Trap, Dolomites, Quartzites and Shales, resting on Sandstones and Conglomerates.

Whale River and other streams find their way to the sea, have also had a similar origin. There are also many similar gaps in the hills, which were at one time occupied by water, but which are now more or less filled up with sand or shingle, and some of them are elevated to a considerable height above the sea-level.

Instead of describing the rocks of the various islands of the Nastapoka chain and of the mainland opposite to them, I shall give a few representative sections, which will be more convenient for reference. Other details of the geology are given on the accompanying map.

The following is an approximate ascending section of the rocks exposed in the cliffs in the vicinity of the lead mine, three miles north-eastward of the Hudson's Bay Company's establishment at Little Whale River:— Section north side Little Whale River.

	FEET.
Massive compact bluish dolomites, with chert, of which are exposed about	70
The lead-bearing band of a similar character to the last, but somewhat drusy	30
Thick-bedded bluish-grey dolomite	20
Interval concealed, about	100
Dark flaggy argillites and shales	40
Flesh-colored, pink and grey quartzites	60
Trap-overflow in five layers, about 250 feet in all, of which there are exposed near the lead mine about	50
	370

The general appearance of these cliffs, and the great trappean overflow which surmounts them, is shown in the accompanying view. The above section begins on high ground, and the total elevation of the top of the cliff of rudely columnar basalt, followed by amygdaloid, is probably upwards of 700 feet above the sea.

On the opposite or south side of the Little Whale River, some of the hills appear to be over 1,000 feet high. An approximate ascending section of the cliffs shown in the accompanying view would be as follows:— Section south side Little Whale River.

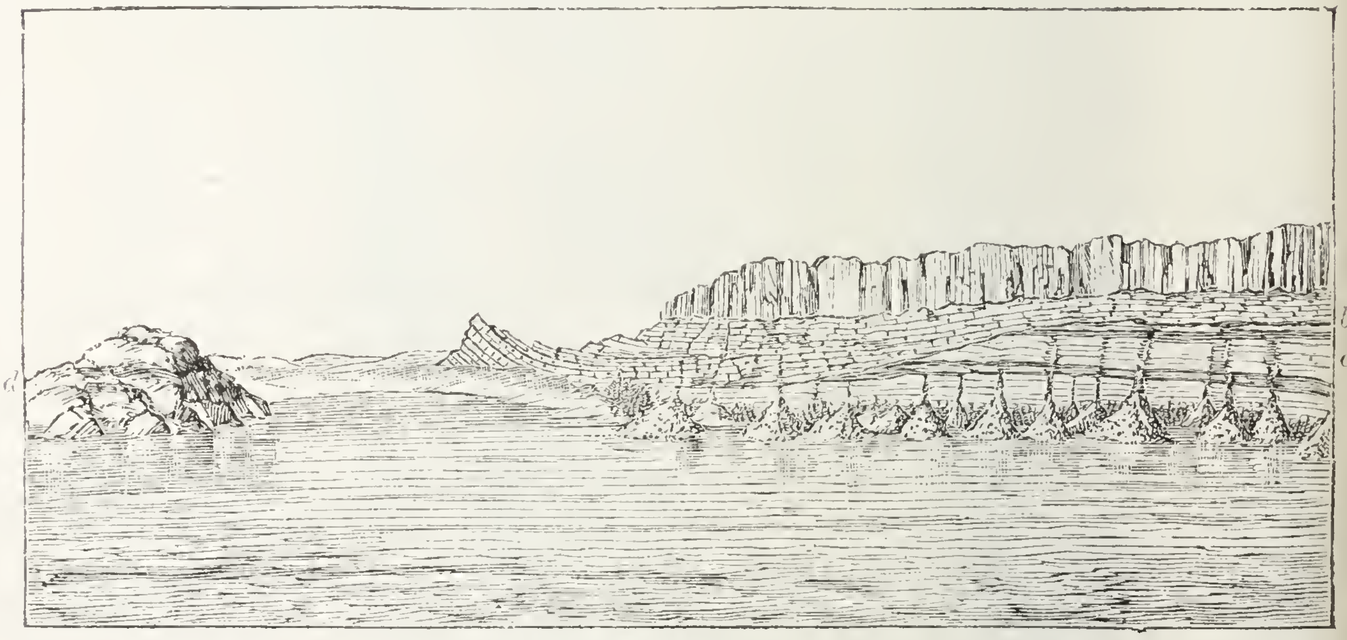
	FEET.
Coarse grey and reddish-grey somewhat altered sandstone with conglomerate layers, and conglomerate with sandstone layers; the pebbles are mostly quartz. The total thickness is probably double that exposed at the base, namely	150
Concealed, but probably a continuation of the last, overlaid by bluish-grey dolomite	350
The lead-bearing band of compact bluish-grey dolomite	35
Massive blue dolomite	30
Concealed about	300

	FEET.
Yellow-weathering compact blue dolomite	40
Single band of solid grey sandstone	5
Thinly-bedded grey sandstone, with ripple-marks, and hard flaggy and shaly argillite	100
Bluish-grey diorite, porphyritic in parts—least thickness	50
	1060

Castle Peninsula.

In the south-western part of Richmond Gulf, and on the north side of the outlet, a remarkable castle-like peninsula rises to a height of seven or eight hundred feet. The lower part consists of coarse grey sandstone passing into conglomerate, with white quartz pebbles, like that of Little Whale River, while the upper part consists of limestones slightly unconformable to the sandstones, and all capped with trap. On the same side, and between the Castle Peninsula and the narrowest part of the outlet, a boss of Laurentian gneiss, about 100 feet high, protrudes through the sandstones and limestones, as shewn in the accompanying section.

Boss of gneiss.



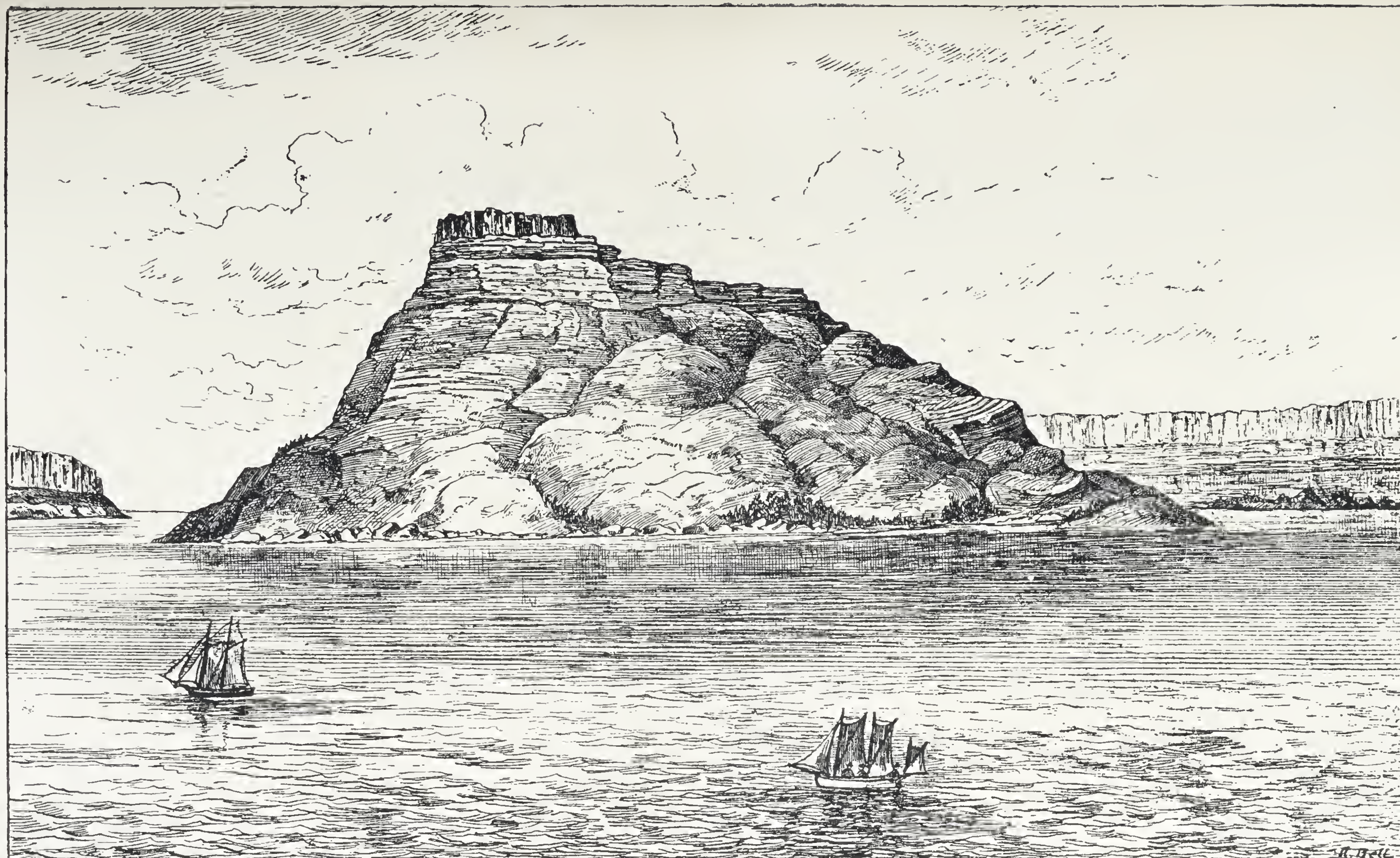
SECTION ON SOUTH SIDE OF CASTLE PENINSULA.

a. Overflow of columnar trap.
b. Dolomite, upturned in approaching gneiss.
c. Sandstone and conglomerate, unconformable to dolomite.
d. Boss of gneiss with sandy bay to east.

Section at Richmond Gulf

On the south side of the outlet of the gulf the following approximate ascending section of rocks is seen rising from the level of the sea:—

	FEET.
Coarse greyish sandstones, upwards of	400
Amygdaloidal trap	150
Bluish, grey and drab dolomites	60
The lead-bearing band of bluish drusy dolomite	20
Thick-bedded bluish dolomite	30
Grey quartzites and argillites	100
Basaltic diorite (followed elsewhere by amygdaloids)	200
	960



Printed by Geo. E. Desbarats. From a Sketch by DR. BELL.

CASTLE PENINSULA AND OUTLET OF RICHMOND GULF, HUDSON'S BAY, LOOKING WESTWARD.

Columnar Trap, resting on Dolomites and Quartzites with Conglomerates and Sandstones at the Base.

Upon some of the islands in Richmond Gulf, and on its south-eastern shores, reddish-grey quartzites occur, which are generally thinly-bedded and somewhat disturbed. The group of rocks above described appears to overlie them unconformably. These quartzites may, perhaps, be of Huronian age. On the southern side of the gulf a massive crystalline greenish diorite is exposed, which may also be classified as Huronian.

Supposed Huronian.

In the high hills to the southward, the upper rocks, at a distance of about two miles from the outlet, dip about N. W. $< 6^\circ$, while those below them, supposed to be the coarse sandstones, dip about S. $< 5^\circ$, shewing a want of conformity, with an angle between the stratification of the two sets of 11°.

Lead-bearing band.

The lead-bearing band appears to be frequently exposed in the escarpments from Manitounuck Sound to Richmond Gulf, and along the west side of the latter. Although comparatively thin, it is probably continuous in the above interval, and from its richness in galena may prove of economic importance.

Uniform dip.

The last of the above sections may be taken as a fair representation of the rocks which form the high and narrow tongue of land, which separates Richmond Gulf from the open sea, and also the first ridge or range of hills all along the coast to the southward as far as the head of Manitounuck Sound. The dip to the westward is very uniform at an angle of about 5°, and the upper beds, which slope under the water all along the outside shore of this narrow peninsula, as well as the continuation of the similar coast to the southward nearly to Manitounuck Sound, are amygdaloidal and usually thickly studded with coarse agates, many of which are very large. They also hold occasional patches of iron pyrites of a curious vesicular variety. Isolated masses of epidosite, from two to twenty feet in diameter, are very common in these amygdaloids. They appear to be of a seggregated or concretionary character. The proportion of the epidote and the intensity of the green colour gradually increase from the circumference to the centre of each mass. On the extensive bare rock-surfaces along the sea-shore, they generally break up, under the weather, into angular fragments which become removed by some natural process leaving round pits or holes to mark the former positions of the epidotic masses.

Epidotic concretions.

Nastapoka Islands.

The Nastapoka chain of Islands begins near Little Whale River and runs northward, nearly parallel to the coast, for about ninety miles. It consists of fourteen principal islands, all of a crescent-like form, narrow and destitute of trees, with numerous smaller islands between them. Some of them are five or six miles long. Their distance from the main shore varies from two and one-half to five miles. The general dip is westward towards the open sea at angles varying between about 3° and 6°. The structure of each island resembles that of all the others, the rocks of the whole chain belonging to one set, illustrated by the sections which follow. The first represents approximately, in ascending order, the strata of Belanger's Island, lying off the entrance to Richmond Gulf, the most southern large island of the chain.

Section at Belanger's Island.

		Feet.
1.	Bluish dolomite, weathering yellow, all in large concentric masses with olive-green slate between. These large masses are again formed of small concentric concretions, two to six inches in diameter	10
2.	Olive-green silicious slate	20
3.	Interval of concealment, thirty or forty chains wide, between the eastern edge of the island and the base of the talus, occupied by numerous small ridges and ancient beaches of coarse shingle up to forty feet above the sea, which with a dip of 5° would represent a thickness of about	200
4.	Greenish silicious shale with grey quartzose sandstone	150
5.	Single band of light grey sandstone	10
6.	Grey quartzose sandstones interstratified with greenish silicious shales	105
7.	Black slate, some of which splits into good flags	15
8.	Highly ferruginous impure dolomitic band	10
9.	Drab-colored manganiferous spathic ironstone in thin bands, some of which weather brown and others black	18
		538

The upper part of this section forms a cliff rising nearly perpendicularly to a height of 348 feet above the sea. A few chains north of the position of number two in the line of section, some grey arenaceous beds hold small veins of a beautiful olive-green chalcedony resembling jade.

Flint Island.

Flint Island, which is of small size, lies three-quarters of a mile south of Belanger's Island. The rocks here dip S. 80° W. (mag.) < about 7°, and consist of forty feet of grey sandstone, overlaid by sixty feet of felsitic slates and argillites, all capped by thirty feet of beds of manganiferous spathic iron interstratified with greenish argillaceous sandstone. The iron ore, which is in great abundance, divides into thin beds, generally weathering black, and the surfaces have a curious finely reticulated appearance resembling honey-comb. One of the specimens of this ore collected on Flint Island, is found by Dr. Harrington to contain 25.44 per cent. of metallic iron and over twenty-four per cent. of carbonate of manganese. These ores are found in great quantities throughout the whole of the Nastapoka chain of islands and will be again referred to in the section on economic minerals. The lower strata of Flint Island are cut by a vein of white quartz from two to twelve inches thick containing much coarsely crystalline siderite which turns black on exposure to the weather.

Iron Ore.

Printed by Geo. E. Desbarats. From a Sketch by Dr. Bell.

VIEW OF THE OUTER AND INNER "BARNS," LAKE NIPIGON, FROM THE MOUTH OF THE WABINOSH RIVER.

Columnar Trap, Resting on Dolomites, Quartzites and Shales.

The southern point of the second Nastapoka Island, between four and five miles west of the outlet of Richmond Gulf, presents the following ascending section:— *Sections at second Nastapoka Island.*

	FEET.
Greenish-grey felsitic slate	20
Greenish sandstone. The surfaces are so completely stained with oxide of iron that the debris resembles a pile of hematite	50
Yellow-and-black weathering manganiferous and spathic ironstone beds.	10
Grey calcareous sandstone with chert	40
	120

This section represents the uppermost strata of the island. At the highest point on its eastern side the following approximate ascending section is presented in a cliff facing the mainland:—

	FEET.
Hard grey, rather thinly-bedded sandstones, with greenish shaly partings	120
Dark greenish-grey massive felsite slate	40
Dark-green argillaceous sandstone, with glossy black surfaces	50
Greyish sandstones with shales—say	90
	300

About three-quarters of a mile north of this place an isolated rock, which we called Gull Islet, rises a few feet above the level of the sea. It consists of massive grey dolomite, full of patches of black chert, and may occupy a place near the horizon of the dolomite at the base of the section of Belanger's Island. *Islet of dolomite.*

Since the strata of the Nastapoka Islands and of the mainland opposite are comparatively undisturbed and have the same strike and dip, it may be assumed that the measures concealed under Nastapoka Sound are conformable, and would amount to about 1,000 feet in vertical thickness. This, with a minimum of 1,200 feet to represent the strata around Richmond Gulf, and 600 for the rocks of the Nastapoka Islands, would give a total of 2,800 feet as the thickness of the whole (Manitounuck) group on this part of the coast. Not only do the rocks of this group, as a whole, bear a lithological resemblance to those of the Nipigon series, but there is a similarity in the landscapes to which they give rise, which is especially noticeable in the style of cliffs formed by the rudely columnar traps of the two sets, as may be seen by comparing the accompanying sketch, taken at the mouth of the Wabinosh River, on Lake Nipigon, with those representing the escarpments at Little Whale River. *Total thickness of strata.* *Nipigon series.*

On one of the islands of the Nastapoka group, which we called Davieau's Island, about sixty miles north of the inlet of Richmond Gulf, the following approximate ascending section was measured. *Section at Davieau's Island.*

The greatest vertical height of the island is 270 feet. It lies two and a-half miles from the main shore, which here consists of Laurentian gneiss:—

	FEET.
Greenish-grey fine-grained quartzose sandstone	40
Black slates	50
Grey sandstone	45
Black slates	30
Band of red chalcedony	7
Black slates and dark greenish-grey shaly sandstone, with magnetic iron	130
Manganiferous spathic ironstone beds, weathering yellow	20
	322

Trappean overflow.

In continuation of the Nastapoka group is an island lying between two and three miles off the main shore, with a length of six or seven miles, beginning opposite the mouth of the Langlands River. About fifteen miles further north is a somewhat smaller island, lying about two miles off shore. These two islands and the northern half of the last Nastapoka Island, to the south of them, are capped by a considerable thickness of trap, which would apparently occupy a higher place in the series than any of the strata of the preceding sections.

Gneiss begins on mainland.

The unaltered rocks, above described, terminate on the mainland (in going northward) between Richmond Gulf and the Nastapoka River, and beyond this limit, Laurentian gneiss holds the shore all the way to Cape Dufferin.

Hopewell Islands.

The Hopewell chain consists of ten principal islands lying between Hopewell Point and Cape Dufferin. They resemble the Nastapoka Islands in form and appearance, but are not so high, and most of them lie closer to the mainland. The rocks of which they are composed appear to be equivalent to the upper strata of the Nastapoka chain. The characters and arrangement of these rocks will be best illustrated by a few sections taken in different parts of the group. The following represents an approximate ascending section on the landward side of the first large island, at a point two miles north-west of the extremity of Hopewell Point:—

Sections on Hopewell Islands.

	FEET.
Black slate	30
Dark-grey thinly-bedded sandstone	30
Massive light-grey sandstone	10
Black shale with two bands of dark-grey quartzite and one band (three feet thick) of ironstone	40
Fine-grained dark greenish-grey trap (maximum of this locality)	40
	150

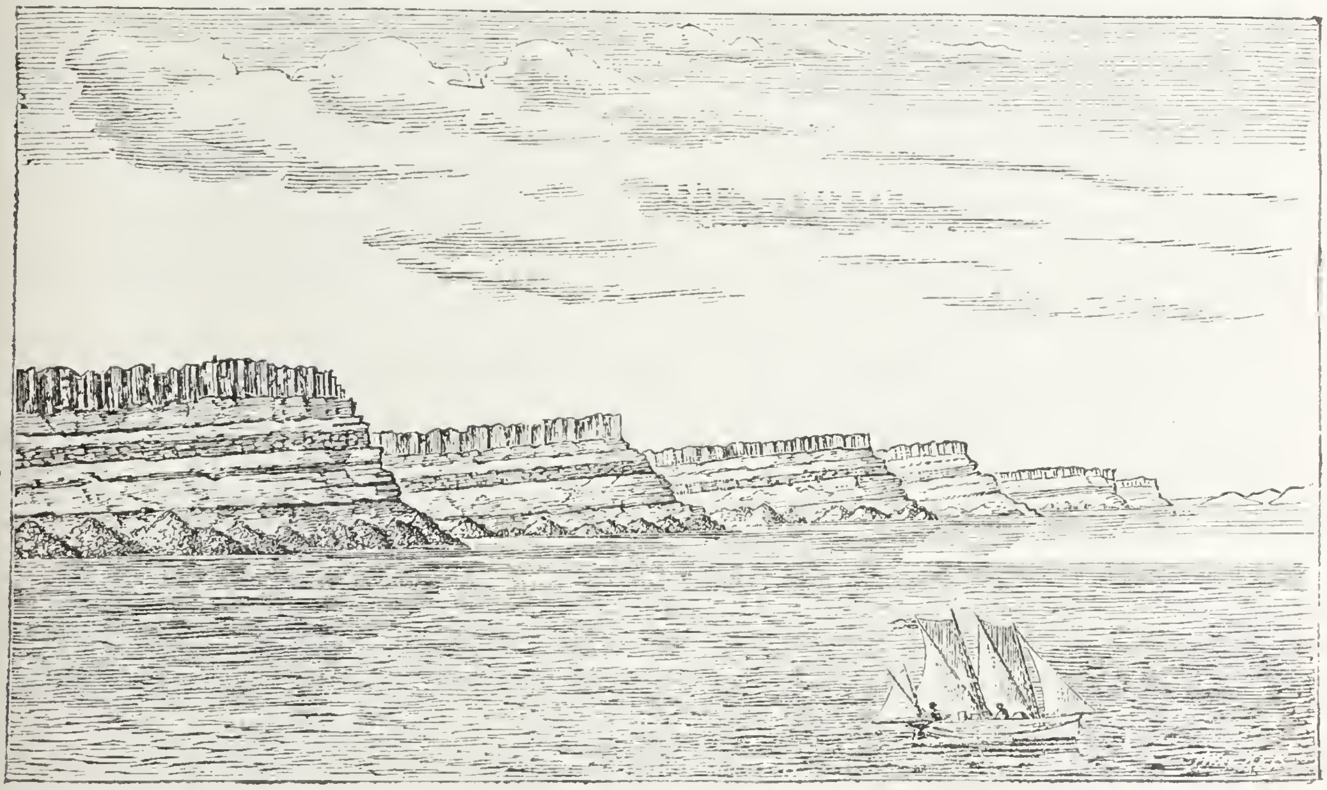
On the largest island in the centre of Hopewell Sound, between the middle of the second island of the chain and the mainland, the following ascending section occurs:—

	FEET.
Black slate and grey quartzite—about	30
Massive dark-grey quartzite—about	60
Very darkly-coloured, somewhat columnar, trap—about	70
	160

At a point, on the landward side of the fifth large island of the group, about three-quarters of a mile north-west of a very narrow strait separating it from the main shore, the following approximate ascending section was measured:—

	FEET.
Black slates and grey quartzose sandstone	30
Light-grey quartzose sandstone	40
Black slate	25
Massive dark-grey quartzite	30
Very dark coarsely columnar trap	45
	170

All the islands of the group have a similar structure, but the relative proportions of the different strata vary somewhat in passing from one to another. The appearance of the inner side of these islands is illustrated by the accompanying sketch, which represents a view northwestward up the first island from near Hopewell Point.



VIEW OF NORTH-EAST SIDE OF FIRST HOPEWELL ISLAND.
a. Overflow of columnar trap. *c.* Hopewell Sound.
b. Quartzites and black slates. *d.* Main shore—Gneiss.

ECONOMIC MINERALS.

Owing to the undisturbed nature of the rocks above described, mineral veins are of rare occurrence among them. The few which we Metalliferous veins.

observed were generally small and consisted principally of quartz and calcspar, with either no metallic minerals at all or only crystals and patches of iron pyrites and siderite and occasional specks of copper pyrites.

Lead. *Lead.* In the lower part of the magnesian limestone portion of the series, there is a band about twenty-five feet in thickness of an open or drusy character in which galena, in bunches, occurs in sufficient quantities to be of economic value. In 1858–59, the Hudson's Bay Company obtained nine tons of this ore from numerous small openings which were made about three miles north-east of their establishment at Little Whale River: but it appears to be equally or more abundant in some spots in the same band of limestone on the south side of the river. This band is traceable to Richmond Gulf, at the entrance of which I found bunches of galena in it, which would weigh upwards of a hundred pounds. Specimens from 'the mine' on the north side of Little Whale River which I brought to Montreal in 1875 were found by Dr. Harrington to contain 5.104 ounces of silver to the ton of ore. That from the south side of the inlet of Richmond Gulf he finds to contain, when separated from the gangue, 12.03 ounces of silver in every 2,000 lbs of the ore.

Copper. *Copper.* I was presented with some specimens of pure copper pyrites, associated with calcspar and quartz crystals, said to have been collected in the vicinity of Richmond Gulf, and I found specks of the same mineral in small calcspar veins about one mile north of the entrance to the Gulf. On the landward side of Long Island, about three miles from its south-western extremity, numerous small veins of calcspar and other minerals, which cut the trap, contain specks and small patches of copper pyrites.

Gold. *Gold.* Dr. Harrington has found traces of this metal in the iron pyrites which I collected from a small vein cutting the gneiss on a point about one mile south of Great Whale River and also in that from other small veins in the dolomite which forms Dog Island close to the main shore a few miles north of Cape Jones. The drift of the Little Whale River valley appeared to show indications of alluvial gold, but numerous pannings at the first fall and elsewhere failed to bring any of the precious metal to light.

Silver. *Silver.* Besides the silver in the galena already referred to, this metal was found by Dr. Harrington in the proportion of 0.145 of an ounce to the ton, along with the traces of gold, in the pyrites from both of the above localities. Small veins of pyrites similar to those of Dog Island occur in the similar dolomites in numerous places along the coast. The dolomite on the south-western side of the southernmost of the two islands which form Teska Harbour is traversed by a group of small parallel veins of white calcspar with iron-pyrites all lying close together and measuring from twenty to fifty feet in width. The group runs N. 35° W. and S. 35° E. (mag.) and underlies to the S. W. at an angle of 10° from the perpendicular. The dolomite between the veins of the group is broken into small angular pieces.

Zinc. Blende is found with calcspar in small veins cutting the dolomites on the south side of Little Whale River, and in crystals along with the bunches of galena in the lead-bearing band in other localities. Although it was nowhere seen in economic quantities, its existence is worth noting, as it may be found to occur in larger abundance on this part of the coast. Zinc.

Iron. The spathic iron-stone bands which have been shown to form the uppermost rocks (with the exception of the trap in the three northern islands) of the whole of the Nastapoka chain are found by Dr. Harrington to constitute valuable ores of iron. An average specimen of a compact variety from Flint Island, he finds to contain 25.44 per cent. of metallic iron and upwards of twenty-four per cent. of carbonate of manganese. A crystalline variety from Davieau's Island gave 27.83 per cent. of metallic iron. These spathic ores form a band which would average not less than twenty feet in thickness throughout the whole group of islands, which, as already stated, have a length of about ninety miles exclusive of the more northern islands. The band is divided into layers of a few inches in thickness. The colour, on fresh fracture, presents various shades of drab, buff and brown. The surfaces weather black and various shades of brown. All the beds may not be equally rich but the greater part of them on all the islands visited appear to be sufficiently so to constitute a valuable ore for the manufacture of spiegeleisen. The enormous abundance of the ore is its great feature. Forming the uppermost band on nearly all these large islands, where the dip is so low and the underlying strata confined to the cliffs along their eastern sides, the iron-stone beds are spread over the greater part of their area, which, in the aggregate amounts to many thousands of acres. The islands being destitute of timber and the rocks much shattered by the frost, &c., the ore, ready broken, may be gathered up in inexhaustible quantities. The islands offer good shelter for vessels and the ore might be conveniently loaded in many places. Iron.

Along the landward side of Long Island for three miles from its south-western extremity, highly ferruginous beds, varying from ten to fifty feet thick, some of which may be valuable as ores of iron, are seen near the water's edge, overlying sandstones and shales and underlying compact trap. On an island about one mile long and situated half a mile south-west of the southern extremity of Long Island, a ferruginous band is seen in a similar position and another higher up, between two thick layers of trap.

Loose masses of a shaly, somewhat argillaceous, bright red hematite were found along the coast in the vicinity of Richmond Gulf and they may have been derived from some of the red bands interstratified with the sandstones, quartzites, &c., among the lower strata around the Gulf.

Magnetic iron-sand is washed out of the drift, in considerable quantities at various places along the coast, such as Great and Little Whale Rivers, near Little Cape Jones and near Langlands River.

Manganese.

Manganese. The spathic iron ores above described being so rich in carbonate of manganese, the black oxide of the metal may be reasonably looked for in some parts of their distribution. The high percentage of manganese in these ores, as already stated, will render them valuable for the manufacture of spiegeleisen, and owing to their abundance and accessibility they may some day be found worth carrying to Europe or the United States.

In my report for 1875, page 324, it was stated that a specimen of black crystalline siderite from near Little Whale River, which had been given to me, contained rather a large amount of manganese.

Molybdenum.

Molybdenum. At Great Whale River I was presented with a specimen of molybdenite said to have been found in the neighbourhood.

Pyrites.

Pyrites. Veins of iron pyrites, in several places along the coast, were mentioned in reference to the occurrence of gold and silver. I also found it in patches in the amygdaloids in the neighbourhood of Richmond Gulf. In 1875 specimens of massive and other varieties of iron pyrites from the region about Little Whale River were presented to me.

Ornamental Stones.

Ornamental Stones.—Among the stones fit for polishing for ornamental purposes may be mentioned the agates, carnelians, epidosites and porphyries of the trappean rocks between the Manitounuck and Nastapoka Sounds. The agates are very abundant in the amygdaloids, and are often of large size, but they are mostly coarse, poorly coloured, and, on trial by different lapidaries, it is found difficult to give them a high polish. The red chalcedony, which occurs as a bed on Davieau's and other islands of the Nastapoka chain, and the olive-green chalcedony, resembling jade, which was found in small veins on Belanger's Island, are suitable for polishing as ornamental stones. The rare mineral axinite, which had never before been observed *in situ* in the Dominion, was discovered in small veins in the trap on the coast, about one mile and a-half south of the mouth of Little Whale River, in crystals, along with quartz, calcspar, epidote, chlorite and asbetsos, and also in the granular form. Both forms are of a purple colour, and the granular variety takes a high polish. Red jasper, with "floating" particles, like that of the Nipigon series near Thunder Bay, Lake Superior, is found on Long Island. A greyish-green argillite with black streaks, like that which was used by the ancient Indians of Canada for making ceremonial and other implements, was found in a cliff on the north side of Little Whale River. The transparent quartz crystals which abound in the druses of the lead-bearing band of Little Whale River, &c., may be mentioned in this connection. A soft green stone, like serpentine, which the Indians carve into tobacco pipes, is said to be obtained a few miles north of Fort George, but I was unable to find the spot. The rocks in the neighbourhood are Laurentian gneiss.

Dolomite for calcining.—The bluish and greyish dolomites, which are so abundant towards the base of the Manitounuck group, are found by Dr. Harrington to contain very little insoluble matter, and to be pure dolomites, well-suited for the manufacture of lime and mortar. Dolomite for calcining.

Hydraulic Cement-stone.—On Belanger's Island and also on White Bear Island I found a very dark-grey compact rock in rather thin beds, having a conchoidal fracture, and weathering to a bright yellowish-brown colour, which would apparently make an excellent hydraulic cement. Beds, which appear to be suitable for the same purpose, are found in several of the Nastapoka Islands. Hydraulic Cement-stone.

Building Stones.—Good building stones, in considerable variety, are met with on the islands all the way from Cape Jones to Cape Dufferin, and on the mainland from Great Whale River nearly to the Nastapoka River. The more massive kinds are found among the dolomites and sandstones or quartzites already described. Although there is little probability of building stones ever being required to any considerable extent on the Eastmain coast, I mention them, and also the materials for making mortar and cement, as there is a possibility of their being wanted in other parts to which they might be most conveniently shipped from this region. Building Stones

Brick Clays.—For the reason just stated, I may also mention that clays, apparently well-suited for making bricks, occur on the banks of the Little and Great Whale Rivers, and in the valleys of some of the smaller streams entering the sea along this part of the coast, as well as in those of nearly all the rivers further south. Brick Clays.

Asbestos was found in small quantities with the axinite, already referred to, about a mile and a-half south of Little Whale River. It was described as occurring in larger quantities elsewhere on the coast, but the localities were not ascertained. Asbestos.

Soapstone.—The Esquimaux of the east coast and the islands of Hudson's Bay use a grey soapstone for making all their kettles and Soapstone.

lamps, which are frequently more than two feet in length. It is of a tough and durable variety. I have seen holes in several of their kettles, after long use, successfully patched by inserting new pieces of stone cemented with clay. As nearly as I could ascertain from them, the soapstone is obtained not far from Mosquito Bay, latitude 60° 45′.

Flagstones. *Flagstones.*—The black slates and flaggy felsites which abound in the Nastapoka Islands, and some of the thinly-bedded sandstones of the Manitounuck Islands and Richmond Gulf, would make excellent flagstones.

Anthracite. *Anthracite.*—The existence of this valuable mineral on Long Island was referred to in my report for 1877, page 325. It has a conchoidal fracture and bright lustre, and was found by Mr. Hoffmann to contain 94·91 per cent. of fixed carbon and only 0.35 per cent. of ash. It is probable that it does not occur as a seam of altered bituminous coal like ordinary anthracite, but rather as resulting from hardened pitch or a mineral like Albertite, by the loss of its bitumen; and may not exist in large quantities. I was prevented by circumstances from visiting the locality at which it is found, which is said to be on Long Island, at four or five miles from its south-western extremity.

Petroleum. *Petroleum.*—On the Abittibi River, which was explored by one of my assistants in connection with the work of the season, bituminous limestones and carbonaceous shales were found, belonging to the Devonian formation, which have a strong resemblance to the petroleum-bearing strata of the same age in the Athabaska-Mackenzie valley. These rocks occur all along the Abittibi between twenty-nine and thirty-nine miles from its mouth, and in one place the limestone contains a little free petroleum.

Soil of Eastmain.

Soil. Along the east side of James' Bay, from the vicinity of Rupert's House to Cape Jones, there is a strip of country, averaging perhaps twenty to thirty miles in width from the sea shore, which, from all that I could learn from others or observe myself, appears as if it might, some day, have a certain agricultural value. Viewed from the bay, it has a gently undulating aspect, and slopes gradually down to the shore. It is wooded with spruce, tamarac, poplars, and small white birch. At Logs. Fort George I saw a quantity of good spruce logs which had been brought down the Big River for building purposes. Many of them measured two feet in diameter at the butt, and their average age, judging by the rings of growth, was nearly 100 years. The soil of the strip of country just described is generally sandy, often underlaid by stratified greyish clays, which occasionally come to the surface; with boulder-drift, or solid rock beneath all, but either of these also sometimes forms the surface. The gardens of Rupert's House, Eastmain and Fort George show that potatoes and all the ordinary vegetables thrive well. The Hudson's Bay Company's establishment at Eastmain is maintained for the purpoe of raising stock. The cattle and sheep which we saw there were in excellent condition. Gardens. Cattle.

Climate and Timber.

As stated in my report for 1875, the climate, in going northward from the height of land beyond Lake Superior, does not appear to get worse, but rather to improve, till James' Bay is reached. Among other possible causes, this is owing to the constantly decreasing elevation of the country, the greater length of the summer day in the north, and the accumulation of warm river-water in the head of James' Bay. Climate and Timber.

The original timber along the lower stretch of Moose River has been mostly burnt within the last fifty or sixty years, but whenever the old spruces have escaped, they are of a larger growth than those seen on any other part of the route from Michipicoten. In regard to the distribution of the timber, it is a curious fact that small white elms appear below the Long Portage of the Missinaibi branch of the Moose, after having been last seen on the lower parts of the Michipicoten River near Lake Superior. The northern limit of the white cedar is just south of Rupert's House. At Great Whale River, the white birch exists only as a large shrub. The poplars disappear between Fort George and this river. The tamarac was found nearly as far north as the spruce, which is last seen on the coast near the northern part of Richmond Gulf. The latter tree, however, is said to extend much further north at a distance back from the sea. Northern limits of trees.

During our journey up the coast and back, in the months of July, August and September, we enjoyed very fine weather the most of the time. There was very little rain and only two or three days of fog. The prevailing winds were from the southward and the temperature was warm and pleasant. The superiority of the weather over that of Lake Superior was a subject of frequent remark among my "voyageurs," who had been accustomed to that lake all their lives. We saw no ice, with the exception of a little "bay ice" at the commencement of our journey, which had been driven in to the neighbourhood of the mouth of Moose River after northerly winds had prevailed for many days. Weather.

I took the temperature of the sea upwards of twenty times during our voyage, which extended over the greater part of July, August and September, and found it to average 53° Fah. I also noted the temperature of the rivers which we visited, and found that of the average of five of them to be 61° Fah. We bathed in the salt water almost daily, and found the temperature agreeable. Temperature of the sea. Sea bathing.

Table of temperatures.

The following table gives the result of the above observations and also the temperature of the air at the different times at which they were made. The Fahrenheit thermometer was used, and whenever the sea happened to be calm the instrument was lowered to a depth of three or four feet below the surface:—

Temperature of the Sea, Rivers and Air along the Eastmain Coast in 1877.

		Date.	Hour.	River.	Sea.	Air in Shade.
1	Rupert's River at Rupert's House.....	July 11	10 A.M.	61°		48°
2	Eastmain River, two miles up........	" 15	9.30 "	59°		66°
3	Middle of great bay south of Cape Hope........................	" 15	2 P.M.		59°	72°
4	Twenty-five miles north of Cape Hope	" 16	12.30 "		47°	65°
5	Eight miles south of Big River......	" 17	5 "		47°	57°
6	Mouth of Big River................	" 17	7 "	63°		63°
7	Twenty miles north of Big River.....	" 18	4 "		57°	62°
8	Wind-bound Point, thirty-five miles north of Big River.............	" 19	2 "		53°	70°
9	Ten miles E. N. E. of Cape Jones....	" 24	4 "		45°	58°
10	Thirty-six miles north-eastward of Cape Jones...................	" 25	7 "		52°	73°
11	Fifty-three miles north-eastward of Cape Jones...................	" 26	12.30 "		48°	82°
12	Black Whale Harbour..............	" 26	9 "		53°	
13	Great Whale River opposite H. B. Co's Post	" 28	1 "	68°		82°
14	Do. after two cold windy days........	" 30	9 "	59°		48°
15	Open sea, forty miles N. of Great Whale River	Aug. 1	6 "		53°	70°
16	"Second" River at fifty-one miles north of Great Whale River.....	" 2	9 A.M.	63°		
17	Off do..........................	" 2	9.15 "		52°	
18	South side Richmond Gulf	" 9	11.30 "		61°	68°
19	South point Cairn Mountain Island, Richmond Gulf................	" 9	3 P.M.		62°	72°
20	Opposite Last or northern Nastapoka Island.........................	" 16	3 "		50°	55°
21	Land-locked Harbour...............	" 17	11.30 A.M.		55°	66°
22	South-east of last Nastapoka Island .	" 25	12.30 P.M.		53°	65°
23	Middle of Nastapoka Sd. between N. River and Salmon Fishery Cove..	" 26	2 "		53°	70°
24	Midway between Inlet of Richmond Gulf and Belanger's Island	" 27	6 "		57°	65°
25	Open sea between Great Whale River and Manitounuck Sound........	Sept. 1	11 A.M.		52°	53°
26	Great Whale River opposite H. B. Co's Post	" 2	2 P.M.	54°		59°
27	Off Esquimaux Harbour.............	" 3	1.30 "		53°	56°
28	Dead dog Cove, after three days' blow	" 6	3 "		51°	58°
29	Mouth of Big River, Fort George.....	" 18	7 A.M.	59°		51°
30	Kimishoo's Bay, forty miles south of Fort George	" 19	7 "		50°	49°
31	Off South Point of Rupert's Bay	" 21	7 "		55°	50°
	Average..........................	....	....	Of five rivers. 61°	53°	62½°

The average temperature of the air between the 11th of July and the 21st of September, from the above observations, would appear to be $62\frac{1}{2}°$, which is very nearly the mean temperature of the rivers; while the average for July and August would be $65\frac{1}{2}°$. As most of these observations were taken in the morning or the evening, and as the nights were generally warm, owing to the prevalence of southerly winds, this is perhaps not far from the true mean temperature for these two months, and it is only $\frac{3}{4}°$ above the average of the mean temperatures, for these months, of ten principal stations from Halifax, N. S. to Fort Simpson on the McKenzie River. Averages.

On our return to Moose Factory, in the end of September, we found that there had been no frost there all summer and the most tender plants, such as melons and cucumbers, beans, balsams, tobacco, the castor-oil bean, etc., growing in the open air, were still quite green and flourishing. Last summer was, however, probably a finer one than usual. No summer frosts.

From all that I could gather, from personal observation and information from others, it would appear that the climate of the Eastmain coast, especially beyond the limits of timber, is rather dry in all years. Considerable rain falls in the spring and autumn, but little in the summer, and little snow in winter. I was informed by Mr. Spencer and Mr. Clark of the Hudson's Bay Company that the ice in Great and Little Whale River and the Nastapoka River, which flow through the 'Barren Grounds,' breaks up in the spring about two weeks earlier than in the rivers passing through the wooded regions further south. Rain-fall. Breaking-up of river ice.

Rivers of Eastmain.

Kitchi-sipi or Big River, which enters James' Bay at Fort George, is the largest stream on the coast. It appears to be fully as large as the Ottawa. It is navigable for boats to the first fall, about twenty-seven miles from the mouth. Next in size is the Eastmain River, which seems little inferior to the Big River. The following are the next largest rivers in the order of their apparent volumes: Rupert's River, Great and Little Whale Rivers, Nastapoka River, Seal River. Principal rivers

Fish and Mammals.

The water about the head of James' Bay is so muddy that fishes of all kinds seem to be scarce, still the porpoises resort to certain parts, even here, for the purpose, it is said, of feeding on small fish. In the rivers and brooks flowing into this part of the bay, the fishes most commonly caught are a species of whitefish (smaller than that of the great lakes), pike, pickerel, carp, chub and, in some places, speckled Muddy water. Kinds of fish.

trout. The last-named fish is found here and there in the mouths of streams as far north as our journey extended.

Clear sea-water

In coasting northward, the muddy water disappears on rounding Sherrick's Mount, but the sea has a slightly yellowish tinge nearly as far as Cape Jones. Here it becomes perfectly bright and transparent, and some forms of marine animal life were observed for the first time. The common sea-urchin (*Echinus granularis*, Lam.), which had not been seen to the south, now became extremely abundant, and continued so as far as we went. The common six-rayed starfish (*Asteracanthion polaris*, Müll.), of the Gulf of St. Lawrence, was found in a few places to the north of Cape Jones.

Sea-fishing.

In the channels among the islands between the Eastmain River and Cape Jones, the Indians were catching abundance of fish in gill-nets set in from one to three fathoms of water. These consisted of the whitefish, above referred to, and a large and fine species resembling that of Lake Superior, sea-trout and "rock-cod." The last-named species seldom weighed more than two or three pounds, and was altogether inferior to the common cod, of the existence of which in Hudson's Bay I could get no reliable information. The favourite fishing ground of the natives is at the mouth of Seal River, a short distance south of Cape Jones.

Seal River.

A few miles north of Cape Jones we found the Indians engaged in fishing with gill-nets, set in about two fathoms of water, close against the shelving rocks of the sea coast. They were taking considerable numbers of a fish which is called salmon in this country, and which has a strong resemblance to the common salmon (*S. Salar*) in outline, fins, head and mouth, and the flesh has the same colour and flavour. The average size is, however, smaller, the largest which we saw during the summer weighing only about ten pounds, but many were nearly as heavy. We saw the same fish amongst those caught at Seal River, also in a stream entering Richmond Gulf, and in considerable numbers in the hands of the Esquimaux, near Cape Dufferin. These people had killed them (with spears like those used by the Mic-Mac Indians) in the mouths of small rivers and in narrow arms of the sea. Sea-trout and the "sea-toad," or sculpin *(Cottus)*, were also among the fish taken by the Esquimaux on this part of the coast. The common capeling (*Mallotus villosus*, Cuvier) was occasionally found cast ashore by the waves. Small trout were abundant in the brooks from Cape Jones, northward as far as we went.

Salmonidæ.

Capeling.

Marine mammals.

In regard to the marine mammals, so valuable for their oil, one would require to spend at least a twelvemonth on the coast and to have special facilities for obtaining information, before speaking with much confidence on the subject. During our coast voyage, the common shore seal were seen about as abundantly as one observes them in the Gulf of St. Lawrence in the summer time, but they may be in much larger number in the breeding season, as is the case in the Gulf, where two vessels have just made a good catch (March, 1878), while most of those who went to the open sea fared but indifferently this year.

Besides the common seal we often saw much larger ones, which, from the descriptions I obtained, I judge to belong to the various species of the large seals of Newfoundland. I may here mention that while making my survey of the mouth of Moose River in the end of September I killed a grey seal which measured eight feet three inches between extremities, and would weigh upwards of 700 pounds. Seals.

White porpoises were seen in considerable numbers all along the coast. In former years they were killed in the mouths of the Great and Little Whale Rivers by raising a barrier of netted rope (previously concealed in the bottom of the river) after a shoal of them had ascended the stream a short distance during high tide. Once secured in this way, a portion of the shoal, at a time, was imprisoned in a smaller barrier and the animals shot from the bank. Of late years, however, they appear to have learned the danger of passing over the submerged barrier and refuse to enter Great Whale River so long as the barrier remains, and this mode of capturing them has consequently failed. The white porpoise.

The walrus is killed by the Esquimaux, principally about the entrance to Hudson's Straits and around the Belcher Islands. In former years this animal is reported to have been seen occasionally as far south as Little Whale River. On the opposite side of Hudson's Bay walruses are said to have been seen near Cape Henrietta Maria. The narwhal is occasionally killed by the Esquimaux in the northern part of Hudson's Bay. The walrus. The narwhal.

In the spring, soon after the shore-ice disappears, the polar bear occasionally comes ashore on Long Island and the smaller islands between it and Great Whale River. In the winter they have been known to range as far south as the head of James' Bay. The polar bear.

Superficial Geology.

In the southern part of the Eastmain coast the glacial striæ have a south-westerly course, but in going northward the direction gradually changes till it has become nearly west at Cape Jones. From this point, as far as we went, the course continued to be about west and north of west, or towards the centre of the bay. The grooving is remarkably well preserved on the bare hills and on the rocks generally from Great Whale River northward. In this region one cannot help Glacial striæ.

being struck by the more modern appearance of the glaciated surfaces, than in the inhabited parts of Canada to the south. The following table shows the course of the striæ in sixty-six localities between Sherrick's Mount and Cape Dufferin:

Table of striæ.

Directions of the Glacial Striæ on the East Coast of James' and Hudson's Bay.

[The localities are arranged in their order from south to north, and the bearings are all referred to the magnetic meridian.]

1.	South-west point of Sherrick's Mount	S. 55° W.
2.	Coast 22 miles north of north point of Sherrick's Mount	S. 70° W.
3.	Governor's Island, mouth of Eastmain River	W.
4.	Coast 9 miles north of Eastmain River	S. 45° W.
5.	Western extremity of Cape Hope	S. 50° W.
6.	Coast 5 miles north of Cape Hope	S. 50° W.
7.	Between 5 and 28 miles north of Cape Hope—increasing from S. 45° W. to	S. 55° W.
8.	Paint Hills, 39 miles north of Cape Hope. Two sets—older (?)	W.
	Do. do. do. do. Newer (?)	S. 50° W.
9.	About 3 miles north-west of Paint Hills. Three sets—oldest(?)	N. 60° W.
	About 3 miles north-west of Paint Hills. Intermediate	S. 70° W.
	Do. do. do. Newest (?)	S. 45° W.
10.	Coast 45 miles north of Paint Hills	S. 70° W.
11.	Coast 50 miles north of Paint Hills	S. 55° W.
12.	Between 40 and 60 miles south of Big River, increasing from S. 50° W. to	S. 60° W.
13.	Kimishoo's Bay, 39 miles south of Big River, and islets in vicinity	S. 65° W.
14.	Between 5 and 35 miles south of Big River—S. 70° W. to	W.
15.	Esquimaux Point, Big River, 1½ mile north-west of Fort George	S. 80° W.
16.	Coast 20½ miles north of Big River	W.
17.	Coast 24½ miles north of Big River	S. 80° W.
18.	Wind-bound Point, 35 miles north of Big River	S. 80° W.
19.	North Fishing Creek	S. 80° W.
20.	Last island off south-west Point of Long Island. Three sets—S., S. 60° W., and	S. 80° W.
21.	South-west extremity of Long Island. Striæ in every direction from S. 20° E. (round by S. W.) to W. The two prevailing directions are about S. 5° W. and	S. 65° W.
22.	Long Island, 3 miles from the south-west extremity	S. 70° W.
23.	Long Island, 22 miles from the north-east extremity	S. 70° W.
24.	Long Island, 15 miles from the north-east extremity	S. 65° W.
25.	Cape Jones—extremity	S. 65° W.
26.	Narrows 10 miles east-north-east of Cape Jones	S. 70° W.
27.	Shipastik, 27 miles north-east of Cape Jones	S. 60° W.
28.	Red Head Island, 57 miles north-east of Cape Jones	N. 50° W.

29. Red Head—main shore ... N. 80° W.
30. Top of White Bear Island ... N. 80° W.
31. Rocky Point, between Red Head and Limestone-block Point ... N. 75° W.
32. Limestone-block Point, 64 miles north-east of Cape Jones. Older (?) set ... N. 70° W.
Limestone-block Point, 64 miles north-east of Cape Jones. Newer (?) set ... N. 80° W.
33. Near Dead Dog Cove, 2 miles south of Teska Harbour. Older (?) set ... N. 70° W.
Near Dead Dog Cove, 2 miles south of Teska Harbour. Newer (?) set ... N. 85° W.
34. South side of Dead Dog Cove ... S. 75° W.
35. West side of Dead Dog Cove ... N. 75° W.
36. Teska Harbour, 67½ miles north-east of Cape Jones ... N. 70° W.
37. Black Whale Harbour, 69½ miles north-east of Cape Jones. N. 70° W.
38. Esquimaux Harbour, 71 miles north-east of Cape Jones ... N. 60° W.
39. Coast 80 miles north-east of Cape Jones ... N. 55° W.
40. Point at south side of mouth of Great Whale River ... N. 60° W.
41. Sides of Boat's Opening, head of Manitounuck Sound ... N. 65° W.
42. Second River, 51 miles north of Great Whale River ... N. 60° W.
43. Black Bear River, 58 miles north of Great Whale River ... N. 60° W.
44. Coast for several miles south and north of Little Whale River ... N. 60° W.
45. Shore at Narrows on south side Cairn Mountain Island, Richmond Gulf. Striæ with same bearing run up to top of hill, 400 feet or more in height ... N. 45° W.
46. Southern point of Cairn Mountain Island, Richmond Gulf, S. 70° W. to N. 55° W., N. 45° W. and ... N. 35° W.
47. North-east side of Cairn Mountain Island ... N. 45° W.
48. Main shore, half-a-mile north of entrance of Richmond Gulf ... N. 70° W.
49. Most southern island of the Nastapoka chain, 5 miles from entrance of Richmond Gulf ... N. 80° W.
50. Belanger's Island, landward side, but south of the centre of the island ... S. 60° W.
51. Belanger's Island, landward side, and opposite the centre of the island ... N. 65° W.
52. Gap in hills about 1 mile north of entrance of Richmond Gulf. Striæ slope up wall of rock ... N. 50° W.
53. Salmon Fishery Cove, 6 miles north of the entrance of Richmond Gulf. Older (?) set ... N. 60° W.
Salmon Fishery Cove, 6 miles north of the entrance of Richmond Gulf. Newer (?) set ... N. 80° W.
54. Coast 25 miles north of entrance of Richmond Gulf. Older (?) set ... W.
Coast 25 miles north of entrance of Richmond Gulf. Newer (?) set ... S. 70° W.
55. Coast between Nastapoka and Langlands River ... N. 65° W.

Glacial striæ.

Glacial striæ.

56.	White Whale Point, 54 miles north of entrance of Richmond Gulf	N. 70° W.
57.	Canon Point, 72 miles north of entrance of Richmond Gulf.	N. 55° W.
58.	Coast south-east of last (most northern) Nastapoka Island.	N. 65° W.
59.	Coast opposite last Nastapoka Island, 109 miles north of entrance of Richmond Gulf	N. 65° W.
60.	Coast midway between last Nastapoka Island and Land-locked Harbour	W.
61.	Two islets 5 miles south of Land-locked Harbour	N. 80° W.
62.	Seaward side of first (or easternmost) large island north-west of Hopewell Head and on main shore opposite...	W.
63.	Porpoise Cove, Hopewell Sound	S. 65° W.
64.	Landward side of third island of Hopewell chain. The striæ run up and over brink of cliff 160 feet high	S. 70° W.
65.	Islands off Five-mile Inlet—average course	W.
66.	Head of Five-mile Inlet	N. 80° W.

Shells in the drift.

The boulder-clays contain numerous shells, of which the most abundant species are *Tellina Grœnlandica* (Beck,) *Saxicava rugosa* (Linn., *Mya arenaria* (Linn.,) *M. truncata* (Linn.,) *Pecten Islandicus* (Müll.,) *Cardium Islandicum,* (Linn.,) *C. Grœnlandicum* (Chem.) (small), *Astarte lactea* (Brod. and Sby.,) *A. Laurentiana* (Lyell) and *Mytilus edulis* (Linn.)

Subsidence of the sea.

"Raised" beaches.

Drift-wood.

Effect on harbours.

There is abundant evidence that the sea-level is falling at a comparatively rapid rate in Hudson's Bay. Since the Hudson's Bay Company's Posts have been established at the mouths of the various rivers, there has been an increasing difficulty in approaching them with large craft. On the islands and shores all along the Eastmain coast the 'raised' beaches are very conspicuous at all heights up to about 300 feet immediately near the sea, but, no doubt, higher ones would be found further inland. Drift-wood (mostly spruce) is found almost everywhere, above the highest tides, in a more and more decayed state the higher above the sea, up to a height of at least thirty feet, and in some places up to forty and fifty feet, above which it has disappeared by the long exposure to the weather. Judging by the rate of decay of spruce-wood in this climate its preservation in large quantities, during an 'elevation' of the land, or rather a fall in the water, to the extent of thirty feet, would indicate a change in the relative level of the sea, amounting to perhaps between five and ten feet in a century. The probability that this fall in the sea-level will continue to go on in the future is worth considering in any proposals which may hereafter be entertained of navigating Hudson's Bay or forming harbours on its coasts.

Record of present level of the sea.

Should Hudson's Bay continue to subside in the future, the rate of fall may hereafter be ascertained by recording its present level in relation to existing features in such a manner as that it may be easily recognized, even after the lapse of hundreds of years. I shall, therefore, mention its actual condition in two places, convenient for this purpose, and which are shewn on the accompanying map. The first is at a narrow strait between the eastern side of the fifth island of the Hopewell chain and a point of the mainland which runs up from the south-eastward. The channel is about twenty yards wide. At high tide our jolly-boat, drawing two feet of water, passed straight through without touching, in a course bearing N. 10° W. (mag.), but returning, at low tide, it was necessary to pilot our way with care in a curving channel in the centre. A short distance northward of this narrow passage, the bearing, by compass, up the bay on the north side of the above point, and which is about three miles deep, is east-south-east. Sailing N. 20° W. (mag.) up the centre of Hopewell Sound, at about four miles from the strait, we passed close to the right side of a high island capped with trap, which lies about two miles east of the northern extremity of the large island on our left whose shore had gradually receeded north-westward from the strait, to that distance. Keeping on in the same course, at twelve or thirteen miles from the narrows we were off the entrance of what I named the Five-mile Inlet, from its estimated length.

Five-mile Inlet.

Turning north-east and passing between two high islands, we entered the above arm of the sea, which has a large bay on the left a short distance in. In ascending the inlet, its course turns a little more to the right and at the end of about four miles, it narrows very much, at the same time curving regularly round in the form of a fish-hook, till it has a westward course and then emerges in a lagoon, which runs north-eastward about one mile and terminates at a rapid brook, on which there is a narrow lake a short distance up. The rocks rise steeply on either side of the passage whose narrowest part is at its entrance to the lagoon, where at low tide, it is only five to six yards wide and so shallow that it was necessary for us to disembark in order to pole the jolly-boat through. On the east side of the mouth of the brook at the head of the lagoon, the Esquimaux have built several stone "caches." A second brook enters the northern bight of the lagoon, close to the first, and a third falls in directly opposite. Owing to the narrow connection of the lagoon with the sea, these brooks dilute its waters so that they have only a brackish taste.

Survey of the Abittibi River.

Survey of Abittibi River.

As mentioned in the beginning of this report, a track-survey of the Abittibi River as far as the lake of the same name, was made by one of my assistants, Mr. A. S. Cochrane, who has plotted his work on a scale of four miles to one inch. The following short account of the river and the geology of its banks is drawn up from Mr. Cochrane's personal description, aided by his notes, map and specimens. The position of the mouth of the river is taken from my own plan of the Moose, and that of the outlet of Abittibi Lake from the late Mr. Walter McOuat's survey of that sheet of water. The distance, in a straight line, between these two points, as thus laid down, is 165 miles bearing S. 12° E. (ast.), while, according to Mr. Cochrane's map, it is 160 miles with the same bearing—a difference of only three per cent. The Abittibi River joins the Moose about eighteen miles above Moose Factory or twenty-five from the open sea. In following the stream itself the total distance to Abittibi Lake was found to be 212 miles, but taking the corrected length of each of the five stretches into which the river may be divided, the aggregate is 186 miles, as follows:

Distances.

1. From the mouth to the Sextant Rapids...........	S. 27° W.,	39 miles.
2. Sextant Rapids to mouth of Frederick House River	S. 5° E.,	60 "
3. Frederick House River to Jaw Bone Creek........	N. 83° E.,	10 "
4. Jaw Bone Creek to Black River..................	S. 13° E.,	54½ "
5. Black River to outlet of Abittibi Lake.............	N. 89° E.,	52½ "

Levels.

Abittibi Lake is about 857 feet above the level of the sea and as the junction of the river with the Moose is about fifty feet above the same level, the total rise in the Abittibi River would be about 807 feet. The first stretch has a swift current like that of the main Moose. A rapid rise takes place in the ten miles about the end of this stretch, or from the fort of the Clay Falls to the head of The Otters. Beginning at fifteen miles higher up the stream, there is a rapid rise for another ten miles, or from the foot of the Long Portage to the head of the Little Long Portage. At the Couchiching Falls, seven miles below the outlet of Abittibi Lake, there is a rise of about fifty feet. In other parts of the river, there are considerable stretches of smooth water between the rapids, in which the current is not too strong for paddling canoes up-stream. The longest of these is between the Long Sault and Duck Deer Rapids, a distance of twenty-eight miles. The following table describes the various portages in their order from the mouth upward to Abittibi Lake:

Portages.

Portages on Abittibi River.

Number.	Name of Obstruction.	Length of trail in yds.	Nature of Obstruction.	How Obstruction is overcome.
1	Moose River Portage..	225	Rapid.	Demi-charge. Pole upward. Run down.
2	Clay Falls do. ..	1031	do.	Demi-charge. Pole upward. Run down.
3	Sextant Rapid........	913	do.	Demi-charge. Pole upward. Run down.
4	The Otters Portage...	4129	Falls and chutes.	By the east side trail.
5	The Long do. ...	3442	do.	Portage both ways.
6	Oil Can do. ...	238	Chute.	do do.
7	Birch do. ...	715	Rapids and chutes.	do. do.
8	A Portage do. ...	146	Rapid.	Portage. Pole up. Run down.
9	Rocky do. ...	392	do.	Portage upward. do.
10	Little Long do. ...	942	do.	Portage both ways.
11	Lop-stick do. ...	140	do.	Portage upward. Run down.
12	Island do. ...	(say) 200	do.	Pole up. Run down.
13	Three Carrying Places Portage	(one) 730	Chute.	Portage both ways.
14	Kettle Fall Portage...	150	Fall.	do. do.
15	Island do. ..	(say) 112	Rapid.	Pole up. Run down.
16	The Long Sault (Lower Portage) ...	130	do.	Portage up. do.
17	The Long Sault (Upper Portage) ...	112	do.	Portage both ways.
18	Iroquois Portage......	150	Fall.	do. do.
19	The Two Portages (Lower)	74	Chute.	do. do.
20	The Two Portages (Upper)...........	130	Rapid.	Run down by large canoes only.
21	Couchiching Portage .	564	Fall and chute.	Portage both ways.

The first or lowest stretch flows through a level country overspread with an even covering of drift, and the banks of the river, which are not high, consist of boulder-clay overlaid by more or less sand or gravel and brownish loamy and gravelly earth. In the second stretch as far up as the Three Carrying Places Portage, a distance of forty-five miles, the river runs in a narrow valley with a clayey bottom and rocky hills, varying from 50 to 200 feet, but averaging 100 feet in height, on each side. No high ground was observed near the river throughout the rest of its upward course, except at the Duck Deer Rapids and at a bend nineteen miles, in a straight line, from the outlet of Abittibi Lake, where hills rise on either side to heights of 80 and 120 feet respectively.

Character of country.

GEOLOGY.

Geology.

A finely granular buff-colored dolomite occurs in the rapids at the mouth of the river. No rock *in situ* was observed from this point for twenty-nine miles, at which distance a brownish-black carbonaceous shale is met with in the west bank. It has a low specific gravity, splits with a conchoidal fracture, is easily cut with a knife, yielding a brown powder, and is capable of a high polish. On being sufficiently heated it burns for a short time, and emits a sulphurous odour. This carbonaceous shale appears to be associated with the Devonian limestones, which crop out about a mile further up, and are seen here and there at the water's edge, under banks of boulder-clay fifty feet high, all the way to the Sextant Rapids, a distance of about nine miles. The limestones, which occur in almost horizontal beds, consist of almost pure carbonate of lime. They are characterized by a prevailing yellowish colour, which, however, is modified with various shades of light grey, buff and pink or red. They are all very soft, have an open or porous texture and low specific gravity and contain the remains of corals. They are more or less bituminous and one of the specimens collected holds a little free petroleum. At the foot of the Sextant Rapids a very light reddish-grey, soft, porous limestone is underlaid by about twenty feet of a reddish-brown or dark chocolate-coloured calcareo-arenaceous marl with irregular green spots.

Black shale.

Devonian limestones.

Reddish-brown marl.

The southern boundary of the Devonian basin crosses the Abittibi River in a north-easterly direction at the Sextant Rapids, which are at the end of the first stretch of the river. Beyond this point, Laurentian and other crystalline rocks are found all the way to Abittibi Lake. From the commencement of the second to the end of the fourth stretch, the general course of the river may correspond nearly with that of the dividing line between the Laurentian series to the west and the Huronian to the east. Most of the rocks observed along the second stretch consist of different varieties of gneiss, which need not be here described in detail, but at the Long Portage and the Oil-can Portage, which is the next above it, the rocks are dark-grey (more or less crystalline) felsites; while between Lop-stick Portage and the Three Carrying-places Portage they consist of greenish-grey felspar and mica schists, having calcareous slicken-sided surfaces, and olive-green calcareous quartziferous hornblende schists. A soft blackish semi-crystalline diorite occurs at the head of the Sextant Rapids, but whether in beds or as a dyke was not ascertained. The felsites of the Oil-can Portage are cut by dykes of dark compact diorite. Towards the upper extremity of the second stretch, Mr. Cochrane met with rocks which appear to be light-red and light-grey varieties of granite

Laurentian and Huronian.

Granite.

of medium texture, but, judging from the hand specimens, one cannot be certain that they are not massive gneiss. Tender grey mica schists, with rusty partings, were the only rocks met with along the third stretch, and also along the fourth, as far as the Duck Deer Rapids, above which gneiss was found for a few miles. In the neighbourhood of the upper extremity of the fourth stretch fine-grained greenish-grey calcareous diorite, with specks of iron pyrites, was found two miles below the Iroquois Portage and again one mile above the junction of the Black River at the end of this stretch. Compact dark-green diorite with conchoidal fracture occurs on the fifth or last stretch at twelve, and again at nine miles below Abittibi Lake. It holds occasional spots of white chalcedony, and the joints are lined with thin partings of calcspar. In some parts the rock is cut by numerous reticulating silicious strings containing grains of iron pyrites. These diorites are probably a westward continuation of similar varieties described by the late Mr. McOuat as extending westward, past the south side of Abittibi Lake, and which he mentions as occurring at the first (or Couchiching) falls about seven miles below the lake. (See Report of Geological Survey for 1872, page 128.) Along the fifth stretch at the Two Portages, and at three other places in the twelve miles above them, Mr. Cochrane found grey argillaceous schists, slightly calcareous and having thin partings of calcspar in the joints. Diorites. Argillaceous schists.

Drift. It has been already mentioned that drift clays similar to those of the main Moose River extend up the Abittibi as far as the Sextant Rapids at the end of the first stretch. Marine shells were observed in these clays for some miles from the junction of the two rivers. At Moose Factory, I was informed that some years ago a party of Indians had found some large bones in the bed of the Abittibi in this part of its course. From the description, I judged them to be those of an extinct elephant. I have already referred to the discovery of the jaw of a mastodon where the Missinaibi and Mattagami Rivers join to form the main Moose River. Drift.

Some loose pieces of lignite were found on the west bank of the Abittibi a short distance above Big Cedar Creek, about twenty-three miles from the mouth. Lignite.

The Burland-Desbarats. Lith. Co. Montreal.

From Photo. by R. Bell.

VIEW DOWN THE NELSON RIVER ONE MILE ABOVE CLEAR WATER RIVER.

GEOLOGICAL SURVEY OF CANADA.

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

REPORT

ON THE

COUNTRY BETWEEN LAKE WINNIPEG

AND

HUDSON'S BAY,

1878

BY

ROBERT BELL, M.D., C.M., F.G.S., C.E.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:
DAWSON BROTHERS.

1879

MONTREAL, May 5th, 1879.

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

Director of the Geological Survey.

SIR,—Herewith I beg to hand you my report and maps, shewing the results of the explorations and surveys which I made last season on Lake Winnipeg and between that lake and Hudson's Bay, in conformity with your instructions.

I have the honor to be,

Sir,

Your obedient servant,

ROBERT BELL.

REPORT

ON THE

COUNTRY BETWEEN LAKE WINNIPEG

AND

HUDSON'S BAY

BY

ROBERT BELL, M.D., C,M., F.G.S., C.E.

In order to reach my field of operations I proceeded to Winnipeg, which I reached on the 14th June. On the 15th I went to Lower Fort Garry to join the Hudson's Bay Company's steamer "Colville," by which Mr. Grahame, the Chief Commissioner, had kindly allowed me to take passage, free of charge, through a part of Lake Winnipeg. The steamer left her wooding station near the mouth of Red River on the 19th, and on the 20th reached George's Island, off Poplar Point, on the East shore of the lake. Here I left her, and on the 21st sailed in a "York boat," from Poplar Point, and reached Norway House in the afternoon, or on the third day after leaving Red River. Norway House, which is situated on the Nelson River, twenty miles below its efflux from Lake Winnipeg, was made my headquarters for the season. Here Mr. Roderick Ross, the gentleman in charge for the Hudson's Bay Company, gave me free storage for my supplies all summer. I was also indebted to the owners of this post, and of Lower Fort Garry, Beren's River, Oxford House and York Factory for much hospitality as well as for valuable and at all times readily accorded assistance in my labors. My best thanks are likewise due to the Venerable Archdeacon Kirkby, of York Factory, for geological specimens collected about Fort Churchill, and also to the Rev. Mr. Rattan, of Rossville mission, for a sketch-map of a canoe-route between the Nelson and Churchill rivers. Journey out. Norway House.

The following topographical surveys and explorations, which were Surveys made.

accomplished without the aid of an assistant, were additional to the purely geological work of the season:

(1.) Track-survey from Lake Winnipeg to Norway House, and of Great and Little Playgreen Lakes.
(2.) Track-survey of the boat-route from Norway House, to York Factory, by way of Oxford House and Knee Lakes.
(3.) Survey of Haye's River in the vicinity of York Factory.
(4.) Track-survey of Nelson River from the sea for about 90 miles up.
(5.) Track-survey of Nelson River, downward, for a distance of 180 miles, from the outlet of Lake Winnipeg.
(6.) Track-survey of the western channel of Nelson River, from Great Playgreen Lake to Cross Lake, including part of the latter.
(7.) Track-survey of the east shore of Lake Winnipeg, from the outlet to Dog's Head.
(8.) Track-survey of the Islands and the west shore of Lake Winnipeg from Dog's Head to Drunken River.

The above work is all laid down on a scale of four miles to one inch, with the exception of the plan of the survey in the vicinity of York Factory, which is on a scale of one mile to an inch. The two accompanying maps, in the compilation of which I was assisted by Mr. George Andrews and Mr. A. S. Cochrane, represent these surveys on a scale of eight miles to one inch. On the map showing Lake Winnipeg, the outline of the entire sheet of water has been completed from other authorities which are acknowledged in the title of the map itself.

Maps.

Observations.

Although the geology of the country was the main object of the investigations, yet care was taken constantly to make notes in regard to the soil, timber, and climate of the region explored, and also respecting the fishes, birds and mammals inhabiting it. A considerable amount of general information was likewise collected, the variation of the magnetic needle was ascertained in some places, and the latitude of York Factory was determined by numerous observations to be 57°, 1′, 40″. Thirty photographs were taken illustrating the character of the country, or shewing some of the more interesting points visited. The height of falls or rapids in the rivers was generally determined by the aneroid barometer, which was also used to find that of hills, banks, &c.

The Hudson's Bay route.

The question of opening communication between the North West Territories and Hudson's Bay was always kept in mind and observations were constantly made in reference to it. A special report on this subject has already been submitted.

The rocks of the greater part of the area examined consist of Laurentian gneiss, having a general uniformity of character and presenting little of special interest. The unaltered palæozoic rocks, which form a border along the south-western side of Hudson's Bay, probably extend about 100 miles inland in the valleys of the Nelson and Hill Rivers, but they are seldom exposed at the surface. One trough of Huronian rocks of considerable extent was found in the region explored, and this will be described separately, while the other geological observations will be included in a general description of each of the foregoing divisions of the season's operations, and in order to condense this part of the subject as much as possible, for facility of reference, I shall give lists shewing briefly the character of the gneiss, as well as its dip and strike, in a sufficient number of localities along each route followed, to serve for all practical purposes. Geology.

1.—Lake Winnipeg to Norway House.

The outlet of Lake Winnipeg is situated about fifty miles south-eastward from the northern extremity of the lake. After flowing for four miles through a channel averaging over a mile in width, its waters enter Great Playgreen Lake, the main body of which is four miles in length, and is separated from Lake Winnipeg by a level peninsula of clay and sand, four miles in width, called Mossy Point. The Nelson River leaves Great Playgreen Lake by two channels, which unite again in Cross Lake, having formed an island between them, fifty-three miles in length, and twenty-one miles in width. As this island has as yet received no name, I propose to call it Ross' Island, in honor of Mr. Roderick Ross of Norway House. The mission village of Rossville, on Little Playgreen Lake, is named after this gentleman's father, who was previously in charge of Norway House. Great Playgreen Lake. Ross' Island.

Following the eastern channel, which is also sometimes called Sea River, the stream leaves Great Playgreen Lake by several branches, which all reunite in Little Playgreen Lake. Norway House is situated on the south shore of this lake where one of these branches falls into it, at a distance of twenty miles from Lake Winnipeg. A former post of the Hudson's Bay Company bearing this name was built on the extremity of Mossy Point, at the outlet of Winnipeg, but it has long since disappeared and the site is now overgrown with trees. Site of Norway House.

2.—Boat-route from Norway House to York Factory.

The travelled boat-route from Norway House to York Factory does not follow the Nelson River (except for a short distance below the former) but a series of lakes and streams lying to the southward of it. The distance between these posts in a straight line is 301 miles by my Route to York Factory.

map. Lake Winnipeg has been ascertained by the engineers of the Canadian Pacific Railway to be 710 feet above the sea. Notwithstanding this considerable amount of fall, in going from Norway House to York Factory, the difficulties of boat-navigation in descending are not great, but are more serious in returning. In the downward journey it is necessary to haul the boat over dry ground only three times, namely, at the water-shed of the Echimamish, the Robinson Portage and the Trout Fall. These portages measure 28, 1315 and 24 yards respectively. All the other rapids are run by York boats, and mostly with a full cargo, but at some of them, more or less of the load requires to be carried past by land. In the upward journey there are in all about twenty demi-charges, or hauling places, and in addition to the three complete portages which require to be made in going down, there is a fourth, the Island Portage, about forty yards in length.

Portages.

East channel.

The boat-route leaves the east channel of the Nelson River twenty-five miles below Norway House, and turns up a small, swampy and marshy stream called Echimamish. In the interval the river is full of islands, and would average about a mile in width, including them. The shores are rather low, but not often swampy. The banks consists of a light-colored clay, with gneiss frequently appearing underneath it, and forming the points and smaller islands. The timber consists of spruce, tamarack, Banksian pine, white birch, aspen, balm of Gilead and willows, with a little balsam fir.

Sea-river Fall.

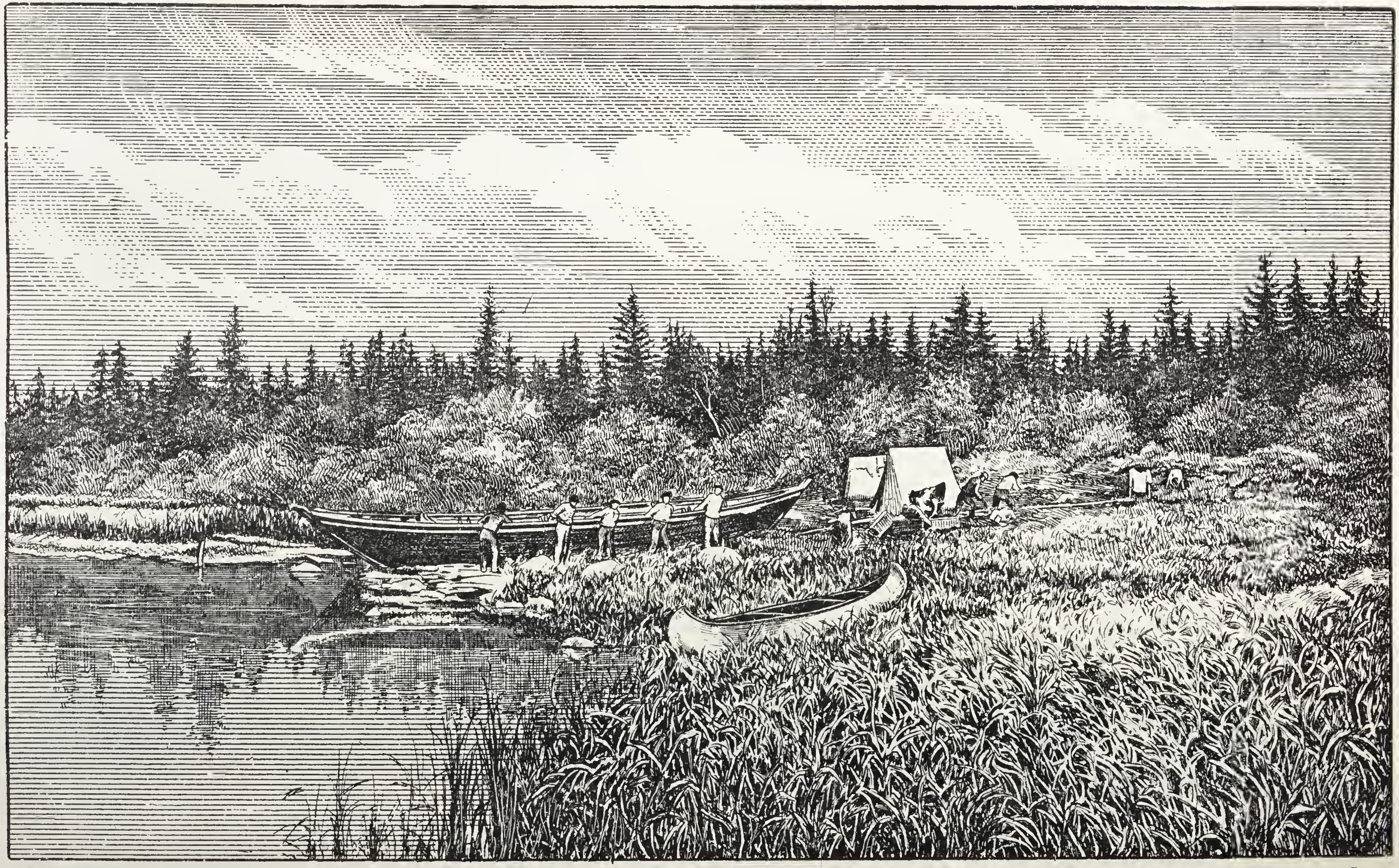
A chute, with a descent of about four feet, called Sea-river Fall, occurs in the east channel at seventeen miles below Norway House, or thirty-seven from Lake Winnipeg. Loaded boats run down this chute, but it is necessary to unload and track them up the current.

Echimamish.

The Cree word "Echimamish" signifies a channel in which the water flows each way. Its course is eastward, and at twenty-eight miles in a straight line from the east channel, we come to an abrupt termination of the western part, at a low rock called the Painted Stone, twenty-eight yards in width, which forms the watershed of the channel. Hairy Lake and two dams, with a rise of about one foot at each, are passed in the above interval. The boats are unloaded and hauled over the little watershed, and launched into what is regarded as a continuation of the same channel. The White-water River, which discharges Little Lake Winnipeg, joins the eastern Echimamish on the south side, at seven miles from the watershed. From this point to Oxford Lake, the stream having no recognised name, I propose to call it Franklin's River, after the late Sir John Franklin, who had a narrow escape from drowning in it, near the White-water, in 1819.

Watershed.

Around Rainy Lake, and on either side of the valley of the Echimamish, low domes of rock occur occasionally near the route, and ridges



From Photo. by R. Bell.

HAULING A YORK BOAT OVER THE ROBINSON PORTAGE.

which appear to rise to a height of seventy or eighty feet, are seen in some places at a distance of two or three miles back. The Echimamish cuts off a small border along the southern edge of the Huronian trough, which will be described further on; but from the confluence of the White-water, gneiss was the only rock observed along Franklin's River all the way to Oxford Lake. Franklin's River flows successively through Robinson's, Pine and Windy Lakes. Robinson Portage, the most formidable one on the whole route, occurs at the foot of the lake of the same name. The carrying-trail, which is as wide and smooth as a good waggon road, passes over the light grey clay soil which prevails everywhere in this part of the country. The descent in Franklin's River, between the extremities of the trail, was ascertained by the aneroid barometer to be forty-five feet.

Robinson Portage.

A swampy lake, without any name, extends for some miles eastward from the foot of Robinson Portage. Seven miles below this portage the river enters a narrow and nearly straight ravine, with walls of gneiss from thirty to seventy feet high, through which it flows for a distance of seven miles to Pine Lake, two rapids occurring in the interval. The south side of Pine lake is bordered by small hills, but to the north-eastward a low tract extends all the way to Windy Lake, around which the country has a slightly undulating aspect. From this lake the river runs north-west, or at right angles to its usual course, and at the end of four miles falls into the head of a marsh on the level of Oxford Lake. Here there is a chute called Wapinaipinis, or the Angling Place, with a descent of about six feet. The marsh referred to opens by a narrow strait into the south-western arm of Oxford Lake.

Oxford Lake.

Oxford Lake runs north-east and south-west, and has a length of about thirty miles, with a maximum breadth of eight or nine miles. It contains many islands, and is much subdivided by long points. With the exception of the south-western arm, it is situated entirely within the Huronian trough, and the rocks around it will be described in connection with this basin. Oxford House, a post of the Hudson's Bay Company, is situated on a rising peninsula formed of light grey clay, at the north-eastern extremity of the lake. This lake is also called Holey Lake, or, more properly, Deep-hole Lake, from a small conical hole on the north side, one mile west of Oxford House, which, according to the Indian belief, has no bottom, but is in reality only sixty feet deep. The extension of the lake beyond Oxford House is called Back Lake.

Trout River.

From Back Lake the water passes, by Trout River, which runs south-east, to the head of Knee Lake—the distance, in a straight line, being eleven miles.

Knee Lake. Knee Lake has a total length of forty miles. It consists of two principal expansions, each running north-east and south-west, connected together about midway between the inlet and outlet by a narrower portion, about nine miles in length, running north and south. The lower part is the widest, and has a maximum breadth of about six miles. The whole lake is studded with islands, but they are particularly numerous in the central part, which is a closely-crowded archipelago. This lake and Trout River lie wholly within the Huronian trough already referred to. A few small hills are seen at the head of the lake and at some other localities near its shores, but, with these exceptions, the country presents all around a low and horizontal outline. The soil consists principally of light grey clay and brown gravelly loam, but near the lake, on the north-west side of the lower expansion, much of it is sandy. The timber on this shore has been burnt within a recent period, but elsewhere it is green and of vigorous growth. Wolverine River, which forms part of the canoe-route to God's Lake, enters the north-eastern extremity of the upper expansion. It may be mentioned that this large lake discharges by the Shamattawa River, and not into Knee Lake, as represented on sketch-maps.

God's Lake.

Knee Lake discharges at its north-east extremity by Jack River into Swampy Lake. Jack River runs north-eastward, and has a length of ten miles, in a straight line. It has a considerable descent in the lower half of its course, the rapids being over ledges of Laurentian gneiss and mica-schist, or boulders of the same rocks.

Jack River.

Swampy Lake. Swampy Lake is a narrow strip of water ten miles long, and has the same north-east course as the river above and below it. Its name is derived from a point composed of peat on the north-west side, about half way down. The surrounding country is low, but not apparently swampy. Around the upper part of the lake the rocks consist of dark-colored mica-schist, with veins and masses of coarse granite. This is the last lake on the route.

From Swampy Lake to York Factory the river curves regularly round from a north-easterly to a nearly northerly course. It is called Hill River as far as the junction of Fox's River, when it becomes the Steel River to its confluence with the Shamattawa, from which the united stream all the way to the sea is called Hayes' River.

Labyrinth of islands. Leaving Swampy Lake, Hill River, for nineteen miles, flows through a labyrinth of small islands. Although the banks are low, there is a very considerable and tolerably regular descent in this distance, the river being broken by a great number of rapids, all of which, however, may be run by boats. The bed of the river, and the innumerable small islands, are mostly formed of angular blocks and fragments of gneiss.

This rock occurs *in situ* at some of the rapids. It is mostly very micaceous. At the end of the stretch so full of islands, clay banks first make their appearance on both sides, and continue all the way to the sea.

Brassy Hill, or The Hill, from which the river derives its name, and which is the only hill known to exist in the whole region, is a remarkable isolated mound of gravelly earth 392 feet in height. Its summit lies three-quarters of a mile east from the river, and four or five miles beyond the lower termination of the labyrinth of islands. Brassy Hill.

The clay banks are about thirty feet high where they begin, but in descending the stream they increase, by degrees, to 100 feet in the neighborhood of The Rock, and then gradually diminish to sixty feet at Fox's River. An average section of these banks in the interval consists of fifty feet of hard bluish or yellowish-grey drift clay, in which the pebbles are not conspicuous as components and boulders are rare, overlaid by twenty or thirty feet of stratified bluish clay with occasional boulders. In the last nine miles before reaching Fox's River, Hill River winds, with great regularity of distance from bend to bend, between banks about eighty feet high, and three-quarters of a mile apart. They consist of forty to fifty feet of drift at the base, and twenty to thirty feet of stratified bluish clay, or the same thickness of yellowish-brown gravelly earth at the top, with occasionally a bed of gravel between them. Clay banks.

From Brassy Hill to Fox River, few islands occur in the river, which has an average width of only about two chains. Several rapids and chutes over ledges of gneiss underlying the clay, occur in the first thirteen miles below Brassy Hill. The last one, at the end of the above distance, or 109 miles above York Factory, is called The Rock from a considerable exposure here of dark-grey, rather coarse gneiss. Gneiss was last seen in the bed of the river about six miles below The Rock, and it is supposed that the palæozoic basin of Hudson's Bay is entered upon in this neighborhood. Hill River.

The character of the river changes at The Rock; and from that point downward no more rapids occur all the way to the sea. The stream is shallow at low water and runs with a swift current to the head of tide-water, about nine miles above York Factory. The gravelly or sandy beach which is exposed during the summer nearly all along between the foot of the clay banks and the water, affords good walking for the men employed in tracking loaded boats up-stream. Change in character of river.

Steel River, or the section of the route between Fox's River, from the left at seventy-nine miles from York Factory, and the Shamattawa, from the right at fifty miles from the same point, has a width of about three chains. Clay banks, with an average height of seventy feet, are Steel River.

continuous on both sides of Steel River throughout its whole course. Marine shells, chiefly *Saxicava rugosa*, derived from the upper beds were noticed all along this section of the river.

The Shamattawa appears to be a larger stream than the Steel River with which it unites and forms Haye's River. This last has an average width of about ten chains as far as the "Penneygutway," a small stream from the left, twenty-four miles above York Factory. Below this, the width is one quarter of a mile, but increases regularly to half-a-mile, and opposite York Factory it has become one mile. About a mile above "Penneygutway" the river gives off a channel on the right, which is of considerable size during floods, but is nearly dry at low water. It emerges again about three miles above York Factory, and is here called Ten-shilling Creek. In descending Haye's River, the clay banks diminish in height from an average of fifty feet at the termination of the Steel River to twenty-seven feet at York Factory.

Islands.

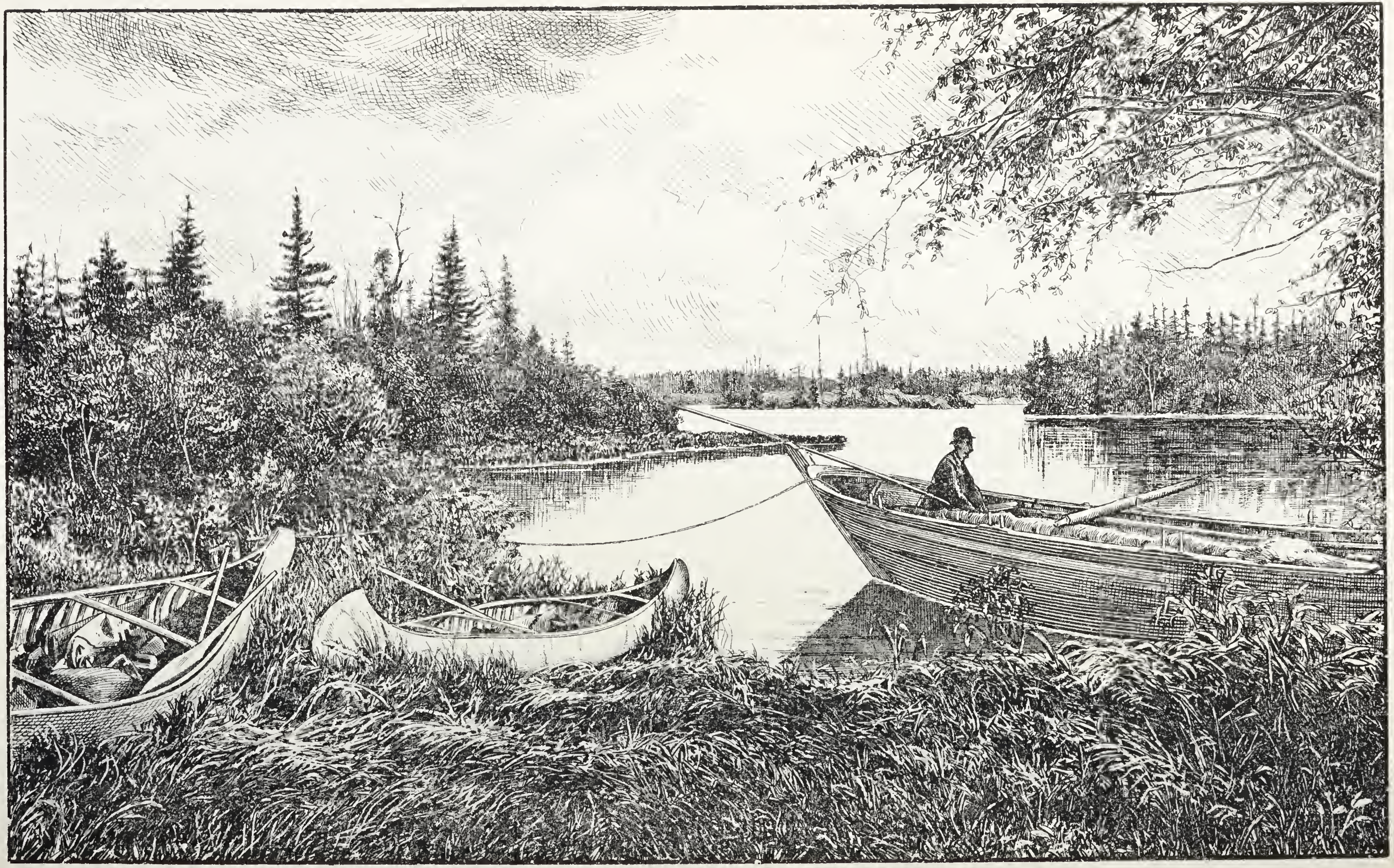
Along the stream above described, from the Rock downward, islands are almost entirely absent, until the head of tide-water is reached. Here three wooded islands occur in succession, and below them is a chain of low islands near the south-east side, covered with grass, and affording abundance of hay for the cattle kept at York Factory.

Palæozoic rocks.

The unaltered palæozoic rocks are not exposed on any part of the above route and their existence under the drift from near The Rock to York Factory is only inferred from the prevalence of limestone *débris* in the shingle, from the absence of the older metamorphic rocks, and from the general character of the country, which resembles that along the lower part of the Nelson River, where these rocks actually crop out.

Laurentian gneiss.

With the exception of the Huronian trough, already referred to, all the rocks seen *in situ* along the boat-route from Lake Winnipeg to Hudson's Bay, which has just been described, consist of varieties of Laurentian gneiss. These are not considered of sufficient interest or importance to merit a detailed description, and it is believed that the following summary of their dip, strike and general character, will be sufficient for present purposes. A knowledge of the direction of the strike in all these localities will be of service in the future working out of the geological structure of the surrounding country. It will be observed that its general run is about west-south-west, or in the same course which prevails over a vast area to the north and north-west of Lake Superior.



The Burland Desbarats Lith. Co. Montreal.

From Photo. by R. Bell.

VIEW UP THE RIVER FROM WAPINAIPINIS PORTAGE.

List shewing the Strike and Dip of the Gneiss along the Boat Route from Lake Winnipeg to Hudson's Bay, with Notes on the Local Character of the Rock.

Strike of gneiss.

No.	Locality	Magnetic Bearing of the Strike.
1.	Along the channel between Great and Little Playgreen Lakes. Massive grey. Contorted. General run	S. 25° W.
2.	Two miles below Little Playgreen Lake. Reddish-grey with large patches of coarsely crystalline hornblende	S. 50° W.
3.	At three and four miles below Sea-river Falls. Dip south-eastward < 70°. Strike from N. 45° E. to	S. 45° W.
4.	The High Rock, between Sea-river Falls and Echimamish. Very micaceous; passing into schist. Dip southward < 70°	S. 70° W.
5.	Between the High Rock and Echimamish	S. 70° W.
6.	Echimamish, above Hairy Lake	S. 40° W.
7.	Echimamish, at the second dam	S. 75° W.
8.	Echimamish, two miles west of the height of land	S. 60° W.
9.	Echimamish, near the junction of White-water River	E. & W.
10.	Head of Robinson Portage. Dark-grey and reddish-grey	S. 80° W.
11.	Foot of Robinson Portage. Dark-grey, close-grained	S. 65° W.
12.	First rapid at about seven miles below Robinson Portage. Grey, massive, compact	S. 75° W.
13.	Outlet of Pine Lake. Micaceous. Dip southwestward < 80°	S. 35° W.
14.	Between Pine and Windy Lakes. Contorted. General strike about	N. & S.
15.	Near Inlet of Windy Lake. Dip S.E. < 65°	S. 50° W.
16.	One mile above Wapinaipinis Rapid	S. 80° W.
17.	Wapinaipinis Rapid. Ordinary reddish-grey, with massive bands	S. 65° W.
18.	South-east shore of Oxford Lake, six miles north-east of inlet. Coarse grey, rough-surfaced, composed of quartz and mica. Strike from S. 55° W. to	S. 70° W.
19.	One mile below outlet of Pine Lake	S. 75° E.
20.	Between Pine and Swampy Lakes. Average strike	S. 70° W.
21.	Island near south-west extremity of Swampy Lake. Tender, grey, micaceous	S. 10° E.
22.	Camp Point, on north-west side of Swampy Lake	S. 85° W.
23.	Rapid at three miles below Swampy Lake	S. 80° W.
24.	Gun Rapid. Micaceous. Crosses the river at right angles. Dip N. < 70°	W.
25.	Seeing Rapid. Ordinary grey. Dips northward < 65°	S. 80° W.
26.	Rocky Launcher Rapid	S. 65° W.
27.	Brassey Hill Rapid	S. 80° W.
28.	Island in the river six miles below Brassey Hill	S. 70° W.
29.	White-mud Fall. Grey, micaceous. Dip, southward < 75°	S. 80° E.
30.	Borwick's Fall. Grey micaceous	S. 80° E.
31.	The Rock. Dark, rather coarse grey	S. 60° E.
32.	Five miles below The Rock. Massive	S. 70° W.

LOWER PART OF NELSON RIVER.

Map.

An exploration of the Nelson River was made for a distance of about ninety miles from the sea, following the stream. From the accompanying map it will be seen that the mouth of Haye's and Nelson Rivers are separated from each other by a low tongue of land, called Beacon Point. The shallowness of the water and the low monotonous character of the shores everywhere in this vicinity renders it difficult to draw a definite line between land and water. Extensive shoals stretch for miles out from the extremity of Beacon Point and from the shores to the north and south of the estuaries of the two rivers. Owing to these circumstances, the outline between the land and water is widely different at high and low tide. The difficulty of mapping the shore accurately is increased by the fact that the sea is receding at an appreciable rate, and also from the circumstance that the tides are of very irregular height, owing to the shallowness of the water for long distances in all directions and the great effect which the winds consequently have in increasing or diminishing the rise and fall.

Mouth of Nelson River.

The mouth of the Nelson River at high tide has a breadth of six or seven miles opposite the extremity of Beacon Point, but it contracts rapidly, having a trumpet-like outline, and for the first ten miles up, the width is from three to four miles. It continues to narrow gradually to Seal Island at the head of tide-water, or twenty-four miles from the extremity of Beacon Point, (at high tide) where it is only one mile and a-half broad. Above this, it varies from half a mile to a mile and a-half as far as we went.

Channel in estuary.

When the tide is out the greater part of the space between the banks in the estuary of the river is dry and consists of a dreary stretch of mud-flats dotted with boulders, constituting a continuation of the shoals further out. A narrow channel with a somewhat irregular depth of water winds down the centre of the estuary. From the soundings which I took it appears to have an average depth of from two to three fathoms at low tide from a point abreast of Beacon Point for about twenty miles up. At the mouth of the river the ordinary spring tides amount to about twelve feet and the neap tides to about six feet, so that at high tide, from three to five fathoms may be found throughout the above distance.

Soundings.

The shallowest part of the river which we sounded was abreast of Gillam's and Seal Islands, or just where the tide ends and the proper channel of the river begins. Here the water was only about ten feet deep. But from this point upward, as far as we went, the average depth of the centre of the river was found to be twenty feet, and sometimes our soundings shewed over thirty feet of water. In this section of the river, the velocity of the centre of the stream varied from about two to six miles an hour, according to the experiments which were made with the submerged tops of spruce trees, in order to ascertain the rate, at least approximately. The swift parts are short and the mean velocity may perhaps be taken at from two and a-half to three miles per hour and the average width at three-quarters of a mile between the water margins. Velocity of stream.

A short rapid occurs a few miles below the highest point to which we explored the river, but it does not appear too swift to be surmounted by steamers. Above it, the Indians report no obstructions for about fifteen miles, when a cascade, called Limestone Falls, is reached. The Nelson River may, therefore, be said to be navigable for river steamers to a distance of about one hundred miles from the sea. Navigation of the river.

The distance from York Factory to the extremity of Beacon Point is about five miles. In going towards the latter, the banks gradually diminish in elevation from twenty-seven feet at York Factory to the level of high tide at Beacon Point. They consist of stratified greyish clay combined with more or less fine sand. Below high tide the beach in the above interval consists of a muddy bluish clay with rounded pebbles and some boulders, and contains marine shells which are tolerably plentiful. Among those collected Mr. Whiteaves recognizes the following: *Leda pernula* (Möll), *Nucula tenuis* var. *inflata* (Hancock), *Mytilus edulis* (Linn.), *Cardium Islandicum* (Linnæus), *Macoma calcarea*, (Chemnitz), *Saxicava rugosa* (Lamark), *Buccinum tenue* (Gray), *Natica affinis* (Gmelin). Clay banks.

As already stated, the shores about the mouth of Nelson River are very low and flat. Banks of clay, at first only a few feet high, begin to appear on both sides about ten miles above the extremity of Beacon Point, and in ascending the river, the banks of clay on either side gradually rise till a point is reached about fifty-four miles, in a straight line, from Beacon Point where they are nearly 200 feet in height, and above this, as far as observed, they maintain about the same elevation either immediately overlooking the river or at a short distance back from it. A layer of peat, averaging about four feet in thickness, was observed almost everywhere at the top of the bank on either side and extending inland. At Flamborough Head, a prominent point on the north-west side, nineteen miles from Beacon Point, the clay bank has attained a height of 126 feet. It consists of hard gravelly drift clay with some boulders at the bottom, and drab-colored stratified clay towards the top. At, and near the top, marine shells are abundant. Among the species observed were *Buccinum undatum*, *Tellina Grœnlandica*, *T. proxima*, *Mya arenaria*, *Leda pernula*, *Saxicava rugosa*, and *Cardium Islandicum*. Flamboro' Head.

About thirty-five miles further up, where the bank on the south east side has reached its maximum height of nearly 200 feet, it consists entirely of thinly-stratified yellowish-grey, fine clayey-sand or sandy clay, the thickest beds not exceeding seven inches, while others are only one inch thick. The thicker and thinner beds alternate with great regularity in some portions of the cliff. In one place in this vicinity, the whole depth of the deposit is seen in a perpendicular wall, which forms a favorite resort for great numbers of cliff swallows, their nests being built under the projecting edges of beds of the hard dry clay. Marine shells of most of the above named species are washed out of this bank, large valves of *Saxicava rugosa* being the most common.

Islands.

No islands occur in the estuary of the river, but from the head of tide, in the distance to which I descended, upwards of twenty, covered with timber, were passed, besides a number of others on which only grass was growing. The wooded islands are comparatively high, while the grassy ones are low and flat, and are evidently swept over by the river ice when it breaks up in spring. From the Puck-wa-ha-gun River (sixty miles from Beacon Point), upward, wide flats covered with good grass occur, here and there, on both sides of the river. The grassy islands and flats probably owe their preservation to the underlying horizontal beds of dolomite, which prevent them from being worn away by the force of the ice.

Silurian dolomite.

The dolomite, which is probably of Upper Silurian age, was first found *in situ*, in ascending the stream, about two miles above the Puck-wa-ha-gun River, or at sixty-two miles in a straight line from Beacon Point, where it is exposed at the edge of the water on both sides of the river. It was also met with on the south-east side at two and again at six miles further up. At the latter place, a cliff of thirty feet of it rises perpendicularly from the edge of deep water, beneath which the escarpment is continued downward.

At all the foregoing localities the rock has a yellowish grey color, is rather fine grained, soft and generally earthy, although some of the beds appear to constitute a tolerably pure dolomite. It is thinly bedded, with the exception of a few bands, for a foot or more in thickness at the last locality. The only fossil observed was an obscure *Pentamerus*, which was abundant in one of the beds, but none of the specimens were sufficiently well preserved to identify the species.

A slight rapid occurs near the highest point reached. Below it the river is narrower than it is above, and here there is evidence of great ice-packing in the spring. On the sloping bank on the north-west side, the timber is prevented from growing below forty-five feet above the river. The outermost trees standing on this level are barked by the ice and boulders, which have been pushed diagonally up the slope.

Effects of ice in the spring.

A great amphitheatre is excavated in the opposite bank, evidently by the water passing a temporary dam of ice, blocking up the river by piling at this point, after a spring shove. On the 18th of July last, some ice still remained, on the north-west bank, opposite to this amphitheatre-like excavation, but was melting rapidly under a hot sun.

The timber along the lower part of Nelson River consists principally of spruce, tamarack, aspen and balm of Gilead. On the islands and lower levels, the spruce attains a good size and would be very suitable for building purposes, but on the level ground, stretching away from the tops of the banks, the timber is smaller, and the ground is covered with a thick growth of Sphagnum, under which a layer of peat, of variable thickness, is seen at the brink of each steep clay bank. Timber.

The detailed survey of a portion of Hayes' River, which was made in the vicinity of York Factory, extended from the mouth for a distance of about twelve miles up the river. The distances were ascertained by the Rochon micrometer-telescope, and the bearings were taken with a prismatic compass. The accompanying map, on a scale of one mile to the inch, shews the principal topographical features of this section of the river as determined by this survey. Survey of Hayes' River.

Immediately after my return to Norway House, I proceeded to make a track-survey of the Nelson River downward. This was accomplished to a distance of 180 miles from the commencement of the river at the outlet of Lake Winnipeg. Before returning, partial surveys were also made of Cross and Sipi-wesk lakes, which lie in the course of the river in this distance. Finally, a track-survey was completed of Great Playgreen Lake and the channel on the west side of Ross' Island and the Whiskey-jack Portage, which leads from it to Cross Lake. Survey of Nelson River.

The region through which the upper two-thirds of the Nelson River flows may be described as a tolerably even Laurentian plain, sloping towards the sea at the rate of about two feet in the mile. The river, for the first hundred miles from Great Playgreen Lake, does not flow in a valley, but spreads itself by many channels over a considerable breadth of country. This tendency to give off "stray" channels is characteristic of numerous rivers throughout the northern and comparatively level Laurentian regions, but it is perhaps more strongly marked in the Nelson than in any other. In the above section of this stream the straggling channels are of all sizes, from mere brooks up to large rivers. In their various courses towards the sea these channels, here and there, unite either wholly or partially, but often only to divide again, and thus they constitute a sort of network of rivers, the islands between them being of all sizes and shapes. The channels themselves consist of a series of dead-water stretches separated by chutes or rapids at longer or shorter intervals, which, however, vary Numerous channels.

much in the different channels. The greatest descent at any one of the chutes visited takes place at the White-mud Falls, and amounts to about twenty feet. These falls are divided by islands into three parts, and the "discharge" on which they occur is supposed to represent about half the volume of the Nelson River. The White-mud Falls were considered to represent more than twice the quantity of water which passes over the Chaudière Fall at Ottawa. Should this estimate be correct, the whole body of the Nelson River would be more than four times as great as the Ottawa at the above fall.

Volume of water.

The channels explored are shewn pretty correctly on the accompanying map, which serves to give a good idea of the general character of the river. Following the channel on the east side of Ross' Island, the first break in the smooth water extending down from Lake Winnipeg is the Sea-river Fall at thirty-seven miles from the outlet. At twenty-one miles further down we come to Pipestone Lake, which is on the same level as Cross Lake, and separated from it by an irregular strait five miles long. Between the level above Sea-river Fall and that of Pipestone Lake there are, in all, ten rapids with a total fall of about thirty feet. Making an allowance of ten feet more for the current in the smooth portions of the river, there would be a difference of about forty feet between the level of Lake Winnipeg and that of Pipestone and Cross Lakes. By the channel on the west side of Ross' Island the navigation is uninterrupted from Lake Winnipeg all the way to Big-reed Lake, one part of which comes within four miles of the southern extremity of Cross Lake. Between Cross and Sipi-wesk lakes ten more rapids occur, with a total fall of about eighty feet. This, with twenty feet for the current in the intervals between the rapids, would give a total descent of 100 feet from the one to the other. Below Sepi-wesk Lake no rapids, properly speaking, were met with as far as I went, but two others are reported to exist before Split Lake is reached. Above Sipi-wesk Lake the first rapid occurs at the Chain-of-Rocks, four miles up, and is very slight, having a fall of less than two feet. It could, no doubt, be easily passed by steamers. But the Red-rocks Rapids, at seven miles from the lake, are more serious, and would terminate the upward navigation of this section of the river. From these rapids, downward, including Sipi-wesk Lake, there appears to be no insurmountable obstruction to the navigation of the river by steamers till the higher of the two rapids above Split Lake is reached, a distance of upwards of 100 miles.

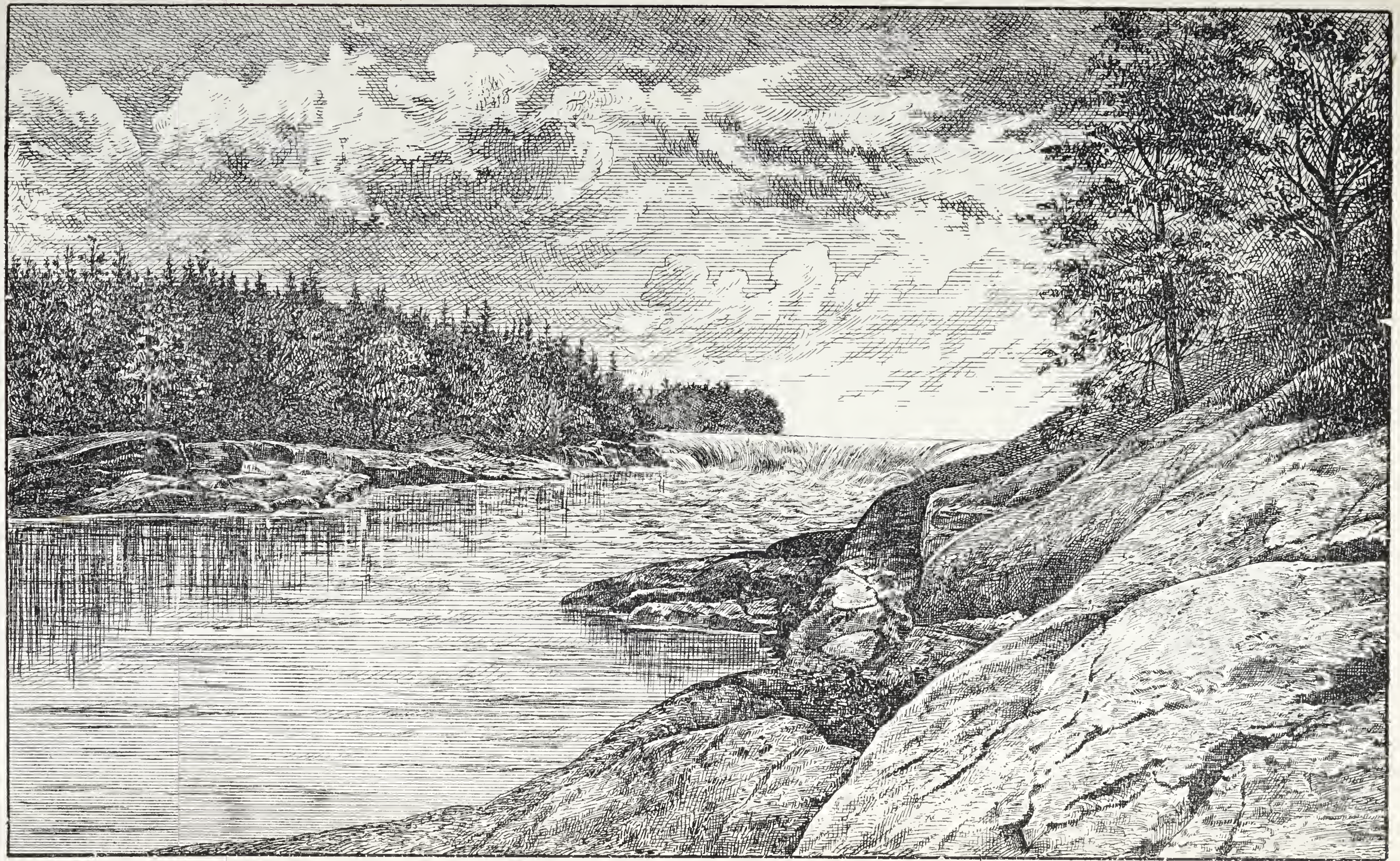
Pipestone and Cross Lakes.

Fall of the river.

Navigable stretch.

Sipi-wesk Lake and the first twelve miles of the river below it run nearly north-east or with the general strike of the Laurentian gneiss and mica-schist on which they are situated, but at the above distance the river assumes a course bearing due north by compass, (nearly

Course and character of the river.



From Photo. by R. Bell.

SOUTHERN CHANNEL OF WHITE-MUD FALLS, NELSON RIVER.

north-by-east astronomically) or diagonally across the strike of the gneiss and the course of the glacial striæ, both of which have a general N. E. and S. W. bearing. The branches from the right, in this interval, run south-west, while those from the left flow north-east. The whole of the waters of the Nelson River appear to have come together in this stretch for the first time since leaving Great Playgreen Lake. The width now averages about a quarter of a mile, or rather more, with a depth of from forty to fifty feet. The current runs at the rate of about three miles an hour in the middle, except at two very narrow parts where it is considerably greater. Owing apparently to the considerable depth of water across the greater part of the bed of the stream-strong eddies are found on both sides which greatly facilitate the up, ward navigation of this part of the river.

The remarkably straight north-and-south stretch of the river is reported to extend as far as Split Lake. Its eastern bank consists almost entirely of drift clay, while gneiss is exposed nearly all along the west side. This singular part of the river no doubt owes its location to the existence of a great dyke of dolerite, which appears to run along its whole course. Its width probably corresponds nearly with that of the bed of the stream, which has been excavated out of the trap, the latter appearing only on the extremities of points on either side and on the two or three small islands. The dolerite is divided by joints parallel to its course and is very friable. It is coarsely crystalline and has a dark brown color near the surface, owing to the presence of oxide of iron, but some fresh fractures shew a dark, somewhat greenish grey color. In some parts, white calcspar and compact olive-colored serpentine are developed in thin sheets in the numerous longitudinal joints and also in the horizontal and vertical tranverse partings, so that rectangular pieces of the dolerite, which crumble out, are completely encased in these minerals. Small streaks of magnetic iron, running parallel to the walls, were found in one part of the dyke.

Great trap dyke.

Serpentine.

The dyke itself may have a width of from 200 up to 1,000 feet or more, and owing to its friable nature and to its decomposing more rapidly than the gneiss of the surrounding country, it has been easily removed during the glacial period, and the present channel excavated. In some places the gneiss immediately adjoining the dyke on either side has been altered and jointed parallel to the walls, by the action of the trap. This would also aid in facilitating the scooping out of its channel. Both the gneiss and the harder points of the trap forming its walls are rounded and striated by glacial action.

Excavation of river channel.

The same dyke may be continued, with an altered course, up through Sipi-wesk Lake. At a point on the west side of the river, two miles above the inlet of this lake, a great dyke makes its appearance and is probably a part of the same one which crosses the stream two miles further up, forming the Chain-of-Rocks. The dolerite is here of the same character and contains the same peculiar serpentine as the dyke along the straight stretch of the river just described. Along the latter stretch, and also on the shores of Sipi-wesk Lake and the river above it, dark grey finely crystalline dolerite is frequently seen in the form of dykes of greater or less width, and also as patches filling angles in the walls of gneiss overlooking the water. On the sides of the straight stretch, these dykes generally run nearly parallel with the main one, but some of them follow the south-westward course of the stratification of the gneiss, and diminish in size in receding from the river, as if they were offshoots from the great dyke.

Other trap dykes.

Huronian rocks are developed in considerable force around Pipestone and Cross Lakes, apparently in continuation of the Oxford and Knee Lake troughs, but with this exception, the whole region explored along the upper part of Nelson River is occupied by Laurentian gneiss, diversified only by mica-schist and trap dykes. As these rocks appear to have little local interest from either a geological or an economical point of view, it is believed that the following list, shewing strike and other particulars in thirty-six localities in this region, will serve every purpose as well as a more detailed description.

Great gneiss region.

Strike of gneiss.

List shewing the Strike of the Gneiss at Various Locations along the Nelson River, arranged in their order from Lake Winnipeg downward. The Bearings refer to the Magnetic Meridian.

1. Northwestern extremity or outlet of Great Playgreen Lake. Dip S.E. < 60° .... S. 40° W.
2. Southern arm of Cross Lake from Whiskey-jack Portage to Big-stone Point. Reddish-grey, mostly massive. Dip south-eastward about < 45°. Average strike about .... S. 20° W.
3. Eastern channel, four miles above Pipestone Lake. Grey ... S. 30° E.
4. Rapids at inlet of Pipestone Lake. Massive, fine-grained, red. General strike .... S. 45° E.
5. From western outlet of Cross Lake to Pelican Falls. Massive. Strike with river about .... S.
6. White-mud Falls. Strike straight and regular. Dip northward < 45° .... S. 70° E.
7. Bladder Portage. Grey .... S. 60° E.
8. Two miles below Bladder Portage. Grey .... S. 60° E.
9. Rapid just above Red-rocks Portage. Nearly black, cut by granite veins. Very micaceous and full of large garnets.... S. 40° W.
10. Two miles below Red-rocks Portage. Grey, micaceous, schistose. Dip westward < 45° .... S. 25° W.
11. South-west extremity of Sipi-wesk Lake. Dip eastward, < about 75° .... S. 30° W.

12\. Sipi-wesk Lake, north-west side, twelve miles below south-west extremity. Dark grey, hornblendic.................. S. 60° W.

13\. Sipi-wesk Lake, south-east side, thirteen miles from south-west extremity. Grey, micaceous. Bedding vertical ...... S. 55° W.

14\. Sipi-wesk Lake, fifteen miles from south-west extremity. Very micaceous, grey. Bedding runs in a straight course... S. 40° W.

15\. Sipi-wesk Lake, twenty miles from south-west extremity. Coarse, grey, micaceous, tender. Dip S.E. < 60°.......... S. 45° W.

16\. Sipi-wesk Lake, twenty-six miles from south-west extremity. Micaceous .... S. 50° W.

17\. Outlet of Sipi-wesk Lake. Ribboned, reddish color; contains nodules of iron pyrites, which decompose and form red particles in the surface gneiss.......................... S. 65° W.

18\. From outlet of Sipi-wesk Lake, for eight miles down Nelson River. Stratification vertical, or at high angles to north-westward; not contorted. General strike with course of river regular.. S. 70° W.

19\. Two miles above Devil's Brook. Epidotic, with compact felspar .... S. 75° W.

20\. Eighteen miles below Sipi-wesk Lake. Grey, quartzose, micaceous .... S. 45° W.

21\. One mile above Landing-lake River. Red and grey in alternate bands. Rather coarse. Dip N.W. < 70°......... S. 40° W.

22\. Two miles below Landing-lake River. Grey, micaceous ... S. 45° W.

23\. "Sturgeon's Calling Place," three miles below Landing-lake River .... S. 20° W.

24\. Between Chain-of-Lakes and Broken-mouth Rivers from S. 35° W. to.. S. 50° W.

25\. Broken-mouth River. S. 75° W. to .... S. 85° W.

26\. Three miles above Island River. Dip southward < 70°..... S. 80° W.

27\. Just above upper mouth of Island River. Coarse, grey, Dip S.E. < 50°... S. 45° W.

28\. Just below upper mouth of Island River. Dip eastward < 45° .... S. 25° W.

30\. From Spelling Brook to Stake-net River. Dip N.W. < 70° to 75° .... S. 50° W.

31\. One mile below Stake-net River. Massive, grey, micaceous. The gneiss in this neighborhood contains many isolated rounded masses of a different character from the matrix. and lying at various angles to the stratification. They are probably imbedded boulders .... S. 70° W.

32\. One mile above Devil's Rapid........................... S. 60° W.

33\. Devil's Rapid.. S. 7 ° W.

34\. One mile below Devil's Rapid........................... W.

35\. Three miles above Goose-hunting River. Massive, grey, quartzose .... S. 45° W.

36\. Mouth of Goose-hunting River........................... S. 75° W.

The general aspect of the country along the upper part of the Nelson River is even, or slightly undulating, the highest points seldom rising

Aspect of the country.

more than thirty or forty feet above the general level. Whiskey-jack "Mountain," opposite the foot of Sea-river Falls, is only from thirty to sixty feet high. The "High Rock," four miles above the entrance to the Echimamish, has an elevation of only about fifty feet. Such terms, applied by the inhabitants to mere banks and hummocks, indicate the general level nature of the country. On the north-west side of the inlet of Sipi-wesk Lake the hills rise to a height of from 100 to 150 feet, and appear to be composed of clay or drift materials. Along the north-west side of the lower part of this lake, the ground has an elevation of about 100 feet. Partridge Hill, seven or eight miles eastward of the outlet of the same lake, is the highest point observed in the district, and has an elevation of about 200 feet over the water.

Nature of the surface.

The solid rocks of the region are generally overspread with the prevailing grey clay, which, in some cases, is liable to bake and crack in the sun, but in others it forms a soft, mellow soil of excellent quality. Of course a good deal of fixed rock is exposed at the water's edge along the principal water-courses, but even in these situations the upper parts of the banks, including those of the smaller islands, are generally composed of clay.

On either side of the channel west of Ross' Island, the country is rather barren. The shores are low, and consist mostly of points and knobs of gneiss with sandy bays, and bogs and marshes between them. Whiskey-jack Portage, which connects the heads of two bays from opposite directions, passes along a strip of dry, coarse sand, which looks as if it might have formed the north-western side of an ancient water-course.

Huronian Trough.

Position and extent of Huronian trough.

The Huronian rocks of Pipestone and Cross Lakes, the Echimamish, Oxford Lake, Trout River and Knee Lake all probably belong to one basin or trough running in a south-westward course, conforming with the general trend of the Laurentian gneiss and mica-schists. Its extremities probably lie near the west side of Cross Lake to the south-west and the outlet of Knee Lake. Its total length would, therefore, appear to be about 143 miles, and it has probably an average breadth of about fourteen miles, and an area of about 2,000 square miles. It presents a considerable variety of crystalline schists, coarse diorites, &c. These, like the Huronian rocks in other parts of the Dominion, may prove to be the repositories of valuable minerals, and, therefore, the area indicated is of more interest than the great gneissic region around it. The principal varieties of rocks examined within this trough, will be described in the order of their occurrence from south-west to north-east. The directions of the strike, &c., are referred to the magnetic meridian.

Rocks of Pipestone Lake.

On the southern shore of the main body of Pipestone Lake the prevailing rock is a dark green laminated calcareous hornblende schist, with vein-like streaks and lenticular patches of white quartz. It runs N. 70° W., and dips southward at an angle of about 75°. On an islet about one mile off the central part of this shore there is a softer hornblendic schist with laminæ of white calcspar and bunches of quartz with chlorite, associated with a glossy-surfaced chloritoid schist. An island about a mile to the north-west of the last is composed of massive grey, rather coarsely crystalline, diorite. The islands in the outlet of the lake consist of green hornblende and mica-schists, with irregular veins of bluish-grey quartz conforming with the stratification, which here runs N. 70° W. and dips northward at an angle of 80°. Along the strait five miles in length, which connects Pipestone Lake, with Cross Lake the rocks on both sides consist of grey mica-schists, with pebbles of different kinds and rounded grains of quartz, either closely crowded together or scattered sparingly through the mass. At a point on the south side of the strait, and two miles from Pipestone Lake, a conglomerate band occurs in the midst of a grey, rather soft, and somewhat fine-grained mica-schist running N. 55° W., dip N.E. < 80°. The pebbles in the conglomerate range from coarse sand up to the size of a child's head. Most of them approach a spherical form, and consist of fine-grained, hard grey syenite. Others are of white quartz, and are also well rounded. At a point on the north side of this strait, just before entering Cross Lake, a few large and somewhat angular boulders of a light grey steatitic schist rest on the pitted surface of a massive grey silicious mica-schist holding an abundance of small pebbles, which have a tendency to occur in bunches. The steatitic schist, which an Indian afterwards informed me is to be found *in situ* somewhere in the vicinity, breaks into ligniform splinters, and is used by the natives for making tobacco pipes, from which circumstance the adjoining lake derives its name.

Indian Reserve and other islands.

Along the eastern side of the (Indian) Reserve Island and adjacent smaller islands, from Otter Island to Big-stone Point, the rock is a dark green calcareous hornblende-schist with some fine grained mica-schist of the same color. The strike is S. 60° W., dip south-eastward < 85°. At Big-stone Point, the Laurentian gneiss begins. A dark grey, coarsely crystalline massive diorite occurs along the narrows on the east side of the Reserve Island, and the opposite point on which Chief Taipistainum resides. Two miles further north, a light-grey massive quartzite was found on both sides of the same channel. The extreme north point of the Reserve Island is formed of a dark grey granite or granitoid gneiss, in which the lamination is very obscure. A small dyke of fine grained dark-grey dolerite running N. 5° W. here cuts this rock. Grey mica-schist was found on all the islands visited in the western part of Cross Lake, between the Reserve Island and the outlets. On an island, a mile south of the central outlet, (one of a chain running with the strike) the mica-schist is of a conglomerate character, being full of pebbles and small lenticular masses of grey syenite and quartzite. The matrix is rather coarse, dark-grey, with rusty surfaces in some parts and holds a few garnets. The bedding is vertical and runs S. 55° W. On several other islands which were visited around the western extremity of the lake, the strike of the grey mica-schist was S. 25° to 30° W., dip north-westward, $< 80°$. The north-west shore of Cross Lake is formed of Laurentian gneiss, and the channels of the river, soon after leaving the lake, have a rapid descent. Both the geological and the geographical features of this locality therefore bear a strong resemblance to those of the outlets of the Lake of the Woods.

Dyke of dolerite.

Echimamish.

On the Echimamish, the Huronian rocks were first seen about twelve miles east of the Nelson River, from which point they are continuous to the junction of the White-water, excepting for a short interval, occupied by gneiss between the second dam and the watershed, in which the stream makes a detour to the south and passes beyond the boundary of the Huronian basin. Up to the first dam the Huronian rocks consist of glossy grey and greenish grey fine-grained mica schist, in a vertical attitude, the strike varying from W. to S. 60° W.

At the first dam a very dark grey quartzite, composed of grains of vitreous quartz mixed with finer silicious particles, is interstratified with thin layers and groups of layers of nearly black clay-slate, and holds bunches of smoky vitreous quartz. It is associated with grey felsite slate. The strike is S. 80° W. and the bedding vertical. Immediately to the south of the dam mica-schists again make their appearance. Close to the Laurentian gneiss, six miles further up the stream, dark-grey slaty quartzite occurs with the same strike as the gneiss, namely S. 75° W. About a mile west of the watershed, at Painted Stone, the gneiss gives place to greyish mica-shist, having a strike varying from S 60° W. to S. 70° W. At the water-shed and for a mile down the south side of the eastern section of the Echimamish, the rock is a grey quartzite, strongly ribboned with reddish and lighter grey streaks. The strike is S. 70° W., vertical. Fine-grained greenish-grey mica-schist having the same strike occurs on the opposite side of the channel. Beginning about two miles east of the water-shed, coarse reddish granite and a gneissoid rock become associated with the mica-schist as far as the junction of the White-water, five miles further.

As stated in a previous part of this report, Laurentian gneiss was found along the whole course of Franklin's River, the Huronian rocks appearing again on the south shore of Oxford Lake five miles east of the opening from the Wapinaipinis marsh, which may be considered as the mouth of Franklin's River. Franklin's River and Oxford Lake.

The junction of the two formations, which appear as usual to be conformable with each other, occurs just where the south-west area opens into the main body of the lake. Here the last of the Laurentian series consists of gray coarse rough-surfaced quartz and mica-rock. The first rock on what is considered to be the Huronian side of the boundary between the two series, consists of highly crystalline dark green hornblende-schist, ribboned with fine lines of white quartz grains. It is identical in character with the hornblende schist which is usually found at the base of the Huronian bands in the region to the north-westward of Lake Superior. This schist is interstratified with bands of finely ribboned grey gneiss, which like all the Huronian gneisses I have ever met with, is slightly calcareous. The strike at this locality is S. 70° W., but on an island about a mile further on our course to Oxford House a fine grained hornblende runs S. 50° W. At the distance of another mile, a rather massive crystalline diorite was found on one of the larger islands. Three miles further we passed through a gap, called The Doorway, in a chain of islands. Here the rock is a grey micaceous slate conglomerate. The rock of the islands about three miles south-west of the Seven-mile Point, or ten miles from Oxford House, consists of a soft, greenish, calcareous mica-schist with rounded pebbles and grains, mostly of white quartz. Seven-mile Point is formed of a grey finely micaceous slate conglomerate in which the pebbles are abundant, well rounded and composed principally of grey-syenite and light-grey quartzite. Junction of Laurentian and Huronian rocks. Calcareous gneisses. Slate conglomerates.

Chloritic schist with pebbles of syenite and pebbles or patches of compact white and grey quartzite is exposed along the upper part of Trout River about one mile and a-half south-east of Oxford House. The strike varies from N. 55° to 65° W. Midway between Oxford and Knee Lakes, soft fine-grained ash-grey and dark iron-grey mica-schist occurs in the bed of the river for a distance of two miles. The stratification is contorted. At Trout Fall, one mile above Knee Lake, the water pours nearly perpendicularly about ten feet over a rather massive grey argillaceous and finely micaceous quartzite running N. 30° W., and shewing rather indistinct diagonal stratification. On the south side of the inlet of Knee Lake, layers of fine-grained magnetic iron are interstratified with grey siliceous and micaceous schists, running about east and west. This ore has a great effect on the compass, even at some distance off. A strong magnetic disturbance was also Trout Fall and Knee Lake.

noticed at about two-thirds of the distance from Oxford Lake, probably due to the same cause.

Grey and coarse greenish-grey mica-schists, running S. 65° W., were met with around the south-western extremity, or head of Knee Lake. Grey quartzite was found about six miles down the lake, and again at about twelve miles. In a narrow part of the lake, full of islands, between the last distance and "McKay's Rocks," grey mica-schists, generally of a soft nature, are largely developed, and strike from S. 45° to 55° W.

One part of the narrows in the middle of the lake contracts to a few chains, and has a perceptible current passing through it. A small islet in this current and the western shore abreast of it consist of fine-grained

Magnetic iron.

magnetic iron in thin layers, interlaminated with others of quartzite and mica-schist. The rock is twisted and corrugated, and breaks with a splintery fracture. The local magnetic attraction is so great in this neighborhood as to render the compass quite useless. A short distance to the southward a coarse crystalline diorite having a north-and-south strike is exposed. The numerous islands in the narrow central part of the lake consist of greenish-grey schists, amongst which hornblendic, argillaceous and micaceous varieties prevail. The strike in the centre of the archipelago is N. 75° to 80° W. The point on the south-east side, fifteen miles from the outlet, consists of hard, finely crystalline slaty, green diorite with calcareous surfaces and joints. At a point on the north-west side, six miles from the outlet, the rock is a mica-schist conglomerate. The matrix is fine-grained, dark-grey and hard, while the pebbles and boulders, which are well rounded, consist of grey syenites, the largest of them measuring two feet in diameter. The strike is here S. 80° W. Laurentian gneiss, running N. 75° W., makes its appearance on the Jack River about three miles below the outlet of Knee Lake, and continues thence all along the route to a point six miles below The Rock. Between Knee and Swampy Lakes it is very micaceous, and is cut by many veins of coarse light-colored granite.

Track-Survey of a Portion of Lake Winnipeg.

Survey of Lake Winnipeg.

As stated in a previous part of this report, a track-survey was made of the east coast of Lake Winnipeg from the outlet to the Dog's Head, and from thence, of the west shore and the islands as far as Drunken River, which lies within the actual surveys which had been made by the Dominion Lands Department. The total distance between these localities is 206 miles. The error in these surveys, which did not prove to be great, was well checked from point to point by a number of latitudes. By means of this work and the track-surveys of other portions of the coast line which had been made by previous explorers, together with the Dominion Lands surveys around the southern extremity, I have been enabled to complete the map of the whole lake, which accompanies this report. The coast between Lorn's Strait and Fort Alexander, for which no definite authority could be found, is less accurately represented than the other portions.

Map.

Geological features of the east shore.

From a geological point of view, the east coast of Lake Winnipeg between the outlet and the Dog's Head does not appear to present much of interest or importance. The whole shore is low and sandy, with points and numerous small islands and reefs of Laurentian gneiss. These and the shallowness of the water render navigation rather difficult in approaching the land in large vessels. A light grey clay like that of the Nelson River region was frequently noticed, and was said to occupy a good deal of the surface from the lake shore inland. I was informed by a person who said that he had traversed the country, that towards the height of land a good deal of clayey land of fair quality extends southward almost to Beren's River. But for some miles inland the country east of Lake Winnipeg, from one extremity to the other, as far as it has been explored, is reported to consist mainly of rock and swamps. It is, however, very imperfectly known, the explorations hitherto made being of very limited extent compared with the whole area. It affords but little promise of valuable timber or minerals. The north-western limit of the white and red pine is about the Winnipeg River and the eastern border of the prairies.

Minerals and timber.

On the east coast of Lake Winnipeg, besides the Laurentian gneiss, a belt of Huronian schists, chiefly micaceous, occupies a long stretch of the shore between Big Island and Point Metasse. A *reconnaissance* of this part of the coast was made in 1874, and these rocks are referred to in my report for that year, page 39. The gneiss of the portion of the east coast explored the present season does not require a more extended description than is contained in the following list, shewing the strike at intervals throughout this section :—

Strike of gneiss.

List shewing the Strike of the Gneiss at Locations along the East Side of Lake Winnipeg.

1. Twenty-five miles northward from Poplar Point............	S. 25° E.
2. Point opposite Spider Islands, mostly very massive coarse grey	S. 25° E.
3. Spider Islands. Grey. Dip eastward < 80°...............	S. 28° W.
4. Coast near the Shoal Islands. Coarse, dark grey, massive...	S. 25° E.
5. Poplar Point. Massive grey with black patches. Contorted. General strike..	S. 45° E.
6. Four miles south-east of Poplar Point. Grey. Dip westward < 45°..	S. 12° W.

7. Point opposite George's Island. Contorted. General strike.. E. & W.
8. Lob-stick Island, near Beren's River. Massive, dark grey... S. 60° E.
9. Point three miles south of Beren's River.................. S. 55° E.
10. Pigeon Point. Massive-grey. General strike about........ S. 45° W.
11. Main east shore opposite Dog's Head. Grey and red in alternating layers running in straight lines................ W. 70° W.

Surface Geology.

Clay soil.

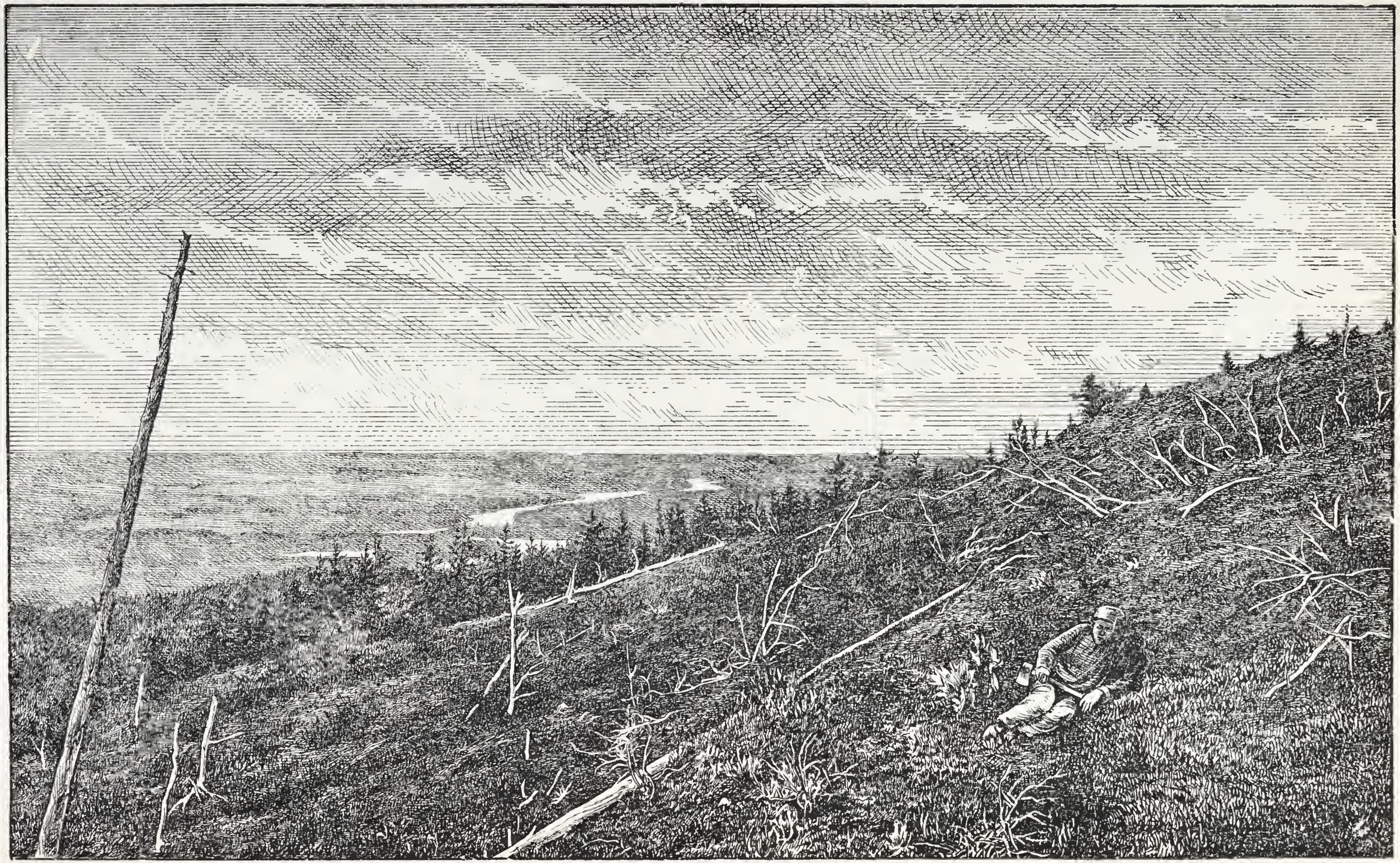
The nature of the superficial deposits and the character of the soil have been referred to in describing the regions explored during the season. The prevalence of a light-colored clay, often constituting a good soil, free from boulders, over such a large region, is a fact of much importance in regard to the future value of this part of the country. This deposit is said to extend over the greater part of the region between the Nelson and the Churchill Rivers, and even beyond the latter. As we have seen, however, sandy and barren tracts are not wanting.

The lower portions of the clay banks along the Hill, Steel and Haye's Rivers, and also along the lower level of the Nelson River, are composed of a fine kind of drift, in which the clay itself forms the bulk of the mass, boulders being generally absent and pebbles scarce. The stratified clay, which usually forms the upper parts of the banks has a rather lighter color than the drift clay below. In the region lying towards the sea, in which the clay banks occur along the rivers, the country appears to be everywhere nearly level and covered with a monotonous growth of rather small timber, consisting chiefly of spruce and tamarack. The accompanying view from the top of Brassey Hill, which extends over a distance of thirty miles, will serve to give an idea of the appearance of the surface of the country throughout this great region, which extends to the east and north far beyond the limits of last season's explorations.

View from Brassey Hill.

Composition of the drift.

In regard to the source of the materials composing the drift along the above rivers, I found, among the pebbles, besides gneiss, green schists and the unaltered yellowish-grey earthy dolomite, supposed to underlie the country for a hundred miles from York Factory, a large proportion of various rocks of the Manitounuck and Nastapoka groups, with which I was familiar, on the east coast of Hudson's Bay, and which resemble those of the Nipigon series. Among the latter occurring in the drift, may be mentioned the very dark grey quartzite with occasional light spots, which, on weathering out, form rounded pits on the surface, the bluish-grey dolomite with concentric, cherty, concretions, similar dolomites having reddish layers, the blackish slates



The Burland Desbarats Lith. Co. Montreal

From Photo. by R. Bell.

VIEW FROM BRASSY HILL.

accompanying the dolomites and quartzites and a peculiar variety of red jasper such as that of Long Island.

In my report for 1877,* I have shewn that on the Eastmain coast there is evidence proving that the waters of Hudson's Bay are receding. The same phenomenon is manifest in the neighborhood of the mouths of the Nelson and Haye's River. It is said that within the recollection of the generation preceding the present one, the island called Mile Lands, just above the present site of York Factory was submerged at high tide. Now it is a dry island, several feet above high tide-mark. Hay Island, in the middle of the river, opposite to York Factory, has not yet become overgrown with trees or bushes, although it is now never swept by the ice breaking up when in the spring, and the Hudson's Bay Company stack their hay upon it with perfect safety. Four-mile Island has become overgrown with small poplars, while it is evident that at no very distant period Six-mile Island formed two islands, which are now covered will full-sized trees, while the old channel between them now supports a growth of tall bushes. Further up the river, similar dry channels, more or less ancient, separate former islands from the main shores, and the appearances indicate that the conditions which once existed here, have been removed further down the river. It is said that about the beginning of the present century some vessels wintered in Ten-shilling Creek, which could not now approach its mouth, and an old sketch-map shews a channel connecting Haye's and Nelson Rivers which does not now exist. There is no evidence of the sea anywhere encroaching upon the land. On the contrary, the wide open border between the woods and the water indicates that the latter is retiring. On Beacon Point and the opposite side of Haye's River, in traversing this border from the sea inland, one meets first with sedges and grasses; next come bushes, then small trees, and finally, the full-sized timber of the country. There is much old drift-wood near the tree-line, which is now apparently never touched by the water. The Indians say that their old goose-hunting grounds along the coast to the northward of the mouth of the Nelson River are now deserted by the geese, the water having "dried up."

Subsidence of Hudson's Bay.

The country to the northward of Lake Winnipeg is emphatically a region of lakes. The general character of the district renders it possible for the rock-basins to occupy a large proportion of the whole area. The solidity of the fundamental rocks and the impervious nature of the clay combine to render permanent all the lakes which may have been

Region of lakes.

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* The phenomenon described would perhaps be more correctly stated as an elevation of the land. A. R. C. S.

formed during the later geological history of the region. Besides the larger lakes the mixture of land and water in some of the intervening tracts appears to be interminable. The origin of this condition is evidently owing to the glacial force having crossed at greater or less angles, the strike, cleavage or jointing of the rocks. The fact of the deep channel of the long straight stretch of the Nelson River between Sipi-wesk and Split Lakes having been scooped out along the course of a large dyke of decomposing dolerite, has already been noticed. The smaller lakes are generally not deep, and considerable areas of their shallower portions are covered with tall reeds growing from the bottom.

Origin of small lakes.

The glacial striæ are usually well-marked on the rock-surfaces in all parts of the region examined. The section of Hill River between Swampy Lake and Brassey Hill, in which small islands are so very numerous, appears to be an exception in this respect. In this part of the river the descent is unusually rapid, and the gneiss is much broken up into angular masses of all sizes in a manner not observed in any other locality. The general course of the striæ is southwestward, but it is often locally modified by the contour of the rocky surfaces in the neighborhood. The walls of the narrow ravine in the gneiss in which Franklin's River flows for seven miles before entering Pine Lake, are both horizontally striated. Gaps in the continuity of the walls are filled with drift, containing rounded boulders, numbers of which are also perched on the rocks on either side of the ravine. In some localities the glacial scratches cross each other at considerable angles. This is the case especially at The Rock in Hill River and on Sipi-wesk Lake. Wherever the rivers flow in rocky channels, these have apparently been excavated during the glacial period before the deposition of the softer deposits. The streams have sometimes cut down through a considerable depth of drift in order to follow a rocky channel lying beneath. A singular case of this kind occurs on the Nelson River above the Puck-wa-hagan, where both sides at the edge of the water consist of flat-bedded dolomite with banks of clay above it, and a comparatively deep river channel below the level of the dolomite of either side.

Intersecting striæ.

Old rock-channel.

List of glacial striæ.

The following list shews the directions of the glacial striæ in sixty-six localities scattered over the region explored. The bearings refer to the magnetic meridian. The variation around Lake Winnipeg averages about 15° E.; at Norway House it is 13° or 14° E., and at York Factory $5\frac{1}{2}$° E., diminishing between the last two places proportionately to the distance :

List of Glacial Striæ.

East Shore of Lake Winnipeg.

1. Rabbit Point	S. 33° W.
2. Pigeon Point	S. 40° W.
3. Point three miles south of Beren's River	S. 42° W.
4. Hudson's Bay Company's post at Beren's River	S. 45° W.
5. Lob-stick Island, near Beren's River	S. 42° W.
6. Point opposite George's Island	S. 15° W.
7. Four miles south-east of Poplar Point	S. 15° W.
8. Poplar Point	S. 20° W.
9. Shoal Island Point	S. 15° W.
10. Point opposite Spider Islands	S. 20° W.
11. Spider Islands	S. 25° W.

Along the Boat Route from Lake Winnipeg to Hudson's Bay.

12. Montreal Point, near outlet of Lake Winnipeg	S. 30° W.
13. Kettle Island, in outlet of Lake Winnipeg	S. 25° W.
14. Playgreen Point, Great Playgreen Lake	S. 40° W.
15. Channel between Great and Little Playgreen Lakes	S. 45° W.
16. One mile below outlet of Little Playgreen Lake	S. 30° W.
17. East Channel, Nelson River, between Pine River and Sea-river Falls	S. 40° W.
18. East Channel, Nelson River, three miles below Sea-river Falls	S. 45° W.
19. East Channel, Nelson River, below The High Rock	S. 45° W.
20. East Channel, Nelson River, two miles above Echimamish	S. 35° W.
21. Hairy Lake and for seven miles above it, S. 30° W. to	S. 45° W.
22. Echimamish, at the first dam	S. 30° W.
23. Echimamish, at the second dam	S. 20° W.
24. Echimamish, two miles west of junction of White-water River	S. 30° W.
25. Robinson Portage	S. 20° W.
26. Seven miles below Robinson Portage	S. 30° W.
27. Portage two miles above Pine Lake, runs with course of rocky defile, about	S. 20° W.
28. Outlet of Pine Lake	S. 45° W.
29. Outlet of Windy Lake	S. 35° W.
30. One mile above Wapinaipinis Rapids	S. 45° W.
31. Wapinaipinis Rapids, two miles above Oxford Lake	S. 35° W.
32. Island five miles south-west of The Doorway, Oxford Lake	S. 40° W.
33. One mile south-east of Oxford House	S. 35° W.
34. Little White-mud Rapid, between Oxford and Knee Lakes	S. 50° W.
35. South-west extremity of Knee Lake	S. 45° W.
36. Three miles north-east of south-west extremity of Knee Lake	S. 25° W.
37. Ten " " " " " " "	S. 30° W.
38. Fourteen miles " " " " " " "	S. 35° W.
39. Archipelago in north-and-south narrows about mid-way down Knee Lake	S. 40° W.

40. North-west shore of Knee Lake, six miles from the outlet... S. 50° W.
41. Outlet of Knee Lake.................................... S. 50° W.
42. One mile above White-mud Fall, Hill River............... S. 20° W.
43. Borwick's Fall, Hill River............................. S. 10° W.
44. The Rock, Hill River. Older set run N. 87° W. Newer set. S. 18° E.
45. Six miles below The Rock .... S. 20° E.

Along the Nelson River, from Great Playgreen Lake downwards.

46. In different places around the north-eastern extremity of Big-reed Lake.. S. 30° W.
47. Six miles south-east of Pipestone Lake.................. S. 40° W.
48. Four miles south-west of Pipestone Lake................. S. 30° W.
49. South shore of main body of Pipestone Lake.............. S. 25° W.
50. Outlet of Pipestone Lake................................ S. 40° W.
51. North-east point of (Indian) Reserve Island and smaller islands in Cross Lake .... S. 40° W.
52. From western outlet of Cross Lake to Pelican Falls........ S. 50° W.
53. Bladder Portage... S. 50° W.
54. Two miles below Bladder Portage......................... S. 50° W.
55. Two miles below Red-Rocks Portage .... S. 45° W.
56. South-west extremity of Sipi-wesk Lake.................. S. 50° W.
57. Islands four miles down Sipi-wesk Lake.................. S. 40° W.
58. Sipi-wesk Lake, twelve miles from south-west extremity, S. 45° W., and... S. 80° W.
59. Average course throughout south-western half of Sipi-wesk Lake, S. 40° W. to.................................. S. 45° W.
60. Current Narrows, five miles above outlet of Sipi-wesk Lake.. S. 60° W.
61. From outlet of Sipi-wesk Lake for seven miles down river, S. 55° W. to .... S. 60° W.
62. Mouth of Landing-lake River............................. S. 50° W.
63. Two miles above Stake-net River......................... S. 40° W.
64. Head of Devil's Rapid................................... S. 75° W.
65. One mile below Devil's Rapid............................ S. 40° W.
66. Mouth of Goose-hunting River............................ S. 75° W.

TIMBER, CLIMATE, &c.

Northern limit of twenty-two varieties of timber.

In going northward from the United States boundary at the Lake of the Woods by way of Winnipeg River and lake, the Nelson River, and the sea-coast northward of its mouth, the different species of trees which are found growing at the boundary line disappear in the following order:—Basswood, sugar maple, yellow birch, white ash, soft maple, grey elm, white and red pine, red oak, black ash, white cedar, serrated-leafed poplar, mountain ash, balsam fir, white birch, Banksian pine, balm of Gilead, aspen, tamarack, white and black spruce, willows. For information as to the region beyond the Nelson River, I am indebted to officers of the Hudson's Bay Company. The ash-leafed maple is only met with after reaching the prairie region, and disappears to the north-eastward between Lower Fort Garry and Lake Winnipeg. The dwarf variety of the red cedar extends widely over the prairie country, and is found on the shores of Lake Winnipeg. Outside of the general northern limit of any of these species of timber, straggling trees or small groves of a stunted variety are sometimes met with. The proper north-western limit of the white cedar is about the Winnipeg River, but small trees occur south side of Long Point, on the west shore of Lake Winnipeg, and the last of it is seen in the form of bushes around Cedar Lake, on the lower part of the Saskatchewan River. Small trees of red oak are found as far north as the English River for some distance above its junction with the Winnipeg, but stunted bushes belonging to this species extend to Beren's River. The red and white pine maintain a good size to the Winnipeg River, where they both cease rather abruptly in their northward range, and are not found to the westward. The general northward limit of the balsam fir is about the latitude of the Echimamish, but isolated bushes of it were found as far as Knee Lake. The white birch terminates about the junction of the Shamattawa and Steel Rivers, and the Banksian pine in nearly the same latitude. The poplar and the tamarack are said to disappear between the Nelson River and the lower part of the Churchill, while the black spruce is found for some distance beyond Seal River. White spruce of fair size for building purposes is found on the islands and flats along the lower part of the Nelson River. In going northward, there is of course a gradual diminution in the size of the trees and the height of the forest, as well as in the number of the species. Owing, however, to the fires which sweep over large tracts at different periods, it is seldom that one sees the full size to which the trees are capable of growing. A small area of the timber has been preserved on the west side of Ross' Island, where the West River enters Big-reed Lake, and here many of the white spruces measure three feet in diameter. Even the most rocky tracts support a growth of trees large enough to be of value for many purposes, should this great territory ever become inhabited by civilized men. The accompanying view of the Manasitchewan Fall (where the water is precipitated directly into the Nelson River in about latitude 55° 30′,) also shews the usual character of the forest in the more rocky parts of the region.

Forest fires.

View shewing character of forest.

The forests and the flora generally of the Nelson River region indicate a milder climate than that of the corresponding tract on the opposite side of Hudson's Bay. This appears to be at least partly due to the southerly winds which prevail in summer, bringing the warm air, probably from the valley of the Mississippi down that of the Red River and over the whole length of Lake Winnipeg, which has a high

Warm winds.

and even temperature during the summer months. This condition of things also prevents the occurrence of summer frosts in the Norway House region, which appears to enjoy a climate fully as good as that of the Province of Manitoba. Small fruits, cucumbers, musk-melons and vegetables of all kinds come to maturity at Norway House. Barley is a sure crop. Hitherto, as there has been no object to be gained in attempting the cultivation of wheat, the experiment does not appear to have been tried in this region; but there is every probability that it would succeed, as this cereal is known to come to great perfection in the Athabaska and Peace River region, in localities more than a thousand miles to the north-north-westward.

Crops at Norway House.

Warm water and climate.

Nelson River carries with it towards the sea the high temperature of Lake Winnipeg, derived partly from the rivers of the south and west. The effect of this is to induce a rank growth of reeds, rushes, and a variety of water plants in the clayey mud along its banks. The climate of this region is pleasant in summer, without an excess of rain, and in winter the weather, although cold, is said to be bright and uniform, with only a moderate amount of snow. The land would be easy to clear of timber; and, considering the unlimited supply of wood for building purposes, fuel, &c., the prevalence of good water, in which a variety of excellent food-fishes abound, as well as the greater proximity of this region to Europe, it offers some inducements to immigrants which are not to be met with in the greater part of the prairie country to the westward.

Abundance of food-fishes.

Crops at Oxford House.

At Oxford House, barley, peas, beans, root-crops, vegetables and hay thrive well, and the surrounding district might make a good dairy and stock-farming country. Even as far as York Factory, potatoes and some kinds of vegetables may be successfully cultivated. It is said that at a certain depth, the ground remains permanently frozen along Steel and Haye's Rivers and the lower part of the Nelson. There is certainly evidence of the existence of frost in the banks of these rivers and under the peaty layer above them in the month of July, but it is known that in southern parts of the Dominion the frost penetrates to a greater depth into the face of exposed banks than into the level ground, and is frequently found in such situations in the middle of summer. Ice or frozen ground may also be found in some swamps or under peaty ground throughout the summer in any of the provinces. Should it be found that the subsoil towards York Factory is permanently frozen (which is not improbable, although not proved) this circumstance would not render it entirely unfit for cultivation, since when cleared, it is known to be thawed during the summer to, at least, a sufficient depth for all practical purposes. In this region about twenty feet below the top of the bank there is a step a few feet

Frozen ground.

wide, the level of which is about the division between the drift and the overlying stratified deposits. From it a thin creamy mud trickles down the lower part of the bank, and this may be due either to the thawing out of frost in the top of the bank or to the surface-water flowing out at the contact of the impervious drift. The high banks are sometimes marked by small land-slides or mud-streams, which, starting from the top, run to the bottom, in a uniform groove, the same channel serving for successive flows of mud.

GEOLOGICAL SURVEY OF CANADA.

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

REPORT

ON THE

PRE-SILURIAN ROCKS

OF

ALBERT, EASTERN KINGS AND ST. JOHN COUNTIES,

SOUTHERN

NEW BRUNSWICK

1877-78

BY

R. W. ELLS, M.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:

DAWSON BROTHERS.

1879

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

Director of the Geological Survey of Canada.

SIR,—The present report embraces the work of the past two years, 1877-78, and relates principally to the area lying to the south of the great carboniferous belt which extends along the line of the Intercolonial Railway, westward from the Petitcodiac River, and between that railway and the coast of the Bay of Fundy; and while due attention has been paid to the tracing out of the boundaries of all the formations included in this area, a large portion of the time has been devoted to the determination of the structure of the great belt of metamorphic and other rocks which skirt the coast both east and west of the city of St. John, and which extend inland for eight to ten miles, forming a broad plateau, till it is overlapped by the Primordial and Lower Carboniferous formations of the interior. The area embraced in these two seasons' work may be roughly estimated at 2,500 square miles, in which were measured, principally with odometer and chain, some 1,600 miles of roads, while additional surveys of coast lines and streams were filled in by pacing. These surveys include a topographical traverse of the Kennebecasis Bay from Hampton to the St. John River, with its islands, and of the Belleisle Bay. In my work of 1877, I was assisted by Mr. Frank Adams, at that time a student of the McGill Science School, and in 1878 by Mr. Wallace Broad, B.A., both of whom proved themselves well-fitted for the work assigned them and possessed of a good knowledge of topographical and geological details. Our thanks are specially due to the Crown Lands Department of New Brunswick for the use of their valuable odometer, which they have kindly furnished us for the past five years, as also for assistance in the making of tracings, and for copies of their Provincial Map.

I am, sir,

Your obedient servant,

R. W. ELLS.

MONTREAL, December, 1878.

REPORT

ON THE

PRE-SILURIAN ROCKS

OF

ALBERT, EASTERN KINGS AND ST. JOHN COUNTIES,

SOUTHERN NEW BRUNSWICK,

BY

R. W. ELLS, M.A.

The formations described in the following Report, included in the work of the past two seasons, may be enumerated as under:

Subdivisions of the rocks.

1. Pre-Silurian (Huronian and Laurentian).
2. Primordial (Lower Silurian).
3. Upper Silurian.
4. Devonian.
5. Lower Carboniferous.
6. Millstone-Grit.

The principal formation in the area examined, as before stated, is a vast belt of metamorphic and other rocks, for the most part highly crystalline. Reference was briefly made to this series in the Report of 1876-77, on the Lower Carboniferous of Albert County, in which their origin was provisionally assigned to the Huronian, but no attempt was then made to exactly define their limits or characteristics. They border the coast of Albert and St. John counties from the mouth of Point Wolf River on the east to Melvin's Beach, about five miles east of Quaco, in St. John County, on the west, and extend inland to a distance of twelve to fifteen miles, forming a high plateau, with a general elevation of from 1,200 to 1,400 feet above sea level, flanked at both extremities by Lower Carboniferous conglomerates. On its

Extension of the pre-Siluria

northern flank it is also frequently overlapped by Lower Carboniferous sediments, which occupy the valley of the Kennebecasis River, and which also occur in valleys of erosion among the hills of the metamorphic belt itself. In its westward extension a belt of Primordial Lower Silurian intervenes between it and the Lower Carboniferous. The coast line is exceedingly rough, lacking good harbors, but broken by numerous streams, large and small. These have cut out deep channels, the banks of which often rise abruptly from 400 to 600 feet. The streams themselves are usually very rapid and broken by numerous falls, which render their exploration a work of great difficulty and danger. Throughout a great part of the area occupied by these rocks, no settlements exist, roads are almost entirely wanting, and a dense forest spreads over the country, making the working out of the detailed structure exceedingly difficult. Exploration along the coast is also rendered dangerous from the tremendous tides of the Bay of Fundy, which rise often to a height of fifty to sixty feet, and whose movements have to be carefully watched in order to avoid almost certain destruction.

Character of the coast.

The geology of the pre-Silurian rocks of this portion of New Brunswick has been for a long time a fruitful source of discussion. In the first reports * on this group, its age was assigned by Prof's. Hartt and Bailey and Mr. Matthew, on lithological and stratigraphical grounds, to the Little River group of the Devonian.† Subsequent and more carefully conducted observations shewed the fallacy of this conclusion, and it was then placed in the Huronian, ‡ and subdivided into three groups—Coldbrook, Coastal, and Kingston. In this report it was also intimated that a portion of the series in Albert County, in its lithological character, bore a strong resemblance to rocks of Laurentian age in St. John County. These points of resemblance consist chiefly in the occurrence of bands of protogene or greenish syenite and gneiss, with which also occur beds of crystalline, graphitic and other limestones. They differ, however, from the typical Laurentian about St. John, in the presence of large masses of red crystalline felsite and felspathic, talcose and chloritic schists and slates. In these features, as well as in the relation of the limestones to the felsites and other rocks, they bear a marked likeness to the crystalline series of Southern Cape Breton § as well as to the so-called Hastings group of Ontario, their lithological aspects being almost identical.

Former views as to its age.

Supposed Laurentian.

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* Report by Prof. Bailey to the New Brunswick Government, 1865.

† Report by Prof Hind, 1865.

‡ Geological Survey Report, Bailey and Matthew, 1870-71.

§ Geological Survey Report, Fletcher, 1876-78.

The geological structure of the pre-Silurian rocks of Southern New Brunswick, south of the central coal-field of the Province, may be stated as disclosing a series of anticlinal axes, of which three exist in the southern belt of St. John, Kings and Albert counties. These anticlinals have a course N. 65° E. magnetic, generally parallel to the coast and to each other; the intervening synclines are filled in with Primordial and Upper Silurian beds, which are, however, in many places obscured by the great mantle of Lower Carboniferous sediments of the Kennebecasis Valley.

Anticlinal structure of the pre-Silurian rocks.

A map shewing the arrangement and distribution of all the formations from the Laurentian to the Carboniferous, both inclusive, has been constructed on a scale of one mile to an inch; in which all the surveys extending over a period of six years, and embracing the counties of Queens, Sunbury, Kings, St. John and Albert, with portions of Charlotte, York and Westmoreland, have been carefully laid down on a projection: and the characters of all the rocks, with dips and strikes, inserted, thus furnishing a complete geological sketch of the entire southern part of New Brunswick east of Charlotte County. This map, reduced to a scale of four miles to the inch, is herewith submitted. The number of miles of roads and streams surveyed for its construction is over 3,500, principally with odometer and chain.

Map.

In their lithological aspect, the rocks forming the southern metamorphic belt present great diversity. Their general character is of two kinds, altered sedimentary and volcanic. In the former we propose to class the great belt of protogene or metamorphic syenites, with their associated gneisses, micaceous, talcose, chloritic and other schists and slates, the true felsites and conglomerates, crystalline limestones and dolomites. In the second we include the great body of petrosilicious rocks so-called, with breccias and other ash rocks, which in places shew bedding, but which is often so obscurely marked as to be exceedingly doubtful; with these also occur huge masses of diorite, coarse and fine, often filled with magnetic iron, and true syenites and granites. These latter are common to both divisions. Of these two groups, the altered sedimentary is the more extensively developed in the eastern or Albert County area, while the second group has its greatest development in the counties of St. John and Kings. Near the contact of the two groups of sedimentary and volcanic rocks, we find an extraordinary development of generally coarsely crystalline diorites and syenites, which would seem to form the basal portions of the volcanic part of the series, and to separate them often from the metamorphic well-banded felsites and gneisses which seem to form the upper part of the older sedimentary rocks. The great bulk of the

Lithological characters.

Volcanic rocks.

syenites (protogene) of the first or sedimentary group are evidently metamorphic, for in many places a gradual transition can be traced from the green slates through schists, felsites and gneisses to the syenites. Intrusive dykes of diorite, syenite and granite occur, however, though their bulk is small as compared with those of metamorphic character.

First anticlinal.

Of the three anticlinals that are met with in this southern area, the first, or most southerly, may be traced from its first appearance beneath the overlying beds of Crooked Creek valley, in eastern Albert, westward through the southern portion of the country. It can be seen on the eastern part of the Shepody Road, where that thoroughfare bends to descend the mountain to the north-west of Hopewell Corner, and forms the steep descent of the mountain to Shepody. Westwardly, it is met with on the Upper Salmon River about three miles below the Shepody Road, whence it can be traced through high hills to the Kings County Line, crossing the Bennett Road, which runs from the Shepody Road to the mouth of the Upper Salmon River, about midway, where the syenites and gneisses have an extension of about three miles southerly. It is again met with on the Goose River in St. John County, about two miles from its mouth, whence it gradually approaches the coast, coming out below Martin's Head. The second extends from Caledonia Mountain westward through Goulden Mountain, whence it sweeps south-westerly through the southern part of the Mechanic Settlement, and strikes the Shepody Road just beyond the Kings County Line, extending along this road some eight miles. Its further extension west can be seen on the Big Salmon River, about four miles from its mouth, beyond which it is obscured by more recent beds. In the examination of the country under discussion, numerous traverses were made across its entire breadth and its structure carefully ascertained. One of these, from the mouth of the Upper Salmon River to Elgin Corner, affords a good exposure of rocks for the whole distance, the order of succession of which may be stated as follows:—

Second anticlinal.

Section.

1. Rubbly hard green slates and epidotic and fine diorites, the slates having a regular dip of S. 35° W. to S.< 50°. These are associated with bands of talcose and chloritic schists, felspathic, passing in places into a gneiss, and thence into a syenite rock composed of quartz, and felspar, and some green mineral, probably talc or chlorite. These rocks form the southern side of the coast anticlinal axis, which extends in a direct line N. 65° E.

2. Hard, reddish-grey weathering syenitic rock, as above, sometimes a granite, from the presence of mica. Associated with the syenites are often seen bands of reddish felsite, fine-grained, often well-bedded, but sometimes with the stratification indistinct. This belt occupies a breadth of nearly four miles, and forms the central portion of the anticlinal axis. This is succeeded on its northern side by—

3. White weathering schistose imperfect gneiss, having a reddish tinge from the presence of red felspar, and a green tinge from the presence of chlorite or talc, shading off into—

4. Green schistose felspathic rock, sometimes talcoid, and forming a regular talco-felspathic schist; at times also shewing, by the presence of grains of quartz and felspar, a gradual passage into gneissoid beds. Associated with these are frequent masses of diorite, some of which appear bedded, others lacking apparent stratification, and generally fine-grained, green, and hard; in places mottled and seamed with fine lines and patches of yellowish epidote. The schistose and gneissoid beds extend to the Shepody Road, which has a general course of east magnetic, along which, for nearly the whole distance from the Kings County Line, this set of beds often crumpled and glossy, is well exposed, with a general dip N. 50° W. $<$ 50°. Near the base of this group are found also thin bands of cream-colored, rusty weathering dolomite. Crossing the Shepody Road, we find a succession of these talcose and chloritic schists for two and a-half miles, with a uniform dip N. 25°–30° W. $<$ 50°, with included bands of fine nacreous schists, and apparently overlaid by—

5. Gneiss similar to that of (3) above; reddish-grey and chloritic, and with the same dip. Division 4 would, therefore, seem to occupy the axis of a synclinal basin; the gneissic rocks of Division 3 being brought into their present position by an overturn of the beds of the second anticlinal. These are again apparently overlaid by—

6. Chloritic syenites with bands of felsite similar to those of Division 2. With the syenites and schists are associated massive outcrops of coarsely crystalline diorites, magnetic and often very hornblendic. The syenites and diorites of this group extend along the whole length of the Mechanic Settlement road to the Kings County Line, whence they extend south-west, forming a second anticlinal. North of this road, the road to Elgin keeps close along the Pollet River, almost directly across the strike of the beds, and shews a succession of felspathic, chloritic and syenitic rocks, which rise into lofty hills on either side, one of which, Goulden Mountain, has an elevation of 850 feet above Elgin Corner. These syenitic and associated rocks are flanked on their northern side, about Elgin, by the green chloritic rocks, similar to those seen on the coast (Division 1); but in their eastward extension at Pleasant Valley, six miles east of Elgin Corner, the slates are not seen, the felsites and syenites of the mountain being overlaid by a thin band of green slate conglomerate directly associated with a belt of crystalline limestone, often graphitic, and bearing much resemblance to some of the Laurentian limestones about St. John. These limestones are exposed for a length of about a mile, with a breadth of from 50 to 100 feet, when they are overlapped by the basal beds of the Lower Carboniferous formations, described in Report of 1876-77. The general dip of all the beds of Divisions 2, 3, 4, 5 and 6 is N. to N. 50° W. $<$ 50°–70°.

It will be seen on reviewing the preceding section, that with the exception of the southern or coast division, the whole series has a uniform northerly to north-west dip at angles ranging from forty to seventy, generally about fifty-five. This, with a surface breadth of

Approximate thickness.

fourteen miles, would give a thickness of not far from 40,000 feet. Assuming however, that the two ridges of syenite rock, with their associated gneisses and felsites, are of the same horizon brought up into their apparent position by folding, we reduce this immense thickness to about 14,000 feet. The apparent conformity in dips throughout the whole extent, would therefore be due to an overturn of the beds of the second anticlinal, whereby the lower beds are brought into an overlying position; the summits of the anticlinals being removed by denudation.

The eastern extension of this range of metamorphic rocks terminates abruptly in bold hills at the Albert Mines, and overlooks the Valley of the Demoiselle Creek further south, where they are lapped around by Lower Carboniferous sediments. To the east of this in Westmorland County, the surface is covered by carboniferous rocks, chiefly of Millstone-grit age. At two places, however, we find bosses of the old metamorphic range obtruding themselves. Of these one may be noticed on the road from Memramcook Corner to Upper Sackville at Beach Hill,* where reddish altered grits and breccias occur with boulders of quartz rock, covered over by a thin mantle of Millstone-grit drift. These old rocks contain copper, and, from their resemblance to the rocks of the coast, mark probably the prolongation of the metalliferous belt in this direction. The second outcrop, which may, however, be an extension of one of the more northerly anticlinals, is seen a few miles north of Moncton, between Indian and Lute's mountains. Here reddish and flesh-colored crystalline felsites are seen, similar in character to those just described, and to those of the Kingston belt, of which they are probably the extension. In addition to these two localities, an outcrop of granite and syenite is met with on the Intercolonial Railway, just below Calhoun's Mills, about four miles north of Memramcook Station, but this may be intrusive and of later date. It is, however, pre-Carboniferous, as conglomerates, largely composed of its debris, form the basal beds of the Lower Carboniferous at this place.

Outcrops of pre-Silurian rocks.

Granite outcrop.

Change in strike.

A noticeable feature in the strike of the metamorphic rocks is seen as their eastern extremity is approached; the regular strike of N. 65° E. sweeping gradually round to E. and S.E., the dip, however, remaining northerly at the regular angles.

In the many traverses made across the breadth of Albert County and southern Kings, the same general characters previously described are seen, and the synclinal structure of the central portion of the area is clearly discernible. This synclinal can be traced westward from Albert County, where it is easily seen, along the line of the Shepody Road, in a

* Bailey's Report to New Brunswick Government, 1865.

Synclinal in eastern Kings and St. John counties.

regular course through the northern part of St. John County and southern Kings. It is well-marked on the Little Salmon River, in St. John County, as also on the Big Salmon River to the west, where rocks of a less altered character than those of the old ridges of Albert County are observed to fill a synclinal valley bounded by gneissic and syenitic rocks. This synclinal structure was first observed and described by Mr. G. F. Matthew.* These rocks consist largely of grey and purple grits and slates, with large bands of purple conglomerate, composed of generally white quartz pebbles in a gritty paste, together with thin, fine, shining argillites and felspathic conglomerates. They would seem to form the upper beds of the metamorphic series, as they overlie both the petrosiliceous beds in the western portion and the altered felspathic schists to the east. A section was made across this belt from the Shepody Road to the mouth of the Little Salmon River, and the following succession of rocks was passed over:—

Section from Shepody Road to mouth of Little Salmon River.

Hard greenish felsites with syenite veins, rock at times approaching a syenite or granulite.

Reddish protogene syenite.

Schistose gneissoid felsites and syenitic gneiss.

These may represent the southern side of the second anticlinal.

Space without exposures for 1,000 paces.

Fine fissile black slates, much crumpled,—N. 40° W. < 60°—occupying the synclinal basin of Little Salmon River.

Reddish crystalline felsites and reddish talco-felspathic schists, dip N.W. < 75°.

Purple, dark, crumpled micaceous grits, N. 10° E. 70°.

Fine fissile purplish-red slates, thin and crumpled, N. 60° W. < 70-90.

Mottled purple and green non-crystalline grits, or recomposed ash rock.

Felspathic schists.

Red felsites, with green, earthy slaty rocks and hard, green slates.

Red felsites, N. 60° E. < 30°.

Purple felsites and purple-colored schists.

Reddish felspathic rocks, schistose and well-banded.

Purple-grey rocks, slaty and schistose, S. 30° E. < 35°.

Green and purple schists and slaty rocks forming crest of hill overlooking mouth of Little Salmon River.

Fine black slates and purple felspathic grits, probably a repetition of those noted above.

Dark schistose slates to bottom of hill.

Thence to the mouth of the river or coast, we pass over a series of felspathic and chloritic beds, including bands of nacreous schists, and cut by large masses of diorite, the schists dipping N. 20° W. < 50°.

Big Salmon River.

Going west about eight miles, another traverse was made on the Big Salmon River from its mouth to the contact of the granite, about half

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* Geological Survey Report, 1870-71, page 99.

a mile above the Forks. The rocks along the shore as we enter the river are purple felspathic slates, dip S.E. < 60°, which, 100 yards further, become green and chloritic, the dip remaining the same.

Associated with these beds are bright-green chloritic slaty schists cut by dykes of hard, rusty, green diorite, reddish-dark crystalline felsite with quartz veins, bright-green talco-felspathic schists and purple grits and fine conglomerates. An anticlinal structure is apparent in these beds, by which the regular dip of S.E < 50° changes to N. 20° W. < 50, and the rocks become much twisted and faulted along the line of anticlinal. Going up the river, we pass over nacreous schists and green slate conglomerates and large masses of reddish crystalline felsites, well-banded, the whole dipping regularly N. 60°–90°, but with evidence of several breaks. These extend up to the Forks, above which, on the east or main stream, we find large ledges of petrosilex; breccias and concretionary felsites lying on the southern side of a syenitic ridge, with an apparent south dip. On the North-west Branch, a ridge of syenites and petrosiliceous felsites extends northward to near the northern limit of the pre-Silurian rocks on the Hammond River, where they are overlaid by green talcose mica schists. Dip, N.W. < 70°.

Vaughan's Creek.

The most westerly section made by us on this belt was on Vaughan's Creek, which enters the Bay of Fundy at the eastern limit of Quaco Village. On this stream, after passing the outline of Lower Carboniferous rock which extends up about one mile, with a dip at its northern limit of S. 20° E. < 20, proving the basin character of this deposit, we come to hard crystalline felsites, well-banded, dip, S. 15° E. < 90°. Above this, for nearly a mile, we have soft reddish and purple grits and fine conglomerates, cut by numerous small quartz veins, forming a synclinal trough; the dips on the southern side being N. 25° W. < 65°, and on the northern S. 30° E. < 45°–80°, where they come in contact with beds of hard, flinty felsites, porphyritic and brecciated, dip, S. 30° E. < 60°. Thence, up the stream, we have a succession of felsites, talcose schists and ash rocks, with conglomerates, thrown into a series of folds, the same beds as are well-exposed on the road south from Hammond River to Quaco Village.* To the east, the whole coast from Point Wolf to Quaco was carefully examined, and several traverses were made up the streams, on all of which rocks resembling those lately described were found. Along a great part of the coast the beds on the shore have a seaward dip, generally S. 10° E. < 40°–60°, though in many places they are disturbed by areas of intrusive diorites and felsites. At Martin's Head, an outlying island about midway between Point Wolf

Point Wolf to Quaco.

* See accompanying Report by Prof. Bailey.

and Quaco, the beds of this series have a dip north-west which may be the north side of another parallel anticlinal, or may be due to the eruption of a large mass of epidotic diorites which occupy the seaward side of the head.

Reference has been made briefly to the two descriptions of rocks comprised in the area under discussion, viz., sedimentary and volcanic, the difference in whose characters has in former reports led to a division of the formation into two groups—Coldbrook and Coastal. The eastern portion of the metamorphic belt, although containing in places dioritic and other volcanic rocks, of limited extent, is occupied principally by the metamorphic sedimentary beds described on page 3D; but as we go westward into Kings County, we find these just at the Mechanic Settlement post-office, a short distance west of the County Line, associated with the great bulk of coarsely crystalline diorites that extend to and beyond the Pollet River eastward, in Albert County, along with the series of hard, flinty-silico felspathic beds, styled, in this and other reports, petrosilex, which in places graduate into breccias and other ash-looking rocks. The characters of this group are well described under the head of Coldbrook Huronian.† Their position in relation to the sedimentary portion has been subject of discussion, but they are probably portions of one and the same series, and are flanked by schistose, felspathic and micaceous beds and green slates similar to those seen in the central synclinal basin. In this volcanic group of rocks, bedding though sometimes discernible in the felsites is for the most part very obscure, and apparent dips are very variable. They extend westward from the Mechanic Settlement towards St. John, forming a portion of the high ridge in the rear of Quaco, and flanked on their northern exposures by mica schists. They apparently thin out in their eastward extension, being overlaid by the upper and schistose portions of the group. Their distribution has been described in the accompanying Report by Prof. Bailey.

Division of the group.

Relations of the volcanic portion to the sedimentary.

The third anticlinal axis may be represented by the so-called Laurentian of St. John and vicinity. This formation has been well described as to its characters in the Report of Progress,‡ but its limits have been more accurately determined during the past season. It extends in an unbroken but gradually narrowing belt eastward from St. John City to a point on the Hammond River, about four miles south of Hampton Station, appearing again, however, a few miles east, and forming a portion of a ridge, in which it is exposed for a distance of nearly eight miles, with an average breadth of one-fourth of a mile. The rocks of this outcrop

Third anticlinal axis.

† Geological Survey Report, 1870-71.

‡ Geological Survey, 1870-71, Bailey and Matthew.

are the usual greenish syenites and felsitic rocks, with crystalline limestones similar to those further west about St. John. The further prolongation of this so-called Laurentian ridge is covered over by Lower Carboniferous beds, which extend thence over the greater part of the country eastward, but its strike would carry it parallel to the main metamorphic belt to the south, and would render probable the supposition that the older portion of the rocks of Albert County represented by the felsites, gneisses, syenites and crystalline limestones, south and east of Elgin Corner and in Pleasant Valley, are the equivalents in point of age with the so-called Laurentian limestones of St. John. It may be mentioned, however, that in the Report of 1870-71, the authors do not definitely assign the limestones of St. John to the Laurentian formation, but merely compare them with limestones of supposed Upper Laurentian age of Western Canada; and if of Laurentian age, they are certainly the upper member of that formation.

Extension of the so-called Laurentian of St. John.

We would then sum up the structure of the southern metamorphic belt of Albert, Eastern Kings and St. John counties thus—

Conclusions.

1. An older portion represented by the syenites, hard felsites and felspathic quartzites and limestones of the anticlinal ridge south of Elgin and Pleasant Valley, and partially represented in the southern ridge south of the Shepody Road.

2. A newer and overlying series, consisting of felsitic, siliceous, brecciated and ash rocks at the base, with talcose, chloritic and other schists, ash rocks, and purple grits and conglomerates. Subdivided by Prof. Bailey into Divisions 3 and 4. These lie unconformably upon the rocks of No. 1 in Albert and Eastern Kings, as well as upon their supposed equivalents about St. John, and east. They occupy the synclinal basin seen on the Shepody Road, in Albert County, and westward on the Big and Little Salmon rivers and Vaughan's Creek, and form the greater part of the coast from Point Wolf to Melvin's Beach.

3. Primordial Lower Silurian, resting generally upon the upper portion of No. 2.

Eastward extension of the pre-Silurian rocks of Kingston Peninsula.

Crossing the valley of the Kennebecasis Bay and River, which is largely filled in with deposits of Primordial and Lower Carboniferous age, we come to the Kingston Peninsula. The rocks of this area form the subject of Mr. G. F. Matthew's accompanying report. They are concealed from view a short distance east of the road from Bloomfield Station on the Intercolonial Railway to the head of Belleisle Bay, by Lower Carboniferous beds. They have, however, been recognized in their extension eastward in a series of hills known as Jordan's and White's Mountains, where they appear from beneath the mantle of Lower Carboniferous conglomerates, as well as farther east in Westmoreland County, about seven miles north of Moncton, where they form a limited area at Lute's and Indian Mountains. Westward from the Kingston Peninsula these rocks can be traced into Charlotte County as far as our observations of the past season extended, to the New River.*

On the north side of the Belleisle Bay also, rocks similar in character to those described are seen in extension of the pre-Silurian ridge north of the Long Reach of the St. John River, being continued across that river through Rocky and Foster's Islands and the extremity of Oak Point. They occupy the greater portion of the northern side of Belleisle Bay, and extend eastward to Snyder and Kierstead Mountains, beyond which they are concealed from view by deposits of Lower Carboniferous and Millstone-grit age. At several points these rocks are seen to be overlaid by beds of dark grey slates which resemble in character some of those of Primordial age, but no fossils were recognized. Further north, along the county line of Kings and Queens, another ridge of Huronian looking rocks, petrosilex, breccias and schists with epidotic and chloritic beds was seen extending from the south-western part of Queens in a broken outline surrounded by Upper Silurian beds to the vicinity of Goshen Settlement, about twenty-four miles east of the St. John River. The separation of the rocks of this belt from the Upper Silurian is very difficult, but it seems probable from the unconformable attitude of the two sets of beds that a portion at least are pre-Silurian in point of age. The characters of these rocks have been well described in Report of Progress, 1870-71. Country north of Belleisle Bay.

Economic Minerals.

The principal minerals of economic value, contained in the rocks of southern New Brunswick, are copper and manganese ores. Of these the latter are confined almost entirely to the Lower Carboniferous beds which, as a general thing, are found overlapping the pre-Silurian belt, lately described. It is worthy of note, that in nearly every case of its occurrence in both Kings and Albert Counties, the principal deposits of manganese are found near the contact of these two formations, as at Shepody Mountain in Albert County, and Markhamville in Kings. Indications of this mineral in the shape of large blocks, evidently not far from the vein, were seen also near the contact of Lower Carboniferous and pre-Silurian rocks at Hillside P. O., Little River Valley, Albert County, south of Elgin Corner; but the extent of the deposit has not yet been traced, nor its value proved. Among other localities for manganese in this county may be mentioned the line of fault along Manganese.

* See Geological Survey Report, G. F. Matthew, 1876-77,

the road to Germantown, just north of the Shepody River and about one mile west of Hopewell Corner, at the contact of Lower Carboniferous and Millstone-grit beds. At the eastern part of Salisbury Bay, near Cape Enrage, a deposit was found near the contact of the Triassic and Millstone-grit. Bog manganese or wad is occasionally met with, but the deposits seen were of little or no practical value.

Copper. *Copper* ores are found at many localities throughout the whole extent of the pre-Silurian formation of the southern part of New Brunswick, but in every known case their attempted development has resulted in failure. They are generally found in quartz veins traversing schists and slates, associated with dioritic rocks, though at times they occur in bands of felsite. The principal localities have been designated in the Report of the Geological Survey, 1870-71, pages 225-27. Operations in these localities are now entirely suspended, from a lack of continuity of the veins as well as from a scarcity of the ore itself. Much of the country, however, is so inaccessible from the unbroken character of the forest, that it is quite possible some localities may yet be found more favourable for profitable returns, as traces of the ore are met with in every direction. In the overlying Lower Carboniferous conglomerates made up from the débris of the older rocks, numerous traces of copper are seen, as also in the lower beds of the Millstone-grit. One locality which has excited considerable attention during the last three years is about two and a-half miles north-east from Dorchester, in Westmorland County, where a deposit of the green carbonate is found with fossil plants of the Millstone-grit age. At this place the plant stems are turned to coal which is impregnated with the carbonate. No regular vein exists, and the deposit is near the contact of the Lower Carboniferous red marls and the grey sandstones of the Millstone-grit. Explorations have been carried on at intervals for the last two years, and considerable money spent, but no satisfactory results are likely to be obtained. No new developments have been made in this industry since 1870, and nothing more need be said, other than is contained in preceding reports.

Tin. *Tin.* The band of coarse dioritic rocks on the Pollet River, four miles south of Elgin Corner, were in 1876 reported to contain a large percentage of tin; according to one reported analysis as much as thirteen per cent. Specimens were obtained from the most promising localities, and assays made in the Geological Survey laboratory. The results were published in Report 1876-7. No trace of tin was detected.

Gold. *Gold* has been reported as occurring at several points in the metamorphic rocks of Albert County but no reliable data could be obtained. Specimens of supposed gold examined, in nearly every case proved to be iron pyrites. Many of the quartz veins, however, show traces of galena and resemble those of the auriferous area of Nova Scotia, and the occurrence of visible gold in the quartz pebbles of the Carboniferous conglomerates of the coast would lead to the inference that diligent search may yet be rewarded, although washings made at several points did not disclose any traces of gold.

GEOLOGICAL SURVEY OF CANADA.

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

REPORT

ON THE

PRE-SILURIAN (HURONIAN) AND CAMBRIAN, OR PRIMORDIAL SILURIAN ROCKS

OF SOUTHERN

NEW BRUNSWICK

1877-1878

BY

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PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:
DAWSON BROTHERS.

1879

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

Director of the Geological Survey of Canada.

SIR,—I beg to submit herewith my report of geological explorations during the two past summers in southern New Brunswick.

In carrying out the instructions which I received from yourself in the spring of 1877, to endeavor to determine more exactly the limits of the belts of Primordial rocks, described in previous reports as extending to the eastward from the city of St. John, it was found necessary to make a careful re-examination of the associated strata. On this account the field of exploration has been unavoidably extended to all the older rock-formations of the area in question. Though involving an additional expenditure of time, this course was deemed desirable because strata bearing much resemblance to some of those which in St. John County underlie the Primordial, have in other parts of the Province been found to occur under circumstances which leave some doubt as to their true position and equivalency. The results thus obtained are such as to substantiate, with but slight modifications, the views advanced in the preliminary report of 1871.

The district to which this report relates lies wholly to the eastward of the St. John River, embracing a considerable portion of the parishes of Simonds and St. Martin's, in the county of St. John, and portions of Upham and Hammond, in the county of King's. To the eastward it is continuous, with a similar area extending into the county of Albert, in which direction simultaneous but independent observations have been made by Mr. R. W. Ells. This gentleman has, at my request, also visited portions of the field explored by me, making an odometric survey of the more important roads, and I am indebted to him for the reduction of the topographical results embodied in the accompanying map. With this exception, the greater part of the topographical work, both in the field and subsequently, was performed by Mr. Wallace Broad, my assistant during the season of 1877.

I am, Sir,

Your obedient servant,

L. W. BAILEY.

REPORT

ON THE

PRE-SILURIAN (HURONIAN) AND CAMBRIAN, OR PRIMORDIAL SILURIAN ROCKS

OF

SOUTHERN NEW BRUNSWICK,

BY

L. W. BAILEY, M.A., PH. D.,

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In attempting to determine more definitely the relations of the several sets of strata in the region examined, more than the usual difficulties have been experienced, as apart from the fact that it is but sparsely settled and over large areas covered with forest, the rocks themselves are of such a nature as greatly to enhance the labor of their examination. Largely made up of volcanic and semi-volcanic materials and of coarse fragmental deposits, they are exceedingly variable in distribution and bulk as well as in color, while through large masses it is often difficult or impossible to detect even a trace of bedding. To this it may be added that the dips, even when recognizable, are frequently, even within short distances, of a most discordant character, apparently indicating, as do the sediments themselves, that they were formed during a period of general disturbance and in the presence of wide-spread and frequent volcanic activity. The region is also throughout highly disturbed, with numerous faults and plications, and includes several large areas of intrusive rocks. Under these circumstances, no attempt has been made to determine definitely the thickness of the several groups, but only to fix their order of succession and distribution. It having further appeared probable, as the result of recent investigations, that some at least of these groups, as distinguished in former publications, actually form a continuous series, while their names have come to be applied to a variety of rocks not originally included under them, it has been thought best in the present report to drop such designations altogether, substituting for sub-divisions of systems a numerical and lithological nomenclature.

In accordance with these views, the entire series of rocks in the region examined may be tabulated as follows, in ascending order:—

Pre-Silurian,—

Division 1.—Syenitic, felspathic and gneissic rocks.

Division 2.—Limestones and dolomites (with serpentine) mica schist, quartzite and dark grey graphitic slates.

[The above divisions are those which in earlier reports have been described as probably Laurentian.]

Division 3.—Felsite-petrosilex group.

(*a*) Red and grey felsites; blue, grey, reddish and black petrosilex and breccia-conglomerate.

(*b*) Dioritic and amygdaloidal ash-rocks and ash-conglomerates.

(*c*) Grey felspathic sandstones and conglomerates, often ferruginous.

[The rocks in this division are those described in earlier reports under the name of Coldbrook group. They are regarded as a lower member of the Huronian system.]

Division 4.—Schistose, chloritic and micaceous group.

(*a*) Chloritic schists, green, grey and purple ash-rocks and amygdaloids, with purple conglomerate.

(*b*) Pale grey, pyritous and rusty-weathering felsites and felspathic quartzite.

(*c*) Hydro-mica schists, chloritic schists and felsites; grey clay-slates and purple conglomerates, with beds of hematite.

[The rocks of this division are those described in earlier reports under the name of Coastal group. They are regarded as the upper member of the Huronian system.]

Cambrian or Primordial Silurian—

(*a*) Purple conglomerates, sandstones and shales.

(*b*) Red and greenish-grey argillites, spangled with mica.

(*c*) White and grey sandstones; grey and dark grey shales and sandstones, with fossils; grey slate and flags.

Devonian.

Lower Carboniferous.

Millstone-grit.

Trias, or New Red Sandstone.

Besides the lithological differences indicated above in the pre-Silurian rocks, evidence of more or less pronounced unconformability may be traced between the several divisions, marking a corresponding number of physical breaks.*

* Some of the apparent want of conformity may be due to subsequent faulting.—A. R. C. S.

In the present report the only groups particularly considered are the pre-Silurian, Divisions 3 and 4, together with the Cambrian or Primordial Silurian.

1.—Pre-Silurian.

Division 3—Felsite and Petrosilex Group.

Under the designation of the Coldbrook group a general description of the rocks of this division was given in the Report of Progress for 1870. The distribntion of these pre-Silurian rocks, as more particularly determined during the past season, is indicated in the accompanying map. It should, however, be stated that over portions of the area therein assigned to Division 3, masses of coarse conglomerate or of schistose strata are occasionally met with, which, from their attitude or composition, would appear to be of more recent origin. Coarsely crystalline syenites are also met with at a number of points and sometimes cover considerable areas, but as their limits are usually ill-defined and they appear to graduate insensibly into the surrounding rocks, no attempt has been made to effect their separate delineation.

The rocks which appear to be the lowest in position, as well as the most highly crystalline within the region under discussion, consist of fine-grained felsites of pale flesh-red and grey colors, of a more or less distinctly stratified character. At various points they may be seen to merge into dark grey petrosilex and felsite-breccias, and at others into compact and unstratified felspar-rock, which by the addition of grains of quartz and of a greenish mineral resembling hornblende, becomes an imperfect syenite. It is chiefly among the felsite rocks that the masses of true syenite referred to in the preceding paragraph are met with, as well as others of coarsely crystalline diorite. Some of these syenitic and dioritic rocks appear to be intrusive, but in the occurrence of rounded grains of quartz, as well as in the appearances they present on weathered surfaces, other portions suggest the idea that they are altered sediments. More particular reference will, however, hereafter be made to some of the larger and better defined areas of syenite rock in the region examined. The relations of these different groups of beds is most intricate and variable, and in general their separation is quite impossible.

Felsites.

Syenite.

In either of the two bands of Huronian sediments to which reference has been made, the most abundant as it is the most conspicuous rock is that which I have designated petrosilex. Though largely composed of felspar, as shown by the character of the weathering, it differs from ordinary felsites in being much harder, ringing under the hammer, breaking with an irregular or conchoidal fracture, and being much less

Petrosilex.

readily affected by eroding and atmospheric agencies. In color it is usually dark bluish-grey, weathering pale-grey or white, but exhibits also various other shades, as pale flesh-red, lilac and green, to black. It is also usually porphyritic, with minute felspathic crystals of a paler color. But perhaps its most noticeable feature is its extreme fineness of texture, bearing in this respect much resemblance to ordinary flint. Notwithstanding this apparent fineness, a larger proportion, if not the whole, of the rock is in reality a conglomerate or breccia, composed of numerous small and angular pieces, thickly imbedded in a matrix of apparently identical character. In many portions this feature is quite conspicuous, but in others would not be suspected were it not for the effects of weathering, revealing at the surface the occurrence of fragments even when the interior is apparently homogeneous. From the prevalence of these features and the intimate relations between the brecciated and non-brecciated strata, I am led to believe that, even though apparently made up of re-composed sediments, they all appertain to a single geological horizon, their peculiar character being due to the nature of the circumstances and to the disturbances in progress during the time of their accumulation.*

Breccias.

In general, as has been observed, the stratification of the petrosiliceous rocks is exceedingly obscure, masses hundreds of feet in thickness and extending for long distances often failing entirely to reveal any reliable evidences of structural arrangement. This is particularly the case on ordinary weathered surfaces, but in the beds of streams, where exposed to a process of constant wear, the stratification is more evident, and at times even conspicuous. It should be added that with the more compact petrosilex beds there are others which are more slaty, as well as some slate-conglomerates, felsites and felspathic sandstones.

Northern Belt.

In the northern belt of Huronian sediments the rocks to which the above description is intended to apply are first seen, to the eastward of St. John, in the range of rather prominent hills running along the northern side of the Loch Lomond lakes, and extending thence to and beyond Barnesville. They are apparently wanting at St. John, as also at Coldbrook, where the only beds seen between the syenite of Division 1 (Laurentian) and the grey sandstones of the Primordial are heavy beds of schistose, red and purple, more or less chloritic conglomerates, pertaining to Division 4; but a little to the eastward of this point they may be seen to rise from beneath the Primordial Silurian beds in the partially cleared track lying just west of the first Loch Lomond lake, and between the Westmorland and Loch Lomond roads. When first

Coldbrook.

Loch Lomond.

* These felsites are undoubtedly of contemporaneous volcanic origin. They do not materially differ from the great felspathic trap series of North Wales and Cumberland, but appear to have been erupted at a somewhat earlier period. A.R.C.S.

seen the petrosilex band is only a few yards wide, but in approaching the lake becomes much more prominent, forming the greater portion of the eminence known as Ben Lomond, together with several other hills of less elevation. The dip of the beds near the western end of the lake (where they are unconformably covered by white and purple sandstones of the Primordial series,) is southerly (about S. 20° E. < 60°), and the same dip apparently holds good throughout the line of bluffs which skirt the lake on its northern side. It is probable, however, that this is but a series of overturned folds, as similar belts are met with along one or more lines to the northward, in the settlement of Golden Grove, separated by depressions mostly occupied by dioritic and ash rocks. The relations of these two sets of beds, which are elsewhere intimately connected, will appear from the following section:—

Golden Grove.

Section from North to South in Golden Grove.

		Traverse Measure.
	Pre-Silurian,—	
	Division 1.—Red syenite, more or less chloritic, on south side of Westmorland Road..........................	
	Measures concealed in deep valley, traversed by a branch of Langstroth's mill-stream, and filled with Laurentian debris..	620 feet.
	Measures concealed—steep ascent of hill nearly 400 feet high.	1,187 "
	Division 3.—	
b.	Dark greenish-grey epidotic and amygdaloidal ash rocks....	730 "
b.	Greenish-grey ash-conglomerate, with large pebbles of amygdaloid in an earthy dioritic base, filled with spots and vesicles of epidote. Dip southerly at a high angle, but obscure..	500 "
c	Measures concealed—to road running north of Mark's Lake.	500 "
c	Coarse conglomerates, holding pebbles of pink-and-grey quartzites, red felsite, dark purple ash-rocks, &c., in a sandy paste, and holding finer sandy layers. Dip distinct S. 20° E. < 70°. These conglomerates extend through the whole length of Golden Grove, and at the eastern end of Mark's Lake (where they overlie some thin beds of micaceous sandy slate and bright purple felspathic sandstone), exhibit alternations of coarse pebbly beds containing numerous white quartz pebbles with finer sandy and gritty beds, the whole dipping quite regularly S. 20° E. < 60°–70°, with a surface breadth of..	1,250 "
a. & b.	Dark-grey fine dioritic rock, similar to that in the hills north of Mark's Lake, but more crystalline—extending to south side of lake..................................	250 "
a. & b.	Grey slaty ash-rocks and dark-grey porphyritic petrosilex, extending to Golden Grove road....................	825 "
a. & b.	Grey and purple ash-rocks............................	533 "

		Trav. Meas.
b.	Purplish-grey ash-conglomerates and breccias, increasing in coarseness to the south, and holding angular blocks from 2 to 14 inches in diameter, in a sandy vesicular paste. Dip S. 20° E. < 60°	550 feet.
a.	Dark-grey porphyritic petrosilex. Dip ?	175 "
c.	Measures concealed, but including ledges of purplish cobbly and slaty conglomerate. Dip S. E. < 60°	100 "
b.	Greenish-grey and purplish ash-rocks, with pale-weathering fragments, and coarse ash-conglomerates holding large round masses, two inches to two feet in diameter, of grey amygdaloid in a purplish-grey sandy and dioritic paste. Dip distinct S. 40° E. < 40°. These rocks extend to the main road on the north side of McFarlen's Lake, with a breadth of	400 "
	[From this point the section is shifted about a quarter of a mile to the east, extending from near McFarlen's along the course of a road leading south to a mill on Loch Lomond shore.]	
	Grey dioritic and felspathic sandstones, somewhat vesicular and having ferruginous spots	400 "
	Measures concealed	475 "
	Grey felspathic sandstone and greenish-grey ash-rock	350 "
	Measures concealed	1,485 "
	Grey felspathic sandstone at intervals	800 "
	Pale-grey rusty-weathering felspathic and somewhat schistose beds dipping S. 50° E. < 80°–90°	500 "
	Greenish-grey sandstone and fine conglomerate. Dip S. 20° E. < 80°	400 "
	Measures concealed, to shore of Loch Lomond	950 "

Of the rocks included in the above section those of group *b*, embracing epidotic and amygdaloidal ash-rocks, are in Golden Grove by far the most conspicuous, and similar beds, though less coarse, are met with at various points both to the west and east of that settlement—in the latter direction to and beyond the Third (Loch Lomond) Lake. The conglomerates of group *c* are also both more voluminous and more varied here than elsewhere, while the underlying petrosilex (*a*) is mostly hidden from view. A little to the eastward of the line of section in its more easterly portion (near McFarlen's Lake) there are, in addition to the beds above enumerated, a peculiar pale-grey but deep rusty-weathering and highly calcareous sandstone, thin beds of hard grey, crystalline hornblende rock, fine greenish-grey conglomerate, in which the paste and pebbles are barely distinguishable, and (near the thoroughfare between the First and Second Lakes) dark purplish-grey petrosilicious conglomerate, containing numerous small concretionary nodules. Where the dip can be made out it is always to the south, usually about S. 30° E. < 70°, but sometimes as low as 30°. All or nearly all of these beds are again met with to the eastward, about the Third Lake and in the vicinity of Barnesville. In approaching this settlement the depression previously occupied by the Loch Lomond waters shows a tendency to bifurcate; one branch (holding the main belt of Primordial sediments) sweeping off to the south, while the other, traversed by the South Stream, an affluent of Hammond River, by keeping more to the north, intersects the Huronian series transversely, and thus affords a view of its character and structure. As stated in a previous report, the general arrangement in this vicinity appears to be synclinal, though from the obscurity of the stratification and the occurrence of numerous subordinate folds, the exact succession is not readily made out. Among the rather prominent hills (Lawson's and others) which bound the valley on its northern side, the rocks are almost entirely sandstones, conglomerates and breccias, similar to those of the hills north of Loch Lomond, and like them appearing to have a general southerly dip at a high angle (S. 20° E. $<$ 80°). Good exposures of the felsite-breccias may be seen in the lower part of the South Stream valley, at and below the falls, half a mile above its mouth, as well as on the main stream of Hammond River, above South Stream bridge (the dip varying from N. 30° W. $<$ 80° at the former, to S. E. $<$ 30° at the latter). A little higher up the valley are true felsites, of a pale red color and somewhat coarse texture, which exhibit a distinct stratification and extend along the stream for a distance of one or two furlongs, in a series of undulations, mostly low, but in places nearly or quite vertical. The relations of the felsites to the associated rocks is not very clear, but from what is seen at other points it is supposed that they are directly connected with the petrosilex and breccia rocks, of which they represent either a local variation, or, possibly, an inferior portion. In their more westerly exposures, where they exhibit some sharp corrugations, they are directly covered by a series of grey and purplish-grey sandstones, with beds of conglomerate composed of felsite fragments, and these in turn by purplish and grey shales. Both the felsites and sandstones are undoubtedly portions of the Huronian series, but the shales, which are much softer and apparently unconformable to the sandstones, may be a portion of a higher formation (Primordial Silurian.)

Barnesville. South Stream.

To the south of the South Stream valley, on the elevated plateau lying between this and the valley of Germain Brook, another tributary of Hammond River, the synclinal structure to which reference has been made is most clearly seen. On the hill-side at Barnesville Corner the rocks consist for the most part of a very compact dark-grey to black or purplish-black petrosilex-breccia, usually nearly homogeneous, but in which occasional fragments of red felsite are imbedded. They

Barnesville Plateau.

have an evident dip to the southward (S. 10° E. < 40-50°), and together with some thinner beds of paler grey, felspathic sandstones and conglomerates, have a surface breadth of about 600 yards. Following them to the south are greenish-grey, ferruginous, felspathic sandstones or ash-rocks, having kaolinized crystals of felspar and holding some felspar pebbles,

Conglomerate.

and to these succeed in turn ledges of coarse conglomerate, filled with well-rounded pebbles of green, red and grey felsite, stratified felspar-porphyry, diorite and epidote, some of which are six to seven inches in diameter, imbedded in a light-weathering sandy and felspathic base. These beds also dip southerly (S. E. < 50°), extending, with a surface breadth of about 300 yards, nearly to where the road crosses the head-

Synclinal.

waters of South Stream, which here flows westerly. After crossing the latter, however, the first out-crops on the hills to the south are massive dark-grey petrosilicious rocks (breccias and conglomerates) much like those of Barnesville, upon which rest beds of grey felspathic sandstone filled with ochreous spots, and coarse conglomerates holding felsite and diorite pebbles, the dip of both sets of beds being now to the north (N. 10° W. < 60°). There is thus an evident reversion of the higher beds (conglomerates and sandstones), and probably of the lower as well, the petrosilex beds which extend thence to the valley of Germain Brook not only resembling those of Barnesville in general aspect, but having, like them, what appear to be intercalated beds of reddish, more or less crystalline, felsites.

Further evidences of this synclinal structure are to be seen in the more easterly portions of the plateau, where it is cut off by the valleys

Hammond River.

of Hammond River and Germain Brook. On the first-named river, near South Stream bridge, may be seen the same felsite-breccias as those already described on the latter tributary, and similar beds again occur two and a-half miles to the eastward of Titus's (upper) mills, being here nearly vertical, while between these points the rocks are in part dark-grey porphyritic petrosilex, and in part Lower Carboniferous sediments, the latter forming the entire northern side of the stream. With the dark grey petrosilex are irregular beds of pale-red

Titus's mill.

and red felsite, which in approaching Titus's mill become at the same time more frequent and more crystalline. In some portions, as in the case of those at Barnesville, a distinct but usually highly contorted stratification is discernible, but other portions are quite homogeneous, and by admixture of a dark green mineral resembling hornblende, become imperfect syenites. Still further east these syenite rocks become yet more conspicuous, replacing all others and forming a nearly

Upham.

continuous line of high bluffs extending past the village of Upham to the mouth of Germain Brook, and along the north side of this brook nearly to Hardingville. It is supposed that these syenitic hills form the rim or margin of the great synclinal trough already described, and that they are simply the petrosilex and breccia-rocks in a more altered form. That they are in great part of fragmentary origin is very evident, and even where apparently most crystalline a rounding of the grains of quartz and the occurrence of irregular cavities or vesicles, suggest that all have been produced by like agencies.

In these high bluffs, around the base of which sweeps the St. Martin's and Upham railway, the more northerly of the two great Huronian belts abruptly terminates, being, as elsewhere, separated from the more southerly belt by a band of Primordial rocks which crosses their strike transversely.

Southern Belt.

In passing to the more southerly belt of Division 3 the same general features are met with as in that already described, but exhibited over larger areas and with greater complexity of detail.

Distribution.

Including a bifurcation at its western end (one branch of which is traceable to and beyond St. John Harbor), the belt in question has a total length of over fifty miles, or nearly to the boundary of Albert County, and a maximum breadth of about nine miles. The latter, however, is subject to considerable variation, being rendered irregular, particularly on the northern side, by overlying sediments (Primordial-Silurian, Devonian and Lower Carboniferous), as well as by considerable areas of intrusive rock. It is everywhere bold and rugged, embracing many of the most prominent hills in this section of the Province, and, except where covered with Lower Carboniferous drift, affords but little encouragement to the cultivator.

Character.

The general character of the southern belt, as well as its relations to higher divisions of the series, may be gathered from the following observations to the south of Loch Lomond and in the vicinity of Black River and Bloomsbury Mountain. It is just south of the western extremity of the First Lake that the bifurcation of the Huronian belt to which reference has been made occurs, one arm (the more northerly) extending thence in the direction of St. John Harbor, while the other and more considerable, including Bloomsbury Mountain, stretches off south-westerly towards the mouth of the Mispeck, the intervening area being occupied by the basin of Devonian sediments described in earlier reports. The first-named belt is both narrow and interrupted, being traceable only in a series of more or less isolated ridges along the southern edge of the Primordial area, of which the most considerable occurs about the northern and eastern side of Lattimore Lake. They here consist chiefly of massive fine-grained and more or less epidotic rocks, without evident stratification, with which, however, are some thinner beds of grey flinty petrosilex, dipping at a low angle (S. E. $<$ 20°). Their relation to the Primordial and Devonian, as seen on the

Lattimore Lake.

eastern side of Courtnay Bay, have been described in the Report of Progress for 1871. In the opposite direction similar beds may be seen to protrude at various points through the barrens about Black River road and Strayhorn Brook, extending thence in the direction of Negro and Otter Lakes, beyond which they are replaced by intrusive syenite. At Garnett Settlement, on the Black River road, the Devonian basin terminates in a series of low bluffs, but in the valley to the eastward, occupied by Black River and its branches, the petrosilex and ash-rocks are still concealed by overlying sediments, these being schistose rocks of Division 4, together with a narrow belt of black slates and sandstones pertaining to the Primordial group. South of these beds, however, the Huronian strata again come prominently into view and are well exposed along both the "Mountain" and Quaco roads. On the first of these two thoroughfares the following section has been measured along the road extending from the Black River bridge, in Garnett Settlement, to the south side of Bloomsbury Mountain:—

Black River road.

Section of Bloomsbury Mountain.

	FEET.
From Black River bridge to cross-road in Garnett's Settlement......	135
Measures concealed	3475
[A little to the eastward of this point the valley occupied by Black River is partly filled with black slates of the St. John group, dipping southerly towards the diorites and petrosilex of Bloomsbury Mountain.]	
Div. 3.—(*a*) Grey white-weathering fine felspathic rocks, obscurely stratified. Dip S. < 40°	175
Dark fine and epidotic petrosilex rocks, occurring at frequent intervals. Dip S. < 30°................	1500
Measures concealed..............................	735
Grey to dark grey, more or less slaty petrosilex, varying from fine to granular, and porphyritic	1325
Measures concealed. Brook at end, with grey petrosilex.	1275
Space, with ledge at end, of dark green diorite	250
Measures concealed..............................	925
Grey white-weathering felsite. Dip distinct S. 10° < 70°	425
Measures partly concealed, but showing in front half ledges of greenish-grey massive dioritic sandstone.	575
Measures concealed..............................	2000
Greenish-grey diorite..............................	100
Grey fine-grained petrosilex. Dip S. 30° E. < 70°.....	100
(*b*) Dark purplish-grey ash-rocks, enclosing angular fragments of petrosilex	200
Coarse dioritic breccia, made of angular fragments of purplish-grey banded petrosilex in an epidotic and dioritic paste..................................	260
Green fine-grained epidotic diorite like the last, but without enclosed fragments..........................	125
Measures concealed..............................	150

	FEET.
Grey, green and purple amygdaloid, conspicuously porphyritic, with paler spots and silicious amygdules..	650
Dioritic rocks, in part porphyritic, in part schistose....	825

[To these dioritic rocks succeed grey slaty felsites, and pale, yellowish-green felspathic schists belonging to Division 4, dipping S. 15 E. < 40°, extending from this point to the bridge over the east branch of Black River.]

Of the rocks exposed in the above section, the petrosilicious beds which form its lower portion are the evident equivalents of those which on the other side of the Primordial belt constitute the range of hills just north of the Loch Lomond lakes, from which they differ chiefly in being less markedly recomposed. The ash-rocks and amygdaloids which succeed are in like manner the equivalents of those of Golden Grove, the breccias at their base marking a breaking up of the inferior beds coincident with the accumulation of the earlier igneous deposits. The felspathic and schistose beds which follow upon the amygdaloids are portions of the Coastal group of former reports, and both by the interposition of these igneous rocks and by the sudden reduction in their dip, indicate a want of conformity to the inferior group. Correlations.

To the westward of the above line of section the particular distribution of the several groups, owing to their being covered with extensive sand-barrens, is not fully known. Dioritic and ash-rocks, which are more or less amygdaloidal, may, however, be seen for a distance of a mile or more along the road south of the upper bridge across the Mispeck River, being followed in the same direction, as at Bloomsbury Mountain, by schistose, felspathic and talcoid rocks of Division 4. To the eastward of the same line of section the beds are better exposed, and may be well seen along either of the roads leading south from Loch Lomond to Quaco. Mispeck.

Along what is known as the Lower Quaco road, traversing the settlement of Willow Grove, the most noticeable feature is the great development of the volcanic or semi-volcanic members of the series and the comparative paucity of true petrosilex. In the northern part of the settlement named and along the road leading to Negro Lake, the rocks resemble those of Division 4, being pale greenish-grey felspathic schists and schistose conglomerates, upon which rest much coarser felspathic and white weathering conglomerates holding pebbles of dark grey petrosilex, red felsite, felspathic schist, syenite, &c. These may be the equivalents of the similar beds previously noticed in Golden Grove, or possibly belong to some higher series, either Primordial or Devonian. To the south of the schistose beds, which have mostly a low dip or are nearly flat, the rocks in the central portion of the settlement are fine-grained diorites and earthy dioritic sandstones, of grey, Willow Grove.

greenish and purplish colors, often very coarsely vesicular, and containing much chlorite and epidote. The first rocks met with of a different character are found a little south of the bridge over the south branch of Black River, being flesh-colored felsites with obscure stratification (N. 10° E. < 80°), followed after an interval of 500 yards by grey flinty petrosilex, distinctly stratified and dipping S. 20° E. < 85°. With the latter high dip they are almost immediately succeeded by alternating beds of green and purple sandy shales, of which the dip is S. 30° E. < 50°–60°. These latter are a portion of Division 4, the rocks of which (chiefly pale yellowish-green and purple talco-felspathic schists with purple slates and conglomerates,) occupy the remainder of the road to where they pass beneath the Lower Carboniferous sediments of Gardner's Creek.

In the hilly and thickly-wooded region lying between the Lower and Upper Quaco roads but few observations could be made. The petrosilex rocks again increase in force in this direction, and on the second of the two roads named, form the greater portion of the Huronian belt. Just south of the Primordial belt on Ratcliffe's mill-stream, the rocks are mostly grey and pink syenites, forming part of a ridge extending westwardly to Otter Lake; but after passing there and to the south of the Hibernian road, grey rusty-weathering felsites come into view, and are succeeded by petrosilex-breccias of grey, dark-grey and black colors, which, with some thinner beds of grey felspathic sandstone, extend to within a short distance of where the road crosses Stony Brook, one of the tributaries of Gardner's Creek

Stony Brook.

South of this brook are ledges of diorite containing large masses of white quartz, and similar rocks interstratified with purple conglomerates dipping S. 30° E. < 80°. These, however, form a portion of Division 4, and with other beds succeeding them will be again alluded to in another connection.

Henry's Lake.

To the eastward of the Upper Quaco road the width of the petrosilex belt again becomes greatly reduced through concealment by overlying deposits, until at Henry's Lake, on the line of the St. Martins & Upham railway, it does not greatly exceed half a mile. The exposures at this point, which have been largely increased by the construction of the railway, are particularly interesting as affording (with Handford Brook, on the northern side of the belt,) the most complete and satisfactory section of the Huronian rocks in any portion of the district examined. As these belong, however, for the most part to Division 4, their further consideration is deferred for the present.

To the eastward of the St. Martins railway a most noticeable fact is the rapid and enormous expansion of the area occupied by the petrosilex rocks, an area now nearly equalling the combined breadth of the two belts to the westward, together with that of the Primordial belt included between them. The cause of this increase is undoubtedly to be found in the fact that the beds in the first-named direction are thrown into more numerous but, at the same time, usually more open folds, the dips being very irregular and generally at comparatively low angles. It may also in part be due to the occurrence of more or less considerable areas of diorite and syenite. As in the Barnesville area, these occur chiefly along the northern and southern sides of the petrosilex belt, are exceedingly irregular in their distribution, and often shade into the associated rock as though they were merely a more altered portion of the latter.

From the almost entire absence of settlements and the paucity of roads or clearings, the observations in this region are necessarily partial and disconnected, being for the most part confined to the exposures exhibited by the streams which traverse it. Enough, however, is known to indicate the general character and range of the rocks which it includes. From Henry's Lake the northern limit of the band extends north-easterly to the Hammond River, of which it forms the southern side as far as the road leading south to Saddleback Settlement. Between the river and this settlement fine exposures may be seen along the course of Sherwood's mill-stream, where the beds consist chiefly of very fine-grained felspathic sandstones—somewhat micaceous, and in part conspicuously ribbanded with shades of grey, dark-grey and purple—overlying dark-grey pyritiferous petrosilex, with some crystalline diorite. The section is nearly a mile in length, but owing to the irregularities of dip, which are peculiar in being usually not far from West and at a low angle (varying from W. $<$ 30° to W. 20° N. $<$ 30° and W. 10° S. $<$ 30°), no opportunity is afforded for a determination of the thickness of the beds. The ribanded beds are similar to some of the strata, to be hereafter described, on Handford Brook, and also appear in the bed of Hammond River at Veysey's mill, where they dip W. N.-W. $<$ 50°, and are overlaid by Lower Carboniferous limestone filled with pebbles of the underlying rock. Sherwood's mill stream.

Near this point there occurs a rather remarkable belt of true mica-schist of pale-grey or silvery aspect, and often somewhat gritty, which, first seen on one of the roads leading south to Saddle-back Settlement, thence extends easterly, with a surface breadth of over a mile, nearly to the head of the Hammond River valley. The beds everywhere dip northerly and lie to the north of the diorites and petrosilex rocks, but otherwise there are no facts from which their age can be determined. Mica Schist.

To the south of these exposures, in Saddle-back Settlement, are numerous hills and ridges which are, for the most part, composed of very dense, dark-grey to black and porphyritic petrosilex, with which, Saddle-back Settlement.

however, is a considerable mass of crystalline red syenite. The latter forms an irregular belt extending eastward through this settlement for about six or seven miles; while to the southward, with the exception of a small outlier of Lower Carboniferous conglomerate, the petrosilex beds (breccias, &c.,) occupy nearly all the area traversed by the north-east and north-west branches of the north arm of the Salmon River. At the falls on the north-east branch, the stream, in a distance of less than a mile, makes a descent of as much as 150 feet, producing a picturesque gorge, through which lumber is driven in considerable quantities, though only with great difficulty and danger. South of the falls another band of red syenite comes into view, separating the petrosilex from the schistose rocks of Division 4, and which is probably continuous with a similar belt crossing the Shepody Road near Cross Brook.

Salmon River.

Shepody road.

The Shepody road, between the valley of Hammond River and that of Crow Brook, intersects the Huronian belt nearly at right angles, and shows numerous exposures of the underlying rocks, but with the usual features of very variable and obscure stratification. Beyond the road, to the eastward, the belt has been traced through Long Settlement (where the petrosilex is covered by wide spread deposits of coarse amygdaloid), to the headwaters of Cedar-camp Creek. On the course of a stream flowing into the latter above Hazen's mill the following section, from north to south, has been made, and affords a good illustration of the features of the group in this region. The section includes a number of folds, but as a whole is a descending one:—

Section south of Hazen's mill (Hammond).

	FEET.
Red felsite-breccias, interstratified with red and reddish-grey very epidotic felsites. They are the same rocks as those of Titus's mill, on Hammond River, and on South Stream, and (with a dip varying from N. 50° W. to N. 20° E. < 60°) overlie dark grey felsites, also epidotic, and dipping N. 60 W. < 40°, declining to N. 20° W. < 30°,—the breadth of the whole about............	500
Similar beds, but bluish, and more petrosilicious, with high and variable northward dip, in part ash-like and amygdaloidal, and passing into dark grey and black petrosilex. The dip of these beds, which are also epidotic and brecciated, is regular (N. 30° W. < 60°) and their breadth about............	950
Breccia-conglomerates, like those at mouth of stream, but with reversed dip—S. 20° E. < 70°............	50
Dark grey to black felsite, breccia and conglomerate. Dip N. 30° W. < 60–80°............	370
Space, including a succession sf rapids and falls over petrosilicious rocks, but mostly inaccessible. Dip at the end, in brownish-red felsites, S. 10° E. < 60°............	1100
Space, with beds at end, of grey epidotic ash-rock, or earthy dioritic sandstone............	125

	FEET.
Hard grey and pyritous felsite, varying in texture from fine flinty to granular, well stratified, and dipping S. 5° E. < 60°	320
Space, occupied mostly by felsites as above, varying in dip, sometimes vertical or with slight inclination northward, but mostly southward. Falls at end over grey felspathic slates and slate-conglomerates, with red felsite fragments. Dip distinct S. 40° E. < 40°..	750
Space, including ledges of grey slaty felsite, holding numerous black slaty fragments	150
Fine-grained, massive felsite-breccias, grey to reddish in color; pebbles mostly of red felsite, both angular and rounded, embedded in a pale grey, bluish-weathering paste	400
Grey felsites. Dip at end S. 30° W. < 50°	560
The same, dip becoming S. 10° W. < 60°	350
Space, with ledge at end, of pale-grey flinty felsite. Dip N. 10° W. < 50°	1800
Fine grey, white-weathering, flinty petrosilex. Dip N. 10° W. < 60°, gradually changing to S. 30° W. < 80°	500

Long Settlement.

Walton Lake.

From the termination of this section southward there are no exposures along the road as far as the point where it is intersected by the road running east to Long Settlement. Occasional outcrops on the hills show them, however, to be chiefly composed of petrosilex rocks, with which, as in the last-named settlement, there are beds of ash-rock and amygdaloid, both more or less injected with veins and masses of syenite. At several points near Walton Lake these petrosilicious rocks, which are black and conspicuously porphyritic, have a distinct southerly dip (S. 20°–40° E. < 70°–80°), and are in the same direction followed by much softer, pale to bright red, white-weathering felsites, also dipping southerly (S. 40° E. < 70°). These are a portion of Division 4, whose superposition on the petrosilex group (Division 3) is thus clearly marked.

Filamaro Settlement.

A still better view of the relations of these two groups is to be had about three miles to the eastward of the last traverse, along what is locally known as the Filamaro road, connecting the head-waters of Cedar-camp Creek with the Shepody road. In the deep and precipitous valley through which this creek passes out from the metamorphic hills the first rocks seen, south of the Lower Carboniferous conglomerates, are grey, red-weathering and distinctly crystalline felsites, associated with grey breccia-conglomerates full of pebbles of grey granular felsite. To these follow bluffs of fine grey, banded and ribbanded felsites, similar to those of Sherwood's and Veysey's mills, on Hammond River, and like them having a westerly dip (W. 10° S. < 70°), to which succeed grey banded and very fine-grained felsites, associated with reddish granular felsite, dipping regularly N. 25° W. < 60°. The whole series to this point has a breadth of about one mile. There is then a brief interval without exposures, beyond which a series of small but very prominent hills come into view, in one of which, known as Cripp's Hill, a very remarkable display, and one well exhibiting the peculiar circumstances under which the Huronian rocks of this region were deposited, may be seen. The general structure of the hill is synclinal, beds of bluish-grey fine-grained petrosilex at the southern end dipping N. 10°-30° W. $<$ 60°, and at the northern end S. E. $<$ 60°, while between, the rocks are exceedingly broken and irregular. This central portion is further peculiar for the variety of rocks which it exhibits, these embracing, in addition to grey and dark-grey petrosilex, heavy masses of ash-rock of grey, green and purple colors, which are highly epidotic and amygdaloidal, breccia-conglomerates filled with fragments both of petrosilex and ash-rock, grey fine-grained felspathic sandstones, and, finally, slaty and schistose beds, some of which are soft and unctuous, and others exceedingly hard, giving, when struck, a clear metallic ring. The whole section does not exceed in length five hundred feet, but in it is contained, as it were, an epitome of the entire Huronian series, as well as an indication of alternating conditions which were probably applicable over far wider areas, the deposition of the petrosilex beds having been apparently interrupted, as well as followed, by periods of general disturbance, in which a shattering of the strata occurred, together with numerous outflows of igneous matter and the formation of breccia-conglomerates, these outflows being repeated from time to time during the deposition of the later shistose beds, but becoming gradually less frequent as the period drew to a close.

Cripp's Hill.

South of Cripp's Hill the rocks, for a quarter of a mile, are chiefly grey felspathic sandstones, but near the Roman Catholic chapel beds of a somewhat different character appear, being greenish-grey slaty, felspathic and micaceous grits, together with fine, fissile, glossy slates, both dipping S. 30° E. $<$ 80°. These rocks resemble some of those in the upper part of Cripp's Hill, are like them, probably, a portion of Division 4, and here mark the northern margin of an overlying synclinal basin, its southern margin being marked by similar slates having a northerly dip a mile or so to the southward, while in the intermediate area are bright-purple conglomerates, together with a very coarse but shistose conglomerate, containing pebbles of petrosilex, red felsite, etc., and dipping N. 10° W. $<$ 70°–90°. In accordance with this structure the true petrosilex rocks come into view a little south of where the road crosses the boundary line between the parishes of Sussex and Hammond, beyond which to the Shepody Road the only rocks seen are granitoid and gneissic beds, to be hereafter alluded to in connection with the rocks of Division 4.

Synclinal.

To the eastward of Cedar-camp Creek the belt of petrosilex rocks, bending to the north-east, becomes greatly reduced in breadth, gradually passing beneath the Lower Carboniferous sediments which bound it upon the north. In the same direction the petrosilex appears to be largely replaced by diorite and syenite, which in Donegal Settlement may be seen intimately associated with it, but further east, in the Mechanics' Settlement, occurs to its almost entire exclusion. The diorites and syenites are much more crystalline here than the resembling rocks to the westward, and are probably connected with those which, to the south and east, cover large areas on the Pollet River and elsewhere in Albert county.

Donegal.

Mechanics' Settlement.

To the east of the Mechanics' Settlement, no rocks belonging to Division 3 have been observed.

Division 3.—Micaceous and Chloritic or Schistose Group.

Characters.

The general character of the rocks of this division have already been given in the preliminary synopsis, as well as incidentally alluded to in connection with the strata of Division 3. From what has been stated, it will further appear that the two groups are intimately associated, and that the passage from one to the other is a gradual one. Between the two, as a whole, however, the contrast is very marked, the transition being chiefly seen in those volcanic and quasi-igneous deposits which are especially abundant along their line of junction, but which, to a greater or less extent, are characteristic of both. While in the second division, already considered, the rocks are rarely schistose, and often, through great thicknesses, very uniform and almost entirely destitute of stratification, as though largely of sub-ærial origin, those of the third division are much more clearly the result of ordinary aqueous deposition, being very distinctly stratified, and, in addition to large quantities of felspathic and chloritic schists, embrace numerous beds of true conglomerate, some of which contain pebbles derived from the underlying series. Petrosilex and felsites occur in both, but while in Division 3 these are usually in enormous masses, and very generally more or less brecciated, those of Division 4 are in comparatively thin beds alternating with schists and conglomerates, and not brecciated. The latter are usually also of lighter colors. But perhaps the most noticeable feature in the group, as a whole, is the possession by the latter, in nearly all its members, of a peculiar glossy or unctuous character, which is in part due to the frequent dissemination of chlorite, but chiefly to the abundance of a pale-yellowish (sometimes purplish) mineral resembling talc, but which, according to analyses by Dr. Hunt, is in reality a hydrous mica. In this as in other features, the group bears much resemblance to the so-called "altered

Contrast of Divisions 3 and 4.

Quebec group" of the eastern townships of Canada. Like the rocks of the inferior division, those of Division 4 are very variously inclined, but along the line of contact between the two there is often a very marked, and sometimes an abrupt, diminution in the dip in passing from the lower to the higher beds, which, together with the abundance of amygdaloids at this horizon and the occurrence of coarse conglomerates (in part made up of pebbles from Division 3), seem to point to their partial unconformability. It is on or near this line of separation that the syenites to which reference has been made are chiefly met with, as well as gneissic and granitoid rocks, which are probably, in part at least, only a more altered form of the schistose series.

Indications of unconformability.

By far the most complete and instructive views to be had of the group under consideration are those afforded respectively by Handford Brook, a tributary of Hammond River, and by the line of the St. Martins & Upham railway near Henry's Lake—the one on the northern and the other on the southern side of the more southerly Huronian belt of St. John and Kings county.

Handford Brook.

The exposures on Handford Brook are mainly between the point of junction of its two principal branches on the one hand, and Upham's (now McAfee's) mill on the other. Owing to the broken and sinuous character of the stream, as well as from the irregularities of the rocks themselves, no exact section of the latter was found to be practicable, but the general order of succession, from south to north, is nearly as follows:—

Section on Handford Brook.

Grey felspathic and sandy rocks, containing numerous small slaty pebbles, dipping northward at low angles and followed by purplish-red and red claystones, into which the sandstones graduate both in color and texture. These rocks occur at and below the driving-dam where the south branch of Handford Brook is crossed by the road leading to Mount Theobald, and, with some grey amygdaloid and toadstone, occupy this branch to its junction with the main stream, a distance of about a furlong. The latter, for half a-mile, then runs nearly on the strike of the beds, which here consist partly of dark-purplish conglomerates and slates (the former containing specular iron,) and partly of purplish-brown striped and well-stratified felsites, which are more or less petro-siliceous, and sometimes pass into or include a true dark-grey petrosilex. The dip in this distance changes from N. 80° W. $<$ 90° to N. 60° W. $<$ 40°. Below the bend in the stream, where the latter begins to flow northward, the succession is as follows:—

Pale-grey and pink felsites and slaty felspathic rocks, often rusty-weathering. These are in part a repetition of the beds above described near the driving-dam on the South Branch, and, like the latter, have but little inclination, forming a series of low and open folds. Both are apparently unconformable to the petrosilex rocks, over which they lie in a series of more or less isolated basins, but with a general northerly dip. They also include beds of conglomerate, in which are enclosed numerous pebbles of petrosilex, and are probably of the same horizon as the beds of similar composition on Cripp's Hill, in Filamaro Settlement, and elsewhere. Like the latter, they are associated with and followed by—

Fine-grained dioritic or ash-rocks, of grey, green and purple colors, containing much chlorite or epidote, and often very amygdaloidal, the amygdules being of calcite and milky quartz, wih chlorite and epidote. They are in part an ash-conglomerate, like those of Golden Grove, and, as these, include numerous beds of ordinary conglomerate, of green, red and purple colors, together with some green chloritic and epidotic slates. The dip of the beds is very generally northward at moderate angles, varying usually from N. 40° W. to N. 60° W. $<$ 60°, but at some points N. to N. 10° E. $<$ 60°. In approaching McAfee's mill the dip becomes more westerly (N. 60° W. $<$ 60°.), and the amygdaloids and associated beds are followed by—

Coarse purple quartz conglomerates, dipping N. 20° W $<$ 20°. These latter mark the base of the Primordial series, of which fossiliferous shales are found, as heretofore noticed, at McAfee's mill.

Henry's Lake.

The section on the St. Martin's and Upham railway, at Henry's Lake, is closely parallel with that of Handford Brook, but exhibits still more clearly the character and relations of Divisions 3 and 4. Just north of the lake referred to, the older rocks are mostly concealed from view by heavy deposits of Lower Carboniferous conglomerate (which here occur far above their usual elevation, and have a low northward dip,) but on passing its western side there appear from beneath the latter, beds of a more crystalline character than are usually met with in this region, viz., dark grey syenite rocks, containing labradorite, associated with a coarsely crystalline, but much softer, friable rock, containing red felspar, mingled with soft acicular crystals. These are near the forks of the road at A. McCurdy's. From this point to the southern extremity of the lake there are no exposures, but just north of the saw-mill at the head of the lake similar rocks are again met with, and for a distance of nearly two miles are finely exhibited in the railway excavations. The succession in ascending order is as follows :

Section south of Henry's Lake.

	FEET.
Div. 3.—Dark grey flinty petrosilex. Dip S. 30° E. 90°.	
Div. 4.—Purple and green slaty conglomerates, with fragments of green and purple slate, pale grey felsite and red jasper. Dip. S. 45° W. $<$ 30°. Interstratified with these rocks and graduating into them are petrosilicious and felsite beds, in part flinty and homogeneous, and in part a coarse conglomerate, full of petrosilex fragments, both greatly shattered and brecciated ; also fine-grained sandy and dioritic rocks, containing much epidote. The surface breadth of the whole is about	2500
Fine fissile dark green chlorite schists	50

	FEET.
Very coarse amygdaloid, of grey, green, red and purple colors, the amygdules mostly of white quartz, with chlorite and epidote. These rocks are distinctly bedded with dip varying from S. 20° W. $<$ 40° to S. 30° E. $<$ 60°, and have a surface breadth of....................................	3000
Measures concealed	775
Purple grits..	225
Greenish sandstone or chloritic grit, overlying fine-grained sandy or slaty rocks, much seamed and broken, and having the flaws and crevices covered with chlorite and epidote. Dip in part E. 30° S. $<$ 50°.	
Dark green, highly chloritic and epidotic, fine-grained rocks, with purple conglomerates, slates and fine sandstones, more or less talcoid; also including two considerable masses of felsite, the more northerly pale-red or flesh-colored, the second and smaller pale-purple, while both are pyritous and rusty-weathering. The dip in some parts is northerly, but usually to the south, and the total breadth about.....	3400

The succession exhibited in the above section applies, as regards its general features, to the whole belt of shistose rocks skirting the petrosilex band along its southern margin. The passage between the two divisions, as before observed, is very generally marked by a decided and often abrupt decrease in the dip, as well as by the occurrence of coarse diorites and breccia-conglomerates, and by thick beds of amygdaloid. This dip, though subject to much local irregularity, is also in both, as a whole, to the south, and the super-position of the shistose beds upon the petrosilex distinct and well-defined. At the same time there are some variations in the extent and special features of the beds at different points, a few of which may be noticed.

Upper Quaco road.

To the west of the Henry's Lake line of section the best exposures are those afforded by what are known as the Upper and Lower Quaco roads. On the upper and most easterly of these two thoroughfares the most noticeable feature is the abundance of a pale or white, very rusty-weathering, felspathic quartzite, or flinty felsite. It occupies about the same position as that of the felsite beds south of Henry's Lake, but is far more voluminous, having an apparent breadth of over 1,000 yards, with a southerly dip, which in some parts is as high as 85°. Similar but more sandy beds have already been noticed as occurring in Golden Grove and Barnesville. As at Henry's Lake, they lie to the southward of a considerable body of dioritic, epidotic and amygdaloidal rocks of grey, green and purple colors, which, with bright green, purple and grey sandstones, purple porphyritic felsite and bluish-grey petrosilex-conglomerate, occur between them and the main body of petrosilex to the north. To the south, near the head of Quigley Brook, they are covered by Lower Carboniferous conglomerates.

Lower Quaco road.

The Lower Quaco road crosses the schistose belt obliquely. Here the dioritic and amygdaloidal rocks are less conspicuous, and in their place there is a much greater development of the true schists, with the associated sandstones and schistose conglomerates. These may be seen almost all the way from the crossing of Stony Brook to Donnelly's Inn, near which, as well as in the Hibernia Settlement, just to the east, they may be seen resting against the petrosilex ridges with the same marked decrease of dip already noticed. Along the Quaco road the inclination rarely exceeds 60°, and is often as low as 30°, generally S. 10°–20° E. < 60°, the beds consisting of pale yellowish-green and purple talco-felspathic or hydro mica schists and green chloritic schists, with grey, flesh-colored and purple slaty felsites in repeated alternations. Many of the schistose beds are quartzose or gritty, though still retaining their glossy or unctuous aspect, and not unfrequently include beds of purple conglomerate and sandstone possessing the same feature. The breadth of the entire belt at this point, measured across the strike, is about two and a-half miles, but as there are undoubtedly faults repeating the measures, the actual thickness of the latter is only a matter of conjecture.

Another very complete view of the rocks of this series is to be seen on the Black River road, south of Bloomsbury Mountain, except that they are here obscured by association with Devonian rocks. The following section on the latter is in direct continuation of that given on page 10 DD, and will serve to exhibit the relations of these two groups:

Section south of Bloomsbury Mountain.

	FEET.
Grey slaty felsites at beginning, overlying dioritic and amygdaloidal ash-rocks. Space mostly concealed	575
Pale yellowish-green felspathic schists, varying to grey and purple. Dip S. 15° E. < 50°	250
Measures concealed, except a ledge at end, of pale pink unctuous slaty felsite or felspathic schist	1300
Grey porphyritic felspathic schist, occurring at intervals as far as the bridge over the east branch of Black River, where occur similar schists, together with pale grey, unctuous and rusty-weathering slates, conspicuously porphyritic with pale angular felspathic blotches. Dip S. 40° E. < 60°	325
Measures concealed	1870
Bright purple slates and slaty sandstones, dipping S. 20° E. < 90° and exposed at several points within a space of	1720
Coarse purple conglomerate with beds of grey grit. The pebbles in this conglomerate are of red slate and sandstone, green diorite, purple amygdaloid, purple porphyry, white quartz and granitoid rock,—all evidently derived from beds of Division 4, and indicat-	

	FEET.
ing that these conglomerates (which dip S. 30° E. < 60°) are of Devonian age. Their breadth across the strike is	525
Coarse grey shales and purple sandstones. Devonian ?	180
Measures concealed	300
Bright-purple slate	50
Talco-felspathic schists, with bright-green slaty beds. Dip S. 20° E. < 75°	40
Bright-green diorite, followed by greenish and purplish hydro-mica schists and glossy grits. Dip S. 10° E. < 50°	320
Bright purple-red, fine conglomerate, with white kaolinized specks. Dip N. 10° E. < 30°	180
Green dioritic and schistose beds	125
Purple schist. Dip S. 30° E. < 40°	50
Measures concealed	220
Grey sandstones, containing irregular beds of impure grey limestone, both stained with green carbonate of copper. Dip varying from N. 20° W. < 50° to N. 30° E. < 10°. (Devonian ?)	75
Schistose and ferruginous greenish-grey granitoid rock. Dip S. E. < 30°	140
Measures concealed	370
Greenish-grey and rusty schistose beds. Dip S. 50° E. < 40°	220
Measures concealed to junction of Mountain road with that leading west, to mouth of Black River	870

Devonian rocks.

The association of Devonian with Huronian strata, indicated in the above section, is still more marked on the main stream of Black River and in the region to the westward, the newer formation being here represented, in addition to other beds, by the grey "Dadoxylon" sandstone, which at St. John and elsewhere forms one of its most characteristic members. It is remarkable that through much of this region (from Black River westward to Mispeck) these two formations should accord almost exactly both in strike and dip, the Devonian being included among the Huronian rocks and both dipping southward at high angles; but, in addition to the fact that the conglomerates of the former are largely made up of the *débris* of the latter, there are points in which this concordance is clearly wanting. The most remarkable of these is on Black River, about half a mile from the bridge at its mouth, and near its point of confluence with the East Branch. At and above the bridge, for about a furlong, the rocks are bright purple highly micaceous beds, in part slaty, but mostly coarse grits, passing into conglomerates, with pebbles of white quartz, quartzite, red slate, etc., with large quartz veins, and varying in dip from S. E. < 70° to S. 15° E. < 40°. In approaching the mouth of East Branch the Dadoxylon sandstone is seen to rise from beneath these last named beds, with a dip S. 20° E. < 75°–80°. This, however, soon declines to S. E. < 40°, and gradually bends around to S. 20° W. < 20°, being

Black River.

East Branch.

followed closely by grey glossy slates having the normal dip (S. 20° E. $<$ 40°) as well as the aspect of the Huronian rocks, while still higher up the stream are other shistose beds of grey and greenish colors, many of which are porphyritic with paler felspathic blotches, as already noticed in the case of those seen where the East Branch crosses the Mountain road. To the south of the Black River bridge, between the latter and the mouth of the stream, some of the rocks have the aspect of Devonian sediments, but the bulk of the beds are those of Division 4, being greenish, granitoid and micaceous schists, having a general dip S. 50° E. $<$ 60°, but much broken, and having irregular veins of mixed quartz and chlorite. West of the mouth of Black River the same granitoid and schistose beds, together with glossy grey and purple slates, grey sandstones and conglomerates, form the hills overlooking the shore at West Beach, between Beveridge's and Thompson's Coves, and are the beds described in the Report of Progress for 1870-71 as containing large beds of iron ore. These are conformably interstratified with the shistose beds, attain at some points a thickness of twenty feet, and occur at intervals as far as the mouth of Black River.

We may now return to the region east of the line of the St. Martins railway. On the main road leading from Upham to Quaco, south of Wood Lake, there are good exposures of ash-rocks and amygdaloids similar to those of the section near Henry's Lake, and with the same diversity of dips, while the schistose beds are concealed by overlying Carboniferous sediments (Millstone-grit). The schistone rocks, however, appear a few miles to the eastward, along the course of Vaughan's and Macomber's brooks. They here include several thick masses of felsite of various colors, from pale purplish red-and-pink to dark grey, and sometimes ribbanded, together with bright purple and red slate-conglomerates, purple grits and sandstones; they appear to form a series of folds, the dip being in some parts northerly and in others southerly, but with great irregularity. The observations during the past two seasons have not extended eastward beyond this point. From the general range, however, of the series as a whole, together with the course of the beds on Vaughan's Creek, it seems probable that the latter are directly connected with the somewhat similar beds described in earlier reports as occurring along the valley of Little Salmon River, and beyond in Albert county. It is to the north of the last-named valley and along the course of the Shepody road that the granitoid and gneissic rocks, described on a former page as here flanking the petrosilex belt, are met with. Among the beds there are many which bear much resemblance to those of Division 4, as before described, while others are more highly crystalline; but whether actually a portion of that division here greatly altered by syenitic intrusion, or, on the other hand, a portion of an older formation coming to the surface, the writer had not the opportunities of determining. They may be seen along the Shepody road at many points between the head of Salmon River and the Albert County line, as also further north in the vicinity of Pollet Lake and the Mechanics' Settlement. Here ledges of grey gneissic rock, of talcoid or protogene aspect, and having bright felspar, may be seen alternating with beds of grey glossy or unctuous slates and greenish-grey hydro-mica schists, both dipping northerly (N. 30°–35° W. $<$ 60°), while on the shores of Pollet Lake are numerous ledges of red syenite, the beginning of a large area of such rock extending southerly and eastwardly into Albert county. To the north of the Mechanics' Settlement, schistose rocks, in the form of grey unctuous slates, were observed on the Penobsquis road overlying diorite and dark grey petrosilex. They dip northerly, as does the petrosilex, and include the beds described in previous reports as containing beds of Albertite.

In the more northerly band of Huronian sediments described as extending from the vicinity of St. John to Barnesville, there are comparatively few rocks which can be distinctively referred to Division 4. They are not, however, wholly wanting, and, where found, hold the same relations to the associated rocks as in the region last described.

Among the localities to which the above remarks apply, one of the most noticeable is that of Carleton, just west of St. John Harbor, where the following section has been made. It is apparently an ascending one, but in reality, owing to an inversion of the beds, descending:—

Section in Carleton.

	FEET.
Grey Primordial slates, exposed along the course of Duke Street, with dip S. 40° E. $<$ 60°	75
Hollow filled with clay, with small ledge at end, of grey micaceous sandstone (Primordial)	400
Measures concealed	75
Grey sandy slate. Dip S. 10° E. $<$ 70°. (Primordial)	125
Purple sandy slate, dip S. 10° E. $<$ 70° (Primordial), and grey sandy slate, spotted with films of mica	160
Measures concealed	115
Purple (very ochreous) and micaceous, hard grey sandstone and sandy slate. Dip S. 20° W. $<$ 70°	50
Bright purple sandy slate	25
Massive greenish-grey, fine-grained diorites, more or less chloritic and amygdaloidal, with veins and amygdules of white quartz. (Division 3 or 4)	500
Measures concealed	160
Grey felspathic slates, about twenty feet in thickness, directly overlaid (with dip S. 10° E. $<$ 60°,) by massive greenish-grey diorites and ash-rocks	50
Measures concealed, to crossing of St. James' street	375

From St. James' street to the railway crossing near the bay shore, a distance of about 1,260 feet, there are no rock exposures along the line of the section, but a little to the eastward, at and about what is known as Blue Rock, are beds which, if extended, would fall into this space. They are greenish-grey, chlorito-felspathic schists, full of ochreous seams and blotches; grey and purple slates and dolomites with seams of calcite, and massive, imperfectly slaty and very chloritic dark green rocks containing much epidote, together with dykes of diorite and irregular lenticular bands, six to eight inches in width, of dense petro-silex. It is the same series which, extending westwardly through Manawagonish Island, reappears on the bay shore in the peninsula of Pisarinco.

The above exposures in Carleton lie to the south of the Primordial belt, and, with their continuation across St. John Harbor and Courtnay Bay, are, as described in previous reports, overturned upon the latter. On the north side of the same belt the schistose rocks of Division 4 are very inconspicuous near St. John (forming a narrow band extending eastward from the Suspension Bridge through Reed's Hill), but become somewhat more prominent further east. On the road to Lily Lake they consist of pale greenish and purplish-grey felspathic rocks, obscurely stratified, and interwoven with grey limestones of Division 2, and purple sandy slates marking the base of the Primordial, both dipping southerly (S. 60° E. < 50°). Near the Coldbrook Iron Works there are heavy beds of coarse grey and purple slate-conglomerate, some of which evidently belong to the Primordial series, while others probably appertain to Division 4 of the pre Silurian rocks. These latter, which are more or less chloritic, cross the Westmorland road about half a mile east of the nail factory and reappear on the old road from Coldbrook to Loch Lomond, where they are associated with pale grey glossy and pyritous felsites, elsewhere common in Division 4, and dip S. 10° E. < 40°. Farther south, and on the same road, are purple and grey ochreous felspathic quartzites (also dipping southerly), bright-purple slates with white talcoid blotches, and pale grey alternating with bright-purple slates, some of which contain small pebbles of grey, ferruginous ash-rocks. From the want of exposures the relations of the different groups in this region cannot be clearly made out, but it would appear that in approaching the petrosilex belt which forms the prominence of Ben Lomond, the rocks of Division 4 bifurcate, or form two belts, of which the more northerly extends up the valley of the Coldbrook Stream to Quinn's Lake (where they consist of schistose felspathic beds of grey, green and purple colors, with purple slates, grits and conglomerates, dipping S. 20°–40° E. < 60°–80°), and the more southerly in the

Lily Lake.

Coldbrook.

Old Loch Lomond road.

Quinn's Lake.

direction of Loch Lomond. The latter is of special interest from the evident unconformability between it and the Primordial belt, the rocks of which, to the south of Coldbrook and near the lakes of the Water Company, bend around a ridge composed of purplish petrosilicious rocks of Division 4, and are again found in isolated patches covering the latter near the western end of Loch Lomond.

The occurrence of schistose rocks and conglomerates resembling those of Division 4 in Golden Grove and Willow Grove settlements, has been already alluded to on an earlier page.

Pre-Silurian rocks of Kings

In connection with the revision of the pre-Silurian rocks of St. John and King's counties, of which the results have now been given, an opportunity has been embraced during the past summer to make a partial re-examination also of the sediments underlying or connected with the more northerly belt of Primordial slates, described in former reports as occupying portions of the Long Reach of the St. John River in King's county. The result of this examination was to show not only a larger development of the Primordial in the valley referred to, but to exhibit a marked parallelism between the inferior beds and those occupying a similar position nearer the coast.

The following section, measured nearly across the strike, from near the mouth of Jones's Creek to the shore of the St. John River, near Caton's Island, will serve to illustrate this point. The section is an ascending one :—

Section west of Jones' Creek.

		FEET.
	Grey slates, with Upper Silurian fossils, and including beds of dark grey crystalline diorite. Dip S. $< 60°–80°$.	
Division 2.	Red crystalline felsite, covered on southern side by grey light-weathering felspathic sandstone. Dip S. < 70	100
	Measures concealed, with ledges of diorite at end	500
	Grey felspathic sandstone and diorite	125
Division 3.	Measures concealed, with ledges at end, of grey, white-weathering, very felspathic sandstone, approaching felsite. Dip S. $< 80°$	830
	The same, with grey felspathic conglomerate	250
	Grey felspathic sandstone	770
	Measures concealed, with ledges of grey sandstone at end	875
	Measures concealed	450
	Grey felspathic sandstone	270
	Measures concealed	125
	Coarse grey diorite	75
	Measures concealed	400
	Grey rubbly felsite	50
	Grey amygdaloidal sandstone, or ash-rock, and dark purplish-grey amygdaloid. Dip S. $< 40°$	600

		FEET.
Division 4.	Measures mostly concealed, but including ledges of pale red talco-felspathic gneiss..................................	400
	Space, with ledge at end, of red granulite....	250
	Purple, red and flesh-colored granulite or quartz-porphyry, composed of much felspar, small grains of quartz, and a pale green mineral, well stratified and dipping N. 10° W. < 80°. These rocks form the greater part of a high ridge overlooking the river having an elevation of nearly 400 feet and a surface breadth of about.................................	660
Primordial.	On the southern face of this hill the granulite last referred to is overlaid by very coarse purple-red conglomerates, containing large rounded pebbles of purple-red granulite in a reddish clay-stone base, and dipping N. 10° W. < 80°. They are believed to form the base of the Primordial series, and have an exposed breadth of	150

The Primordial rocks which succeed to the above and which form the shore of the St. John River near Caton's Island, are described beyond.

To the westward of the above line of section the rocks, with the exception of those constituting the continuation of the granulite ridge and the Primordial beds (purple sandstones and diorites) which overlie the latter, are mostly concealed from view. The granulite ridge is, however, traceable along the entire northern side of the Long Reach Valley, passing in the rear of the Devil's Back, near which its continuity is broken by a lateral dislocation, crossing the mouth of the Nerepis River not far from Nerepis Station. In addition to the granulites a few other rock exposures are to be seen at different points in the valley between the latter and the granite range to the northward, a portion of which are grey slates and sandstones containing Upper Silurian fossils, while others, by their highly crystalline character and general aspect, recall the rocks of the Huronian and Laurentian systems. These latter are most clearly exhibited towards the western extremity of the district, along the roads leading north from the lower part of the Reach, and especially about Long Lake and the stream leading thence to Elliott's mill on the Nerepis River. Along the stream in question the beds consist chiefly of a highly crystalline and granitoid or syenitic rock containing much chlorite, with which are some beds of pale red granular felsite, but further north there are with these, chloritic and felspathic schists, dipping northerly, and holding (at Belyea's) veins of white quartz stained with carbonate of copper. They are probably in part a continuation of the beds described in previous reports as exposed on the St. John and Maine railway (Western Extension), and are either of Huronian or Laurentian age.

The Primordial or St. John Group.

The general character and distribution of the rocks of this group, more particularly as exhibited near the city of St. John, have already been given in earlier reports. The observations made thereon during the two past summers have been partly to give completeness and accuracy to what was previously known, but chiefly to determine the relations of the Primordial to the associated strata, as already in part described in preceding pages.

Earlier Reports.

In the Report of Progress for 1870-71, the only rocks described as directly belonging to the St. John or Acadian group are the dark-colored sandstones and slates which make up its principal bulk, and from the lower beds of which, resting upon a white sandstone or quartzite, the fossils by which its age was determined were derived. A series of red and green argillites, sandstones and conglomerates, described under the name of the "Upper Coldbrook" group, was spoken of as forming an unfossiliferous portion of the same group, as were also certain beds of grey felspathic sandstone, with chloritic schist and breccia-conglomerate, at first described as No. 6 of the Coldbrook-Huronian group. There can be little doubt that these latter beds, which have been described in preceding pages, are really a portion of Division 4 of the pre-Silurian rocks, and that the real base of the St. John group is to be found in the red and purple sediments which succeed. Adopting this view, the uncomformability of the two groups is marked and general.

Unconformability of Primordial to Huronian.

In tracing the Primordial belt eastward from the city of St. John, the first point at which the uncomformability referred to may be seen is in the district lying between the Coldbrook stream and the high-road to Loch Lomond. At the Coldbrook nail factory the dark grey shales holding trilobites, etc., may be seen resting as usual against beds of pale grey or white sandstone, and this in turn upon bright red and purple slates and conglomerates. While, however, the bulk of the latter beds have a dip S. 10° E. $<$ °60–80°, and with a corresponding trend, may be traced eastward to the Old Loch Lomond road, the quartzites and connected beds show a tendency to sweep around to the southward, becoming at the same time broken and faulted. The cause of this change is probably to be found in the occurrence, just south of this point, of an area of Huronian rocks, over or around which the Primordial beds would appear to fold, for on crossing in the direction of the lakes of the Water Company, the white quartzites are again met with, now with a southerly dip (S. $<$ 60°) just south of the ridge of these older rocks. In approaching Loch Lomond, similar discordances between the two groups may be seen, the Primordial beds at some

Coldbrook.

Old Loch Lomond road.

Water Co. Lakes.

Loch Lomond.

points resting upon the rocks of Division 4, and at others upon those of Division 3, besides being broken by numerous faults. Near the western extremity of the First Lake, the characteristic white quartzite below the fossiliferous beds may be seen dipping N. $<$ 60° towards, and only a few miles distant from, the dark grey petrosilex of the Ben Lomond range, and again a little to the westward similar quartzites, with grey sandy and micaceous shales, may be seen overlying purple sandstones and conglomerates with a similar, but much higher, northerly dip (N. 10° W. $<$ 75°–80°). Near Allandale, however, on the Loch Lomond highway, coarse purple conglomerates (containing white quartz pebbles) which belong to this series and which are overlaid by dark grey slates, have a southward dip of 45°; and again, on the Old Loch Lomond road, a similar southward dip of 60°. It would appear as if the Primordial beds were irregularly spread over ridges or among the hollows of the Huronian series, there having intervened both movements and erosion, though from the extent to which the country is here covered with drift the details of their relations cannot satisfactorily be made out.

Allandale.

The facts connected with the distribution and characters of the Primordial rocks south of the First Loch Lomond Lake have already been given in an earlier report, as also lists of the fossils found at Ratcliffe's mill-stream, three miles south of the head of the lake, by which their age was first determined. The beds below the fossiliferous strata at the latter point are as follow :—

Section on Ratcliffe's mill-stream.

Coarse grey shale and hard grey sandstone, nearly vertical.
Fine purple sandstones and grey sandy shales. Dip S. 30 E. $<$ 90°.
Fine sandstones, banded or ribbanded with grey and purple.
Fine olive-grey shale. Dip S. 30° E. $<$ 90°, declining to 70°.
Purplish-red sandy slate. S. 20° E. $<$ 30°.
Purplish conglomerate, with pebbles of quartzite, felsite, red jasper, etc.; the dip declining from 10° to 0°, and subsequently becoming N. 70° W. $<$ 10°. From this point the dip of the beds becomes exceedingly irregular, varying within ten feet from S. 50° E. $<$ 40° to S. 10° W. $<$ 90°, and forming a series of folds, in some of which the conglomerates or sandstones, in others the olive-grey shales, come into view. The beds are also much faulted. About half a mile above, the fossil-bearing beds may be seen to rest upon the syenites before described as extending thence across the Quaco road towards Negro Lake.

In tracing the Primordial belt to the eastward of Loch Lomond it soon shows a tendency to bifurcate, one branch, the northern, extending as far as the head of the Third Lake in the direction of Barnesville, while the main band trends more to the southward, sweeping around a high ridge of Huronian rock, and from the head of Ratcliffe's mill-stream extending eastward to the valley of Germain Brook. Along

Third Loch Lomond.

the highway south of the Third Lake the grey sandy shales of the series may be seen at several points with a dip which is at first N. 25° W. $<$ 30°, but which gradually changes to N. 20° W. $<$ 70°, N. $<$ 80° and N. 10° E. $<$ 50°. Along the course of a small brook at the head of the lake the beds are fossiliferous, and fossils (similar to those of Ratcliffe's mill-stream) may also be found a mile or so to the southward, on the farm of R. Stackhouse. The inferior coarse beds of the series, consisting of purplish-red conglomerates, full of white quartz pebbles, are finely exposed along the course of the post-road to Barnesville, where they dip S. $<$ 30°, and are associated (as at Ratcliffe's) with very fine grey sandstones, banded with purple. The last beds visible in this direction are not far from the head of the Third Lake, but from their course at this point and the occurrence further eastward of numerous large blocks of purple sandstone, it is conjectured that a spur of Primordial rocks may at one time have extended through the valley of South Stream to its junction with Hammond River. The soft grey shales overlying the ferruginous sandstones and purple conglomerates at the mill in Barnesville may possibly be of this series.

Fossils.

Between the head of Ratcliffe's millstream and Germain Brook there are but few exposures of the Primordial rocks, the valley which they occupy being mostly filled with drift as well as reduced in breadth by the approximation of the bordering Huronian belts and the occurrence of an extensive outlier of Lower Carboniferous sediments. They may, however, be seen in Hardingville and at many other points along the valley of Germain Brook nearly to Hammond River, consisting as usual of grey and dark grey (often pyritous) sandy shales and flags, exhibiting numerous and often abrupt corrugations, but having a general northerly dip, which decreases as the main stream of Hammond River is approached. In the valley of Porter's (or Harding's) Brook the lower beds of the series are well-exposed, and may be traced thence in a nearly north-east course across the valley of Handford Brook towards the settlement of Upperton. Both at Porter's and at McAfee's (or Upham's) mill the facilities for the collection of fossils are all that could be desired, but as the beds are here much softer and more fragile than at Ratcliffe's and other points to the westward, the obtaining of good specimens is more difficult. The beds at Porter's are especially remarkable for the abundance of minute trilobites *Agnosti*. Among the specimens collected from this locality during the past season, the following genera and species have been recognised by Mr. Whiteaves:

Hardingville.

Porter's Brook.

Handford Brook.

Fossils.

Agnostus similis. Hartt.
" *Acadicus.* "
" *N.* Sp. (?)

Hyolithus. N. Sp.
Conocephalites orestes. Hartt.
" *Hallii* "
Paradoxides Micmac.

And from McAfee's Handford Brook :

Agnostus Acadicus. Hartt.
Conocephalites Mathewi. Hartt.
Microdiscus punctatus. Salter.
Discina Acadica. Hartt.
Orthis Billingsii. Hartt.

Beneath the fossil beds upon the two streams above-mentioned, the coarser fragmental beds which mark the base of the series are also well-exposed. Their unconformability to the Huronian is well seen in the fact that while on the post-roads meeting at McCoy's Corner they have a surface breadth of over a mile and a-half, with a nearly uniform dip of N. 30° W. $<$ 20°, on Handford Brook, only half a mile distant, the same space is occupied almost entirely by Huronian sediments, and these with numerous corrugations. The succession as seen above McAfee's mill on the last-named stream is as follows, in descending order :—

Section on Handford Brook.

	FEET.
Fine soft and fragile shales, filled with fossils and containing bands of harder grey shale. Thickness about........................	30
Hard grey shales and sandstones, dip N. 10° W. $<$ 40°.............	150
Pure white quartzite or silicious sandstone. The dip of the beds, in the extension of which, a little to the eastward, a quarry has been opened, varies from N. 10° W. $<$ E. 30° to N. 20° E. Their breadth is about..	250

Below these quartzites there is a space of about 1,100 feet occupied by the mill-pond, in which the measures are concealed. Grey sandstones then appear, with a dip N. 30° W. $<$ 30°, beneath which are—

Sandy and micaceous shales, in narrow alternating bands of grey, green and purple ;
Purple sandstones, with scales o mica ;
Purple grits and sandstones ; and
Coarse purple and quartz conglomerates, with thin beds of white conglomerate.

The general dip of these purple beds is N. 30° W. $<$ 30°, varying to N. $<$ 60°, but owing to the windings of the stream, which often runs with the strike, their thickness is uncertain. The conglomerates at their base, which are full of white quartz pebbles, rest, apparently unconformably, upon amygdaloidal diorites already described as being a part of the Huronian formation.

Eastward of McAfee's mill the Primordial rocks are mostly concealed from view. Ledges of purple sandstone may, however, be seen a little

Hammond River.

south of the bridge across the Hammond River in Upperton, beyond which the entire formation passes beneath the Lower Carboniferous series, and is not again met with in this direction.

In addition to the main belt of Primordial rocks above described, reference has been made, both on an earlier page and in former reports, to the occurrence of beds of this age in the valley of Black River in St. John County, as also upon the St. John River in the valley of the Long Reach. At both of these points their relations to the Huronian are in the main similar to what has been above described.

Black River.

The exposures in the Black River Valley are extremely limited, being confined to a few ledges of dark grey fossil-bearing shales occurring about midway between Willow Grove and Garnett Settlement. Their exposed breadth does not exceed 150 feet, and they are apparently overturned, being at one point directly overlain by purple sandstones which come in between them and the diorites of Bloomsbury Mountain, with a southerly dip (S. 30° E. < 20°). In the opposite direction, and on the north side of the river, there are ledges of a peculiar jet-black sandstone or black slate, filled with glassy grains of quartz, but whether there are a part of the Primordial series or not is unknown. A little farther to the eastward, in Willow Grove, a series of grey shales, which are probably Primordial, overlie the pre-Silurian schistose belts of Division 4.

Primordial Belt on Long Reach.

When the Report of 1870-71 was published, the only point at which the St. John group had been identified in the valley of the Long Reach was on Caton's Island, about two miles below Oak Point, although certain dark-colored slates exposed on the western side of the Nerepis River were believed to be a part of the same series. Observations made during the past season not only confirm this view, but show that a belt of these rocks traverses, though with some interruptions, the entire length of the Long Reach valley from its western extremity to Gorham's Bluff, near the mouth of Belleisle Bay. The position and relations of the beds on Caton's Island as well as on the adjacent shore, with lists of the fossils here met with, have been given in earlier publications. To the westward of this point the beds are chiefly coarse purple sandstones and conglomerates, and may be seen at many points along the north shore of the reach as far as the Devil's Back, associated, however, with beds of more or less crystalline diorite and greenish-grey ash-rocks, all dipping southerly at an angle of 40°. The

Devil's Back.

Devil's Back itself is a somewhat prominent ridge, composed of a very homogeneous and obscurely stratified grey felspathic sandstone holding numerous chloritic specks; on the north side of the eminence these felspathic sandstones may be seen to rest directly and conformably upon the purple sandstones, both with a regular dip of S. 30° E. <

20°. Notwithstanding this conformity, it is probable that the mass in question is of Upper Silurian rather than of Primordial age, no rocks of similar character having been elsewhere observed in connection with the last-named series, while they very closely resemble many of the beds forming portions of the Upper Silurian formation as exhibited on the opposite shore of the river.

As far as the Devil's Back, the Primordial rocks lie altogether to the southward of the felspathic and granulitic rocks described on an earlier page as extending in this direction from near Caton's Island. After crossing the creek, however, which on the western side of the first-named eminence flows into the St. John River, the ridge of these rocks lies much more to the southward, and the Primordial beds are found on their northern flank, now dipping northerly. They are well-exposed on the road leading north from the steamboat landing at Jesse Belyea's, and contain numerous remains of trilobites and brachiopods. Beneath the shales, and also dipping northerly, are grey micaceous and rusty-weathering sandstones spangled with mica, which appear to rest directly on the granulitic rocks. These latter would thus appear to form a ridge flanked on either side by Primordial rocks, and to occupy the position of the pre-Silurian rocks of Division 4 in the southern metamorphic hills, to portions of which they also bear much resemblance. The same relation is also indicated at other points along the Reach shore, the purple sandstones (with some shales,) being found on either side of the granulite ridge and dipping away from it. Near Elliott's mill, on the Nerepis, there are coarse, dark, greenish-grey, white-weathering conglomerates containing pebbles of white quartz, grey and red sandstone, mica schist, &c., and dipping northerly (N. 29° E. < 60°), overlain by dark grey, sandy slates dipping N. 10° E. < 50°. This is just south of the great body of syenitic and chloritic rocks, described on an earlier page as occurring on the eastern side of the Nerepis River, and which are either of Huronian or Laurentian age.

Dislocation.

Fossils.

Nerepis River.

On the western side of the Nerepis, the character and relations of the different rocks have already been given in the Report of Progress for 1871. The beds which in position and character here appear to represent the shaly portion of the Primordial occur in the bed of a ravine about one mile above Belyea's Inn, but as far as could be ascertained are without fossils, and are greatly crumpled and broken. The next rocks to the south of these are conglomerates in heavy beds, in which both pebbles and paste consist largely of granulite or purple felspathic grit, similar to that of the range extending along the north side of the Reach. These beds dip northerly, and are underlaid to the south by purple sandstones and felspathic grits, beneath which again, after an interval, are green and red slaty beds and unctuous felspathic schists, dipping N. 30° W. $<$ 70°. These latter have the appearance of the pre-Silurian rocks of Division 4.

Gorham's Bluff. The representatives of the Primordial series at the head of the Long Reach are to be seen in a small cove forming a part of the southern shore of Gorham's Bluff, and consist of ferruginous grey sandstones containing poorly-preserved fossils. They have a southerly dip (S. 40°–50° E. $<$ 50°), and are flanked on the south by recomposed quartziferous felsites of an older series, continuous through Rocky Island with the granulites of the north shore of the Reach, and on the north by rubbly, dark-purple and sandy beds, which form the base of the Upper Silurian formation.

GEOLOGICAL SURVEY OF CANADA.

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

REPORT

ON THE

UPPER SILURIAN AND KINGSTON (HURONIAN)

OF SOUTHERN

NEW BRUNSWICK

1877

BY

G. F. MATHEW, M.A., F.G.S.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:
DAWSON BROTHERS.

1879

Alfred R. C. Selwyn, F.R.S., F.G.S.,

Director of the Geological and Natural History Survey of Canada.

Sir,—In 1877, I had the honor to submit to you a report on the geology of certain parts of Charlotte County, in New Brunswick. Among the formations brought under review at that time was a set of beds to which the name of Kingston series had been applied. Two areas or belts of these rocks had been described as occurring in that county, of which the more northern was found to resemble the Upper Silurian strata of the Mascareen area, and was referred to that formation. But the evidence obtained in Charlotte County was not sufficient to determine the age of the southern belt, which consists largely of crystalline schists, and a decision upon this point had to be left till such time as the eastern extension of this belt could be examined. The result of this examination is contained in the following report.

While I was engaged in this work Prof. Bailey was occupied with the survey of the Huronian formation and the St. John Primordial Silurian group, and with a view to the more careful comparison of the rocks of these series as seen near the coast, and the resembling formations in King's County, some three weeks were spent by us together, partly in one district and partly in the other, in a review of their respective features.

I am, sir,

Your obedient servant,

G. F. MATHEW.

St. John, N.B., December, 1878.

REPORT

ON THE

UPPER SILURIAN AND KINGSTON (HURONIAN)

OF

SOUTHERN NEW BRUNSWICK,

BY

G. F. MATHEW, M.A., F.G.S.

Upper Silurian.

In describing the geology of the Kingston Peninsula, which formed my field of work for a few weeks last summer, I shall first give a brief account of the Silurian rocks on its northern side. During a visit made to this district in the summer of 1877, some beds along the shore of the St. John River had been found to be fossiliferous. The rocks in which fossils are found extend from near Bostwick's Brook, near the upper end of the Long Reach of St. John River, to and beyond Carter's Point, near the lower end of the same sheet of water. The organic remains are mostly enclosed in thin beds of hard grey shale interstratified with fine dark grey felspathic rock, more or less amygdaloidal. But the corals are also scattered through the amygdaloid. The fossils in this and in the shale are of the genera *Orthis*, *Strophomena*, *Rhynchonella*, and *Spirifier* (or a wide-ribbed *Orthis*) ; also joints of encrinites a large spiral shell and corals apparently of the genera *Zaphrentis* and *Favosites.*

In tracing the felspathic rock along the shore it was found to present several variations, from a fine-grained rock of uniform appearance to a coarse breccia-conglomerate, holding blocks of from one inch or less to two feet in diameter. At Whelphy's and Williams's Beach the enclosed fragments are of an olive-grey felspathic amygdaloid, having vesicles filled with calcspar, dark green chlorite, rose-red felspar, white quartz and silvery mica. In places where the conglomerate is absent the rock is usually fine-grained and of a dark purplish or greenish-grey color, highly felspathic, and containing vesicles and irregular veins of calcite. The rock also passes into a flesh-red or grey, quartziferous felsite, speckled with grains of quartz and felspar. Below Carter's Point it contains well-defined beds of red felsite and holds a few poorly-preserved corals. In its several varieties this felspathic rock closely resembles the breccias and ash-rocks of the Huronian formation in St. John County, but the enclosed fossils show that it belongs to a later age.

The dip of the breccias and ash-rocks in which these fossils are contained, and which rise in abrupt hills along the south shore of the Long Reach, is only occasionally determinable, but it has been observed at three principal points along the shore; and varies from a low angle, 20° in the middle of the Reach, to 40° at the easternmost exposures, and 60° at the western end.

At the road from Carter's Point to Milkish these ash-rocks come very near the crystalline schists of the Kingston Huronian formation, but from this point eastward a constantly widening band of Upper Silurian measures separates the two. The width is greatest at Kingston Creek, from which point it narrows again eastward along Bellisle Bay, to a point on the south side, half way up, whereon a Baptist chapel is situated, and where it terminates. In the widest part of the band, viz., at Kingston Creek, there are folds in the Silurian measures; but elsewhere they constitute a simple monoclinal fold, with the base upon the river and the higher beds dipping towards the Huronian schists and felsites. Considered in relation to the Upper Silnrian slates on the north side of the St. John River, however, the slates of this belt form the south side of an anticlinal fold whose axis runs along the course of that river.

At Carter's Point and at the end of Kingston Peninsula (Land's End) the Silurian belt is quite narrow, but on the west side of the river, near Westfield Station, there is a sudden widening of the Silurian rocks and certain groups of beds appear that are not visible in the Land's End. These beginning near Belyea's Inn exhibit the following succession, roughly measured by pacing:—

[As the measures are not well exposed, it is quite possible that portions of them may be repeated by faulting.]

Purplish and dark grey amygdaloidal felspathic rock, porphyritic, and having irregular cavities holding calcspar and round vesicles filled with chlorite	Thickness not measured.
Grey and purple calcareous slate	
Flesh-brown rusty-weathering felsite	

	FEET.	FEET.
Div. 1—Dark grey porphyritic slates, with chloritic scales.....		400
Div. 2—Measures concealed, partly grey clay slates...........	600	
Translucent dove-grey flinty felsites.................	200	
	——	800
Div. 3—Measures concealed, partly hard micaceous slates......	400	
Coarsely crystalline grey felspathic rocks	180	
	——	580
Measures concealed...............................		340
Div. 4—Calcareous felspathic slate	240	
Coarse amygdaloidal calcareous chloritic slate........	180	
Same varieties of rock in alternation	240	
Grey calcareous slates and bands of fine grey diorite..	730	
	——	1390
Div. 5—Pinkish-weathering slaty felsite, &c..................	300	
Fine breccia-conglomerate of similar rock and slaty-grey diorite	250	
	——	550
		4060

At this point the measures are concealed by a gravel ridge, beyond which crystalline schists of the Huronian series appear. The strata of the section above are those which (at page 123–4 Report 1870–1) are spoken of as lower Kingston beds. They dip toward and apparently beneath the crystalline Huronian rocks, but for reasons given above are now regarded as a part of the Upper Silurian series. The gradual increase in width of this Upper Silurian belt along the south side of the Long Reach, as well as the discordance in strike between its ash-rocks and slates, on the one hand, and the crystalline schists (Huronian), on the other, are considered, to show a contact of two unconformable formations. It may be mentioned, also, that patches of slate and schist, supposed to be Upper Silurian, are found within the area of older rocks, as, for instance, on the road from Crawford's Point to Centreville.

Kingston Series.

The tract occupied by these rocks to which attention was chiefly given, is that which extends south-westward from Kingston Creek to Land's End. In it no section of the measures which for amplitude and clearness could compare with that of New River, in Charlotte County, was observed. A summary of this section is therefore inserted for comparison and for illustration of the felsites and schists of Kingston :—

	FEET.
1. Compact felsite and diorite group	950
2. Hornblende and diorite schist group	4550
3. Mica schist group	2360
4. Felspathic gneiss group	2390
5. Chloritic gneiss group	800
	11,050

The observations made in Kingston Peninsula have been noted on a tracing, made by Mr. R. W. Ells from the Admiralty survey of the Long Reach and lower part of the St. John River, with the addition of his own survey of the shore roads around the Peninsula. My own observations relate chiefly to the several cross-roads, and to the Midland road, in Centreville.

Two anticlinal folds were found to traverse this district. One passing through Milkish Creek extends up the Centreville road and onward to Bostwick's; on the north side of this anticline is the mass of Kingston strata described in the Report of 1870–1, pages 121–2. The strike of the beds in this district carry them northward toward the Long Reach, where they come in contract with the Upper Silurian ash-rocks and seem to pass beneath them. The centre of the syncline in this area appears to be a ridge 525 feet high (aneroid measurement) near the middle of the Land's End. The breadth of the Kingston rocks on the south side of this ridge is nearly twice as great as on the north side, and there are probably faults on that side by which the measures are repeated. The strata in the central ridge are dark grey diorite, grey schistose and gneissic felsites, dark grey gneiss and felspathic gneiss. These varieties of rock are such as occur in the felspathic gneiss group.

On the south side of the anticline no very notable exposures were observed in this part of the Peninsula, but gneissic hills again become prominent in Centreville. There are two principal ridges, each about 500 feet high, near Centreville Corners, one to the south and the other to the east, but both on the line of strike of the same mass of gneisses; in the hollow between them the gneiss is much broken and injected with diorite. East of Bostwick's Brook, and also along the west side of Kingston Creek, felsite hills again become prominent, but the strike of the rocks is more northerly than it is in Centreville.

The second anticline extends from the vicinity of Clifton, on the Kennebecasis River, to the head of Kingston Creek; it runs mostly through lakes and low land, but a moderately good section may be observed along the west side of Kingston Valley, crossing the hills which overlook the valley on that side. Beginning at Kingston Lake, beyond which to the northward the measures are concealed by gravel beds, the lower beds (felsites, etc.,) are exposed in two hills. The rocks in them are chiefly dark grey diorite, with dark grey felsite, and beds of breccia-conglomerate, made up of fragments of grey and pale red felsite, and black and dark grey silicious slate, imbedded in grey felsitic paste. Dip S. 50° E. < 90°. On the south side of these hills are beds of clay-slate and hornblendic mica-schist. In the next hill going south the rocks are slaty hornblende and slaty, grey and dark-grey silicious felsite. The ledges are then concealed for a considerable space across the strike, but again become visible in two hills at the southern entrance to the valley. In these the rocks are chiefly schistose, grey, red-weathering felsites, the schistose structure showing a dip in one place of N. 30° W. < 70°. Much of the rock is coarse-grained, containing partly rounded grains of felspar. Beds and dykes of dark diorite are also present and are more abundant in the underlying mica-schists which appear further west, dipping S. 25° E. < 60°.

Age of the Kingston Series.

One of the main objects in the study of the rocks in Kingston Peninsula was to determine their geological age. Having found it possible to separate the ash-beds, slates and schists, on the north side of the Peninsula, from the more crystalline rocks of the centre and south side, it was observed that the latter, in the kind of rocks and their sequence, exhibit a strong resemblance to the Huronian formation of St. John county. This similarity is more noticeable in the eastern part of the Kingston belt than in the western, but the differences are not greater than the Huronian formation itself presents in different parts of St. John county. The following sections will show the resemblance between the two series, as shown at three selected points:—

UPPER SILURIAN (KINGSTON) SERIES.		HURONIAN.
New River, Charlotte Co.	*Kingston, King's Co.*	*St. John Co.*
Compact dark grey diorite and fine-grained flesh-red felsite.	Compact dark grey diorite, compact dark grey felsite, felsite breccia-conglomerate.	Dark grey diorite, Red and grey felsite; grey, reddish and black petro-silex; felsite breccias, coarse conglomerates.
Hornblende Schist, schistose diorite and Hornblende rock.	Hornblendic mica-schist, grey argillite, slaty hornblende, dark felspathic slate.	Chloritic schists, with grey, green and purple ash-rocks; purple slate, &c.
Fine-grained mica-schist.	Fine-grained mica-schist and felsite.	Pale grey felsites, hydro-mica schist, (common mica schist in King's County).
Silico-felspathic gneiss, felspathic gneiss.	Schistose felsites, felspathic gneiss.	Schistose felsites, felspathic gneiss.
Chloritic gneiss, grey argillites.	Chloritic gneiss and syenite, with thin beds of limestone; grey arglilites, &c.	

GEOLOGICAL SURVEY OF CANADA.
ALFRED R. C. SELWYN, F.R.S., F.G.S., DIRECTOR.

REPORT

ON THE

SUPERFCIAL GEOLOGY

OF SOUTHERN

NEW BRUNSWICK

1878

BY

G. F. MATHEW, M.A., F.G.S.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:
DAWSON BROTHERS.

1879

Alfred R. C. Selwyn, F.R.S., F.G.S.,

Director of the Geological Survey of Canada.

Sir,—The following description of the superficial deposits in the southern part of New Brunswick includes the results of observations, made at intervals, during the last ten years or more. These observations have been made chiefly in connection with the survey of the older rocks of the Province named, and have, in part, been published in the *Canadian Naturalist*, Montreal.* The substance of the articles in that periodical has been combined, in this Report, with later observations, into a connected description of the Superficial Deposits.

I am, sir,

Your obedient servant,

G. F. MATHEW.

St. John, N.B., December, 1878.

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* See *Canadian Naturalist*, New Series, Vol. 6, No. 1; Vol. 7, No. 8, and Vol. 8, No. 2.

REPORT

ON THE

SUPERFICIAL GEOLOGY

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The superficial deposits may be considered as forming three principal groups, viz.:— Classification.

I. Unmodified or Glacial Drifts, Boulder Clay, or Till.
II. Modified Drift.
  1. Stratified Sand and Gravel (Syrtensian Deposits).
  2. Leda Clay (Estuarine Deposits).
  3. Saxicava Sand and Raised Beaches (Littoral Deposits).
    a. Lower Leda Clay.
    b. Upper Leda Clay.
III. Modern Alluvium, Shell, Marl, Peat, &c.

These deposits consist of an aggregation of loose materials covering the older rocks, which have been consolidated, and afterwards extensively denuded before the formation of the oldest of tho above groups.

I.—UNMODIFIED DRIFT, BOULDER CLAY OT TILL.

This group is not only the most widely distributed of the three, but is found at all elevations, and is that from which the materials have been derived of which the later ones are composed. A description of the boulder clay and the related phenomena of striated and grooved rocks will therefore naturally form the opening part of this Report.

Great masses of the unmodified drift underlie the brick-clays of the second group in many parts of the State of Maine and the Provinces of

Quebec and New Brunswick, and spread upward to the tops of the highest hills in southern New Brunswick, where, so far as is known, they present all the appearance of a true till, or boulder clay. The later groups evince to a greater or lesser degree by their appearance the sorting power of water, but the boulder clay alone is unstratified throughout. It consists of sand and clay promiscuously mingled, and contains numberless striated stones, and angular fragments of rocks having no definite arrangement in the mass. From the sea level to a height of at least 200 feet above it, the boulder clay has been greatly modified by the action of waves and currents, and within these limits is usually concealed by the clays, sands and gravels of the second group; but at higher levels the unmodified drift is more frequently exposed, with its characteristic features—intermingled sand, clay and striated boulders.

Composition of Boulder Clay.

In general, the stones of the boulder clay are not moved very far from the places where they have been *in situ*. Ten miles or less is the usual limit, but instances occur in which the transportation has been for much longer distances. The following are the most remarkable instances of travelled boulders observed by Prof. L. W. Bailey and the writer:—At Bradford's Cove, on the St. Croix River, are stones containing large Spirifers and other fossils of Devonian age similar to those of the Oriskany Sandstone in the northern part of Maine. Fragments with similar fossils occur on Grand Manan Island, in the Bay of Fundy. A few miles north of St. Stephen a boulder of labradorite was observed, which Dr. T. S. Hunt recognized as the kind of rock which occurs in the Laurentian of the Province of Quebec. At St. John, I have seen trap with heulandite similar to a characteristic variety in the Lower Carboniferous formation at Grand Lake, in Queens county; also pieces of a felspathic sandstone, with Upper Silurian fossils, from Nerepis Valley, in the same county. In the till covering the granite hills in the Nerepis Valley there are comparatively few boulders from any great distance, the stones in the boulder clay being chiefly of slate, shale and sandstone, which have been swept across the plain of Carboniferous rocks and pushed up to the summits of these hills. Here they are mingled with numberless boulders of red and tawny granite derived from the surrounding ledges; but among the blocks of red granite there are a few well-rounded boulders of grey granite, that have come across the Carboniferous area of Sunbury county from the granite belt in the north part of York and Northumberland. Along the south side of this granite range there is a belt a few miles wide, covered with immense numbers of boulders; on the head-waters of the Lepreau and New rivers they are especially numerous. Granite boulders become less numerous in going south from the foot of

Transportation of Boulders.

this range, and their place is gradually taken by the slate, gneiss and dioritic fragments of the ledges in the lowlands, but even on the shores of the Bay of Fundy great numbers are still to be seen. A good instance of upward transportation is that of the stones on the top of Bald Mountain, the highest hill of the Nerepis range. Among these stones are numerous fragments of coarse diorite and hypersthenite, which have been swept up a steep slope on the north side of the hill from ledges 500 feet below the summit. Along the sides of transverse narrow valleys among these hills, and behind points of rocks, there are horizontal belts of boulders which have the appearance of having been forced or carried by ice into these positions.

The color of the boulder clay and overlying clay of the second group of superficial deposits is worthy of notice, as shewing the sources whence the clays have been derived. In the country west of the Magaguadavic Bay they are of various shades of grey, from ash-grey to a dark mouse-color, and such also are the prevailing tints in the adjoining part of the State of Maine. These grey tints are traceable to the wide bands of argillites that cross the northern part of Charlotte county and the southern part of York; the darker shades of grey originate in the Upper Silurian bands of clay-slates and the lighter greys in the Devonian argillites. The latter are generally calcareous, and the boulder clays from this source have a more fertile soil than those derived from other rocks in Charlotte county. The grey color of the clays in the western part of this county is very marked down to the sea shore, where, owing to their hardness, the bright red rocks of the Upper Silurian series seem to have caused no change in the color of the clay.

Color of the Boulder Clay.

The north-east branch of the Magaguadavic drains the northern margin of the Carboniferous area, and has cut its channel in the soft shales, of the Lower Carboniferous formation, which appear along its valley; here a change begins in the color of the clays, which shews itself chiefly in the contrast between the Leda clay and the underlying gravels in the valley of the Magaguadavic, as far down as the mouth of the Piskahegan. The Leda deposit here is mostly sand, but is distinguished from the older modified drift (*i.e.*, the underlying gravels) by its reddish tint. In the granite hills, further east, the red shade becomes more pronounced, varying from a pale fox-color to a warm reddish-brown tint; the clays obtain this deeper shade from the ochre-red Lower Carboniferous beds, and from the purplish-red and chocolate-brown shales of the coal measures in York and Sunbury counties. Still deeper shades of red and brown prevail in the clays of St. John county, to the northward of which areas of bright or deep red and chocolate-brown shales are more extensive than in York or Sunbury.

Red Color from Carboniferous Shales.

This peculiar coloring of the clays in the central part of southern New Brunswick shows that the eroding force was much more destructive in its effects upon the soft but low-lying and comparatively sheltered shales, than on the more prominent but harder rocks of the ridges and hills.

The fertility of the clay lands of this district may also be traced to the deposits of Lower Carboniferous shales to the north of them, which are sometimes highly calcareous, and have included beds of limestone.

Glacial Grooves.

Wherever the boulder clay is removed from the surface of the rocks upon which it rests, these are found to be rounded and scored with parallel grooves and furrows, caused by the action of ice in motion prior to the deposition of the boulder clay. The course of these grooves varies greatly in different regions; in the valley of the St. Lawrence it is south-westerly, and in the eastern part of Maine south-easterly. The striæ on the rocks in the southern counties of New Brunswick exhibit both these trends. A south-easterly course is most prevalent in the western part of Charlotte county, and south-westerly striæ are most numerous in the valleys east and north-east of St. John. These two general courses, as well as the intermediate ones, will be seen to be related to the contour of the surface of the land in the several districts where they occur; for, as a general rule, the furrows conform to the direction of the river valleys, or at least are influenced in their course by these depressions.

Two general courses in southern New Brunswick.

In the following table all the bearings are corrected to the true meridian. Such striæ or grooves as have been observed by Prof. L. W. Bailey are marked with an asterisk; those taken by Mr. R. W. Ells are indicated by an obelisk. Grooves described as "other striæ" are generally older than those recorded in the margin :—

No. 1 Table of Glacial Grooves.

No.	Parish.	Locality.	Exposure.	Course.
		S. W. part of York County.		
1	Prince William .	On E. & N. A. Railway, 3 miles S. W. from McAdam Junction	..	S. 45° E.
2	Manners Sutton.	S. end of ridge running N. W. from N. end of Oromocto Lake. Latest striæ S. 60° E. and S. 40° E..................	S. W.	S. 20° E.
3	"	Harvey Settlement,—road leading to Lester's mill. Latest striæ S. 45° E. and S. 50° E......	E.	S. 20° E. / S. 10° E.
4	"	Harvey Settlement, chapel in. Latest striæ S. 45° E. (few)................	..	
5	"	Cork Settlement ridge, one mile north of Cork Station. Latest striæ S. 20° E. (few)	E.	S. 20° E. / S. 30° E.
6	"	Cork Station	S. W.	S. 20° E.
		Charlotte County to and including Magaguadavic Valley.		
* 7	St. Stephen.....	Dennis Stream, 1½ miles from..........	..	S. 50° E.
8	St. David's	Oak Bay, east side of, opposite S. end of Roger's Island.....................	W.	S. 45° E.
* 9	"	On St. Stephen Branch R. R., Meadow Station	..	S. 40° E.
10	St. Croix.......	Bradford's Cove. Latest striæ S. 10° E.	..	S. 40° E.
11	"	Shore of St. Croix River, opposite Doucet Island. Latest striæ S. 20° E., in a valley	..	S. 5° E.
* 12	"	Chamcook Mountain, W. end of, under cliff overhanging about 60°	W.	S. 10° E.
13	"	Chamcook Lake, E. shore of, on E. side of a ledge that overhangs 20°. Striæ converge from N. W. on the overhanging face.....................	E.	S. 50° E.
14	"	Chamcook Lake, near outlet. Latest striæ S. 25° E	W.	S. 45° E.
15	St. Andrew's....	Chamcook Cove, E. side. Latest striæ S. 10° E.....	S. W.	S. 50° E.
16	Pembroke......	Village, State of Maine, U. S.........	N.	S. 40° E.
* 17	"	River, West Branch, State of Maine, U. S.	..	S. 50° E.
18	Eastport	State of Maine. Broad Cove—N. E. slope of a rounded ledge S. 60° E. On N. W. slope of same ledge.......	N.	S. 55° E.
* 19	West Isles	On Deer Island. Other striæ S. 65° E.	..	S. 50° E.
* 20	"	Pendleton's Island, N. E. end of.......	S. W.	S. 65° E.
21	Dumbarton.....	Wicher Ridge, south slope of..........	S. W.	S. 60° E.
22	St. Patrick.....	Bocabec Bay, head of. Latest striæ S. 10° E.; other striæ S. 20° E.; oldest striæ		S. 40° E.
		Near by, on ledge protected by a higher ledge to the N............ N. 70° E.		
23	"	Bocabec Bay. E. point of last striæ S. 5° E.; other striæ S. 20° E..........	W.N.W	S. 40° E.

No. 1 Table of Glacial Grooves.—*Continued.*

No.	PARISH.	LOCALITY.	Exposure.	Course.
24	"	Bocabec Lake. North side of last striæ S. 35° E....	S. W.	S. 25° E.
* 25	"	Bocabec River. Other striæ S. 55° E....	E.	S. 45° E.
* 26	"	Bocabec Bridge. Other striæ S. 70° E...	N.W.	S. 30° E.
27	"	Duncan road, $1\frac{3}{4}$ miles N. from Turner's mills....	N. E.	S. 25° E.
28	"	Digdeguash Valley, near N. end of Duncan road. Latest striæ N. 70° E.....	E.	S. 30° E.
29	"	Digdeguash Basin, W. of mill at, in deep, narrow valley; course S....	..	S. 30° E.
30	St. George......	Hill between Piskahegan and Magaguadavic River, N. slope of....	W.	S. 60° E.
* 31	"	Magaguadavic River, mouth of estuary, N. side, on steep ledge....	S.S.W.	S. 80° E.
		Near by, on another ledge; other striæ S. 55° E....	..	S. 60° E.
32	"	Creek, on south side of estuary of Magaguadavic River....	N.W.	S. 85° E.
33	"	Letite, mill-cove Brook, at....	N.W.	S. 60° E.
34	"	Letite Harbor, head of. Last striæ S. 75° E....	N.W.	S. 25° E.
35	"	Magaguadavic River, falls of. Other striæ S. 80° E....	S. W.	S. 60° E.
* 36	"	Lake Utopia, W. side of....	..	S. 20° E.
37	"	L'Etang River, N. W. side of basin at head of. Later striæ S. 80° E....	N. E.	S. 60° E.
38	"	L'Etang River, S. W. side of basin at head of. Later striæ S. 80° E....	W.N.W	S. 60° E.
39	Pennfield	L'Etang River, E. side of basin at head of....	S.	S. 15° E.
40	"	L'Etang River, ridge S. E. of....	N.W.	S. 5° E.
41	"	L'Etang River, E. side of narrows of. High hill on W....	N.	S. 60° E.
* 42	"	L'Etang Harbor, Bliss Island, at....	N. E.	S. 30° E.
43	"	Black's Harbor....	..	S. 60° E.
44	"	Beaver Harbor, Head of. Older striæ S. 30° E....	N.	S. 60° E.
45	"	Beaver Harbor. On ridge S. of last. On S. E. slope of ridge is a rounded ledge 4 × 10 × 30 feet, exposed on road side. Oldest striæ S. 10° W.; latest striæ S. 80° E.; chief striæ S. 30° E., curving to....	(S. E.)	S. 40° E.
		On N. side of ledge are a few later striæ S. 20° E....	..	
46	"	Point between Deadman's and Beaver harbors....	..	S. 10° E.
		Charlotte County—Eastern part.		
47	Clarendon......	Bear Brook (broad valley)....	N.	S.
48	"	Sand Brook (narrow valley)....	N.	S. 10° E.
49	"	McLeod road, $1\frac{1}{2}$ miles from Douglas Valley....	N.W.	S. 10° E.
50	"	Falls Brook, in an open valley....	N.	S. 20° E.
51	Lepreau	Harbor, north side....	S.	S. 10° E.
* 52	Lepreau	Basin, eastern end....	W.	S. 20° E.

No. 1 TABLE OF GLACIAL GROOVES.—*Continued.*

No.	PARISH.	LOCALITY.	Exposure.	Course.
		Sunbury and Queen's Counties.		
53	Blissville	Fredericton Junction. E. & N. A. R. R., Ridge one mile S. of	N.N.W.	S. 5° E.
54	"	Forks of Fredericton and Clones road ..	N.N.E.	S. 25° E.
55	Petersville	Fredericton road, E. side of Stony Ridge	N. E.	S. 20° E.
		Parish Church, Headline Hill	..	S. 35° E.
56	"	Ollinville Settlement	..	S. 60° E.
† 57	"	Wilson road, in Clones Settlement.		
58	Gagetown	Oldest striæ S. 35° E.; chief striæ S. 45° E., curving to	(S.W.)	S. 40° E.
59	Hampstead.....	E. of Blue Mountain, on slope to Long Lake	N. E.	S. 35° E.
† 60	Northfield......	Newcastle River, above Yeoman's Bridge	N.	S. 15° W.
		King's County.		
* 61	Westfield	On E. & N. A. R.R., 8 miles from Fairville	..	S. 40° E.
62	"	Near bridge over mouth of Nerepis River, W. side of valley. Striæ course S. 75° E., bending round end of ledge to	..	S. 65° E.
		Near top of hill overlooking this point.	E.	E.!
* 63	"	Brittam's Point, hill S. W. of Parsonage		S. 20° E.
64	"	Summit of Hill, 525 feet high, near Land's End	..	S. 10° E.
65	"	Kennebecasis Island, N. side of (S. of a ridge running N. E.)	S. W.	S. 30° W.
66	"	Kennebecasis Island, N. E. end of hill to E......	S.S.W.	S. 20° W.
67	"	Carter's Point, near corner of road to. Finer striæ cut on points left by these grooves and mark the bottoms of these grooves. Course of the fine striæ W.!	N. ..	S.
68	"	Milkish Valley, on its S. E. slope. Course of valley S. W....	N.W.	S. 15° E.
		These striæ found only on faces sloping to N.; another fainter set run into the deeper hollows and grooves exposed to a down-hill thrust from the E. Course S. 60° W.!		
69	"	Milkish Valley, East of................	S. W.	S. 20° E.
70	"	Milkish Valley, N. side of a low gneissic ridge. Other striæ S. 20° E..........	W.	S. 50° E.
71	Greenwich	Devil's Back, N. side of, on pp. sandst..	N.	S. 25° W.
72	Kingston.......	On Long Reach road, near Whelphy's Beach	S. W.	S. 5° E.
		Also lighter scratches, showing only on S. E. slopes..............N. 60° W.!	..	
73	"	Centreville, eastern base of hill (500 feet high) to S. of..................	E.	S. 20° E.
74	"	Centreville, hill to E. of (Midland road)	W.	S. 5° E.
75	"	Bostwick's Brook, on Long Reach	N.	S. 5° E.
† 76	"	Bellisle Bay, S. side of	N.	S. 15° E.
77	Rothesay.......	Golden Grove Settlement, S. side of valley	N.	S. 5° E.
78	Upham	Barnesville, road going E. from, hill on	N.	S. 15° E.

No. 1 TABLE OF *GLACIAL GROOVES*.—*Continued*.

No.	PARISH.	LOCALITY.	Exposure.	Course.
* 79	"	Barnesville, same road, 2 miles E. of last, on ridge facing a deep valley running N	E.	S. 10° E.
* 80	"	Hill N. of McCoy's corner, on opposite (E.) side of last-named valley........	..	S. 10° E.
* 81	Hammond	John Wallace's, 1 mile E. of Walton Lake	N.	S. 65° E.
82	Musquash	W. branch Musquash River, at Mill Valley, E..........................	N.N.W.	S. 50° E.
83	"	Village, at McGowan's Inn.............	S. E.	S. 20° E.
84	"	Musquash Harbor, W. side of Narrows ..	E.	S. 40° E.
85	"	Musquash Harbor, Connor's Cove, E. side	N.W.	S. 30° E.
86	"	Musquash Harbor, Frenchman's Creek, at bridge, in narrow valley. Other striæ S. 5° E....	N.	S. 20° E.
* 87	Lancaster	Spruce Lake, near outlet	N.W.	S. 40° E.
88	"	Pisarinco Cove, Mill Creek. Other striæ S. 50° E........	N.W.	S. 40° E.
89	"	Pisarinco Cove, N. side................	..	S. 35° E.
* 90	"	On E. & N. A. R.R., 4 miles from Fairville	..	S. 40° E.
* 91	"	South Bay Mills. Other striæ S. 15° E.	N. E.	S. 40° E.
* 92	"	On E. & N. A. R.R., 3 miles from Fairville	N.N.E.	S. 30° E.
* 93	"	W. end of Suspension Bridge	N.N.E.	S. 24° W.
94	"	Sand Cove road. Striæ, on a steep ledge sloping N. W., deflected to S. 80° from	(N. W)	S. 40° E.
95	Carleton	Queen Square, on ledge sloping N. Other striæ S. 4° E..................	N. E.	S. 2° W.
96	"	Belltower Hill, under steep ledge facing	N.	S. 1°5 W.
		Same place, top of hill	..	S. 4° E.
97	Simonds	Lawlor's Lake, summit of valley at. Other striæ S. 20° W.; fainter striæ S. 30° W. and S. 45° W....	N. E.	S. 35° W.
98	"	On Black River road, 3 miles E. of St. John	W.	S. 2° W.
99	"	On Black River road, 1 mile N. E. of Mispec Bridge.....................	..	S. 35° W.
100	"	Mispec Harbor, in valley running S.S.W.	S.	S. 15° W.
101	"	Mispec, Thomas's Cove, near road	N.	S. 40° W.
102	"	Black River road at Brandy Brook	..	S. 20° W.
103	"	Beverage Cove road. Other striæ S	..	S. 15° W.
104	"	Beverage Cove road, descent to Bay of Fundy. Other striæ S. 35° E....	S. E.	S. 50° E.
105	"	Thompson's Cove road	..	S. 30° E.
106	"	Thompson's Cove road, slope to Bay of Fundy	..	S. 40° E.
*107	"	Negro Settlement, N. side of valley of Black River.......................	S.	S. 40° E.
*108	"	Hibernia road, 3 miles S. of L. Lomond	..	S. 50° E.
109	"	Mountain road to Black River Settlement, at Bloomsbury Mountain.......	S. W.	S. 25° E.
*110	"	Hibernia Settlement, ½ mile N. of Dougherty's Inn...................	S.	S. 20° E.
*111	"	Hibernia Settlement, ½ mile S. of Dougherty's Inn. Three sets of striæ, S. 10° E., S. 25° E., and..............	W.	S. 20° E.
112	"	Lake Lomond, N. side of First Lake, at thoroughfare to Second Lake.........	S. E.	S. 20° E.

No. 1 Table of Glacial Grooves.—*Continued.*

No.	PARISH.	LOCALITY.	Exposure.	Course.
113	"	Lake Lomond, N. side of Third Lake, near Lake level	S.	S. 20° E.
*114	St. Martin's.....	Hill W. of Henry's Lake	E.	S.
		Albert and Westmoreland Counties.		
†115	Elgin (Albert Co)	On road from Elgin to New Ireland, on mountain S. of Caldicott's Inn. Other striæ S............	N.	S. 10° E.
†115	Hopewell	Road from Curryville to Hopewell Hill, top of a high hill....................	..	S. 15° W.
†117	"	Woodworth Settlement, N. of Hopewell Hill, near top of table-land..........	..	S. 25° W.
†118	"	Road from Hopewell Corner to Germantown Lake, in a valley...............	..	S. 40° W.
†119	Coverdale	Dawson Settlement, ½ mile S. of Turtle Creek, on flat table-land	..	S. 60° E.
†120	Dorchester	Budreau Quarry. Other striæ S. 10° E..	..	S.

In the above table there are a large number of examples (No. 1 and Nos. 7 to 46) which shew the persistency of the south-easterly trend in the glacial grooves near the United States border, the most easterly courses being those in the parishes of St. George and Pennfield. Another group of lines (Nos. 47 to 55) which average only 15° east of south, is that which crosses the granite hills where they are widest. They are in the south part of Sunbury and east part of Charlotte counties. The striæ east of this (Nos. 56 to 59, and 61, 53, and 82 to 92) descend through the cross valleys in the direction of the St. John River. A fourth group of striæ is that which crosses the peninsula of Kingston, and the hill ranges eastward in Hampton and Upham (Nos. 64 to 80, 108, and 113 to 114), where the average is 10° east of south, with a few westerly courses in the deeper valleys. A fifth group of striæ includes grooves around the city of St. John and eastward of it (as Nos. 93 and 95 to 103). These exhibit the greatest amount of westing (average south 20° west), being directed toward the harbor and roadstead of St. John. In the sixth group a return to an easterly trend (average south 36° east) is observable in the striæ on the land east of St. John harbor, sloping toward the Bay of Fundy. (See Nos. 104 to 107, and 109 to 112.)

These several courses exhibit the influence of the hills and valleys of the southern counties in diverting the striating force from a direct southerly course. Some unusual departures from the normal course of the striæ, in several of these groups, may have a bearing on the question of final or local glaciation in this region. Such are Nos. 22, 28, 37, 38, 45, 62, 67, 68 and 72; and the plasticity of the striating force may also be inferred from the peculiarities of Nos. 12, 13, 62 and 94.

The course of the grooves in the south-western part of Charlotte county, appears to be connected with the peculiar conformation of the sea bottom in the part of the Bay of Fundy which extends in front of the group of islands in the parishes of West Isles and Grand Manan. To the south-east of these islands there is exceedingly deep water, forming a gulf or abyss more than a hundred fathoms deep. It is widest toward the Nova Scotia shore, where the descent to the bottom of the gulf is very steep, there being 100 fathoms at Bryer Island, half-a-mile off the north-west ledge. A tongue of deep water extends from the abyss in the direction of Letite passage, and toward it, and the deeper water beyond, the glacial grooves in that part of the county converge.

II.—MODIFIED DRIFT.

A correct knowledge of the relation of the different members of the second group of surface deposit is of much importance, when for purposes of drainage, road building, etc., it becomes necessary to break up the covering of loose materials which rest upon the surface of the solid rocks in this region. A definite order prevails in the succession of the different members of this group (Modified Drift), which gives the clue to the natural drainage of the land, and to the proper position for sinking wells, locating drains, etc., but which is apt to be misunderstood, owing to the way in which gravelly hillocks and ridges of the oldest member of the group rise abruptly above the level flats or undulating surfaces formed by the beds of the second member.

This member usually consists of clay beds impervious to water, and hence from its upper edge overlaid by sandy beds, or from the lower edge, which often rests upon sand or gravel, springs are apt to rise and flow off. Much money is often fruitlessly expended in sinking water-wells, which might be saved by even a rudimentary knowledge of the relations of the various portions of the surface deposits to each other.

So also in the matter of choosing sites for brick-yards, much advantage would result to the manufacturer if more attention were given to the composition of the clay beds of this group, for they not unfrequently contain within themselves the proportion of clay and sand suitable for the manufacture of bricks. Or spots could be chosen where the sands of the upper member of the group are in contact with the clay beds, and supply the necessary quantity of sand. Attempts are some times made to operate brick-yards where neither of these conditions are fulfilled, but where the sand for mixing with the clay has to be brought from a considerable distance.

In many places there are areas of arable land which remain wet, cold, and unproductive, owing to the fact that such areas are underlaid at a slight depth by clay beds forming shallow basins which hold the water and saturate the porous soil which covers them. In this case, as well as that referred to above, where springs come from the upper or under surface of the clay beds, a judicious system of drainage would greatly improve the land for agricultural purposes.

1.—*Stratified Sand and Gravel.*

(*Syrtensian Deposits.)

This member of the Modified Drift rests immediately upon the Boulder Clay, and there are sections at the coast where a gradual change from the mingled materials of the latter group to the grey stratified beds of the former is marked by the occurrence of a few irregular, alternating beds at the line of contact. Some of these layers being red boulder clay, and others grey gravel and sand. In the flat interior of New Brunswick this member consists largely of sand beds; but in the valleys among the southern hills much coarse material is mingled with the sand, and in narrow, confined valleys the deposit is apt to be composed largely of gravel, and to contain great numbers of boulders more or less rounded and the striæ obliterated. The beds are distinctly stratified and often obliquely laminated. They are mostly of a grey or brownish color, owing to the fact that the clayey particles have been sorted out by the action of a swiftly moving current of water. In sections such as may often be seen in banks along the sea-coast, where the whole series of surface deposits is represented and well exposed, this member shews as a grey band separating the reddish boulder clay beneath from the red Leda clay in the upper part of the series.

Over the open plain of the interior of New Brunswick the sand beds are thin and mostly concealed by Leda clay, but among the hills southward of this plain, where the valleys are deep and narrow, and the cutting power of the current which sorted out the sand was brought into more active play, the arenaceous deposit shews itself from beneath the clay in the form of gravel ridges and domes, and becomes more conspicuous than in the flat country further north.

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*Marine Shoals or Banks. For meaning and use of this name, see Can. Nat., vol. 8, No. 2 p. 106.

Classification of gravel ridges.

The ridges or kames vary in form according to their relation to the neighbouring hills, and to the valleys and gorges between them. The principal forms are:

1st. The *Weather Shoal.* This is found on the north side of a hill, or on one or both sides of the northern entrance to the gorge or valley; it usually has a rounded form, slopes gently down to the low land in front, and often has a hollow behind it, partly separating it from the solid rock of the hill side.

2d. The *Lee Shoal.* This has gathered behind a hill or the outlet from a valley.

3d. The *Centre Shoal.* This is an accumulation of gravelly materials formed in the enlargement of a valley or in the open space beyond its outlet, or upon the tops of rocky ridges. *Giants Graves* and *Whale-backs* are local names for varieties of this type; the former are small, with steep sides, and consist usually of gravel throughout their whole depth; while the latter are large, gently rounded, and have usually a substratum of boulder clay.

4th. *Horseback*, *Boarsback* or *Escar.* This type of gravel bank ususally extends along the top of rounded slate ridges, forming a crest sometimes many miles in length; or it forms a connecting bank between neighbouring hills, or the opposite slopes of the valleys. There is an endless variety of intermediate forms connecting these four types of gravel ridges, due to the varied action of the currents by which they were accumulated.

A description of the most characteristic of the gravel ridges or kames, is given in the following table, in which all the bearings are corrected to the true meridian. When two or more courses are given, the first is that of the northern end of the ridge. Ridges observed by Prof. L. W. Bailey are marked with an asterisk; those noted by Mr. R. W. Ells with an obelisk.

No. 2.—Table of Kames and Gravel Ridges.

No.	PARISH.	LOCALITY.	Kind of Ridge.	Length in miles.	Direction.
1	Prince William	One mile S.W. of McAdam Junc. (E. & N. A. R. R.) at E. end of a granite ridge	Crescent-shaped ice-shoals and whalebacks.	..	S. 50° E.
2	St. James.....	St. Croix River, W. side of, extending from Little Simsquich to Kean's...	Horseback (two courses)	1¾	S. 30° E. S. 20° E.
*3	"	E. side of Canons River, on high land at upper end of Lynfield road ..	Horseback.		S. 40° E.
4	"	On road to Oak Hill, separating Cranberry Lake from the source of Moannes Stream. A ridge in two parts, separated by a hollow running S.	Whaleback and Horseback.	1¾	S. 50° E. S. 45° E.
5	"	On road to Basswood Ridge three miles S. of the last..................	A sharp whaleback.	1¾	S. 45° E. S. 25° E.
6	St. Patrick....	Valley of Digdeguash Riv. A series of ridges crossing the valley.........	Giant's graves, whale back & weather shoal.	2½	S. 40° E.
7	"	Clarence Ridge, mostly of boulder clay	Whaleback.	2½	S. 35° E.
8	"	Morrison Ridge S. of Clarence	Whaleback.	1½	S. 40° E.
9	"	A lower and flatter ridge, S. W. of Morrison Ridge and mostly boulder clay	Whaleback.	1½	S. 40° E.
10	"	W. of Bobee L., flat-topped .	Whalebacks and horsebacks.	1	S. 40° E.
11	Dumbarton ..	E. of Flume Ridge, in valley of Magaguadavic R.		3	S. 50° E. S. 30° E. S. 45° E.
12	St. George....	Valley of Magaguadavic R., betweenPomeroy Bridge and Piskahegan River..	A succession of Kames.	1	about S. 40° E.
†13	Clarendon	S. W. corner, E. of McDougall Lake.........	Horseback.	1½	S. 30° E.
†14	Pennfield.....	From S. end of Clear Lake, along west side of Popologan River...........	Horseback.	2	S. 30° E.
15	St. George....	Lake Utopia, S. of (parallel but less continuous ridges N. and S. of these)	Whaleback and weather shoal.	1½	S. 40° W. S. 50° W.
16	Pennfield.....	Below Cripp's Mill-stream, on road to Black's Harbor	Giant's grave.	..	W.
17	"	Pennfield Ridge, southern end of................	Gravelly plateau.	2½ ¾	S. 65° W. S. 80° W.
18	Musquash	Musquash River, W. of, on post road to Lepreau...	Gravel ridge.	¾	S. 45° W.
19	"	S. of Musquash Marsh (E. of last)	Whaleback.	1½	S. 55° W.
20	"	Musquash Harbor, west of "Narrows"	Whaleback.	1¼	S. 60° W.

No. 2.—Table of Kames and Gravel Ridges.—*Continued.*

No.	PARISH.	LOCALITY.	Kind of Ridges.	Length in miles.	Direction.
21	Lancaster	Pisarinco, ridge ending at Negro Head...........	Flattened gravel ridge.	..	S. 60° W.
22	"	Manawagonish, longest course of Kames, on Post-road to Musquash	Flattened horseback.	$1\frac{1}{2}$	S. 50° W.
23	Simonds	Mount Prospect, top of.....	Whaleback.	$\frac{1}{2}$	S. 45° W.
24	"	E. side of Otter Lake. (For courses and distances of continuation of this horseback, see end of table).................	Horseback.	$\frac{1}{16}$	W. S. 65° W.
25	"	Ben Lomond Hill, 400 paces W. of...........	Horseback and whaleback.	$\frac{1}{4}$	S. 20° E. S. 10° W.
26	"	Head of Loch Lomond, on road to Golden Grove, several parallel ridges at lower levels on hill side	Lee shoal.	..	S. 10° E.
27	Westfield.....	Carter's Point, on Long Reach, St. John River, height about 100 feet... A lower ridge on W. side of this	Whaleback.	$\frac{1}{2}$	S. 20° E. S. 10° W. W. or E.
28	"	N. of Harding's Point, W. end of Long R., 120 feet high (aneroid measure't)	Round flat-topped centre shoal.	$\frac{1}{8}$	....
29	"	Ridge S.W. from Harding's Point, 115 feet high (aneroid measurement)....	Triangular whaleback.	$\frac{1}{8}$	S. 65° E. E.
30	"	Brundage's Point, S. of, on slope of land up from W. shore of St. John R.	Whaleback, horseback, whaleback.	1	S. 30° W. S. 20° W. S. 20° E.
31	Kingston	Clifton, S. of Waddell's Lake (short)..........	Centre shoal.	..	S. 20° W.
32	"	W. of mouth of Bostwick's Brook (along road side) about 150 feet high....	Whaleback.	$\frac{1}{4}$	S. 25° W.
33	"	Centreville, Lake at J. Williams's	Stony ridges.	$\frac{1}{4}$	S. 30° W.
*34	Upham	Barnesville, opposite Dr. Brody's, and southward toward mill...........	Horsebacks.	$\frac{1}{2}$	S. 5° W. S. 35° W.
35	"	In valley of Germain Br'k..	Whaleback.	..	S. 60° E.
36	Hammond (or Sussex)	Crossing valley of Hammond River, one mile below Fowler's Inn......	Horseback.	$\frac{1}{2}$	....
*37	"	John Wallace's. Ridge N. of Walton L. (Course of valley N. 10° E.)		$\frac{1}{8}$	S. 45° W.

North of Otter Lake, in St. John county, and separating it from a marshy tract dotted with ponds, is a remarkable horseback, over which runs the road to Loch Lomond. It begins on the W. side of the outlet of the lake, about 100 paces from No. 24 of the above table. Prof. Bailey gives the following courses and distances:—

78 paces @	S. 81° W.			40 paces @	S. 64° W.		
20 "	S. 68° W.	2nd outlet of L.		88 "	S. 61° W.	L. on both sides.	
86 "	S. 68° W.			108 "	N. 72° W.		
65 "	S. 73° W.	Otter Lake on left.		78 "	N. 64° W.	S. slope of ridge.	
72 "	N. 89° W.			75 "	S. 45° W.	Across end of ridge	

Three tracts of gravel ridges.

In the region covered by the kames described in this table there are three tracts, each characterized by certain peculiarities in the ridges. In the middle tract, which includes the Oromocto and Nerepis valleys, the ridges are mostly short and irregular, and none are recorded in this table. In the other two tracts they are longer, more conspicuous, and frequently coincide with the course of the rocky ridges beneath, but while in the western tract they are directed to the south-east, in the eastern they generally trend to the south-west. It will be seen that the western group of south-east kames occurs in nearly the same district as the first group of glacial grooves, and the ridges coincide in direction with the course of the grooves; but in the eastern district, near the coast, there is a wide difference between the course of the gravel ridges and the striæ or grooves, the two running nearly at right angles with each other; or, as at Lake Utopia, diverging still more widely.

Ridges at Lake Utopia.

Lake Utopia discharges by a deep narrow channel into the Magaguadavic above its lower falls, but is divided only by a gravel ridge from tide level at L'Etang River. The dividing kame is a compound one, consisting in its eastern part of a whale-back or centre shoal, and in its western of a weather shoal terminating against a slate ridge, the two gravel ridges being partly separated by a shallow depression. The centre shoal begins back of Reardon's Corner, with a course south 45° west, and terminates in a point directed south 55° west; the connected weather shoal runs south 50° west against the ridge of clay slate. In a hollow south of the weather shoal, on the west side of L'Etang River are the striæ Nos. 37 and 38 of the first table in this report. The courses of the kames and the grooves, therefore, diverge at this place as much as 120°.

Ridges in Lancaster.

The kames in the parish of Lancaster also diverge at wide angles from the course of the glacial grooves. The gravel banks and ridges begin to the westward of Carleton Heights and the hills about the falls and narrows of the St. John River. There are several ranges of kames in this parish, of which the most southerly begins with a lee-shoal west of Carleton Heights. Its surface, which has been worked over and levelled by the sea, extends south 25° west, and is slightly overlapped by a small weather shoal jutting out from a lower hill beyond.

Sandy flats back of Sand Cove separate this hill from another weather shoal which rises gradually to the rounded ridge terminating at Sheldon Point. The western end of this ridge shews a well-defined lee shoal cut across obliquely by the sea, and exhibiting one of the most instructive sections of the surface deposits to be seen near St. John.*

Toward Sheldon Point the boulder clay may be seen resting upon striated ledges of Huronian rock, and succeeding the clay westward are beds of boulders and gravel, shewing by their overlapping layers, a westward moving current. The swelling outline of the bank is seen to be due to the thickening of the layers over the axis of the kame; and the whole is covered by beds of leda clay with characteristic fossils. The striæ of No. 94, of the first table in this report, which run transverse to the axis of the kame, are on the north side of the "lower hill" near Sand Cove mentioned above. The various parts of this kame are separated from that next northward by a valley filled with Leda clay and marine alluvium.

Middle Ridge in Lancaster.

The middle ridge or kame is higher or more continuous than the last, and has been cut down to a nearly uniform level by the action of the sea. It has along its southern face a distinct raised beach extending about five miles to the westward of St. John. At points where the ridge has been cut in making excavations, its structure and the changes it has undergone may easily be perceived. Originally the kame consisted of a series of rounded ridges, in the hollows of which Leda clay was afterward deposited; although the clay abounds in boulders at some points and elsewhere is sandy, it is a pure clay in more sheltered places, and is recognizable by the red color of the mud it contains. Ridges and points of the pure olive-grey gravel of the kame project upward into, and sometimes through the red deposit, where the subsequent action of the waves has worn down both sets of beds to a uniform level and covered them with a sea-beach several feet in thickness, made up of the ruins of both deposits.

The larger size and the continuity of the range of gravel knolls, now worked down to a nearly uniform level, has served to protect a third series of ridges further north, from the action of the sea. A deep marshy or rather peaty hollow separates it from the middle kame. In the northern kame there are ridges shewing two courses, one south 25° west, the other south 50° west; the latter are nearly enveloped by the former and thus appear to be older. The striæ No. 91 of the first table, with a course of south 40° east, are at the northern end of this group of gravel ridges, which begins on South Bay.

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* This section is described at page 24 EE under "Leda Clay."

Digdeguash River. On the northern side of the range of hills through which this stream winds before entering the sea, there is a small valley about two miles wide and seven long, across which runs, in an oblique line, a series of gravel mounds and ridges which look as though they had been raised artificially. The mounds begin in a bank of gravel of the lee-shoal type, cast down at the western entrance of the valley on its northern side near Falls Brook. To this bank succeed a number of mounds of the form locally known as "Giant's Graves," one of which is used as a grave yard for the parish church near by. These mounds extend along the bottom of the valley in the direction of a larger gravel ridge of a rhombic form lying in the middle of the valley. At a mound near the bridge over the Digdeguash, and at the rhombic mound, there are gravel pits, where the Leda clay beds, which fill the bottom of the valley, may be seen to rise upon and overlap the lower slopes of the gravel ridges. On the flat top of the rhombic mound are two depressions lined with clayey soil. The more easterly and smaller of these has a porous bottom, and the soil is only a heavy loam; but in the other and larger one, the Leda clay covering is sufficiently thick and fine to prevent the rain water from percolating through, and here there is a small pond of water.

Ridges in Digdeguash Valley.

Clay-lined hollows on the gravel ridges.

This large mound is in its turn connected by other sharp, oval mounds of the "grave" type, with a long gravel ridge extending from the bank of the Digdeguash River up against the shoulder of a granite hill on the south side of the valley. In this basin the course of the kames nearly coincides with the glacial grooves, as may be seen by comparing No. 28 of the first table with No. 6 of the second. The gravel knolls in this valley appear to rest on the Leda clay, but the sections exposed on their sides shew that they really have their bases beneath the clay.

Formation of Lake Basins.—The clay-filled hollows of the rhombic mound in Digdeguash valley exemplify on a small scale the process by which many lake basins in this region have been produced. The powerful current which threw up the gravel ridges, made corresponding hollows or basins wherever the configuration of the land permitted free and rapid erosion. In the basins thus prepared, the Leda clay was subsequently deposited and served the purpose of a lining impervious to water, when the land subsequently rose above the sea. In some cases the discharge from these lake basins is over rocky ledges, the (higher) barrier ridges of gravel remaining intact. Such is the case with Lake Utopia, referred to above. Spruce Lake, seven miles south-west of St. John, and the lake-like expanse at the mouth of the St. John River, are similarly confined by gravel ridges. In other cases the discharging stream has pierced the gravel ridge; a fine

Basin at Harcourt Lake.

example of this is Harcourt Lake, a pond in Douglas Valley, in Queens County. The meeting of two currents at the outlet of this valley has caused the gravel which they swept along to accumulate near Welsford Station, where it has produced a triangular flat-topped bank. The bank is steep on the south-east, but slopes away gently on the north, and at the foot of this northern slope lies Harcourt Lake. The discharge from the lake is along the eastern side of the gravel ridge, which has been cut away by the force of the stream to within twenty feet of the bottom of the basin. At this level the stream lost its excavating power, and the Leda clay lining preserved the lake from further diminution of its volume. The Loch Lomond chain of lakes in St. John county, as also Bellisle Bay and Washdemoak Lake on the St. John River and Sherwood Lake and Clear Lake and others on the south side of the Nerepis Hills are basins, closed in the same way by gravel deposits.

A third class of lakes, or rather ponds, caused by the formation of gravel ridges or banks, are those without apparent outlet. These are generally small ponds which overflow and discharge through the surrounding gravel when raised by rain above a certain level; they are commonly seen at the sides of horsebacks, &c.

Tidal Erosion in the Bay of Fundy. In order that a comparison may be made of the effect of tidal wear in the Bay of Fundy, with the phenomena of the Gravel Ridge, or Syrtensian period, I give in the following pages the result of an examination of the soundings in various parts of that bay, as shewn by the Admiralty Chart. For although an ocean current, constantly setting in one direction, cannot be expected to produce exactly the same result in transporting loose materials on the sea-bottom as the tides which flow alternately up and down the bay, the agreement is sufficiently close to illustrate the method by which the gravel beds were built up.

Erosion in Passamaquoddy Bay.

In the Bay of Fundy the velocity of the tide varies from two to three knots at its mouth to seven or eight knots in the Parrsboro passage near its head. Near its mouth, on the New Brunswick side, a portion of the bay is separated by a chain of islands, and is called Passamaquoddy Bay. These islands present on a small scale a barrier similar to that which, during the period when the gravel beds were accumulated, separated the ocean waters on the north side of those on the south side of the southern hills of New Brunswick. Passamaquoddy Bay has two principal outlets among these islands, viz., Quoddy River (a salt water strait) and Letite passage. The rush of the tide through these passes causes a roaring sound which may be heard for many miles, and the whirlpools in them are strong enough to upset boats and careen large vessels; both channels are full of deep holes, ledges and pointed rocks. At Quoddy River the tide passes over barriers having only fifteen fathoms of water at low tide, yet within, owing to the erosion of the tidal current, there is fifty fathoms in the narrowest and straightest part, and thirty fathoms where it merges into the shallower water of Passamaquoddy Bay; in the contour of the twenty and fifteen fathom lines, tidal erosion may be traced quite to the head of the bay on the Robbinstown shore, along which runs the channel that connects Quoddy River with the estuary of St. Croix River.

Tidal wear at Letite Passage.

Opposite the Letite passage, tidal wear on the bottom of Passamaquoddy Bay is even more conspicuous. One would naturally expect to find in this bay the channel of such an important river as the Magaguadavic—the largest entering the sea between the St. John River and the United States border; yet no trace of it can be detected beyond the five fathom line; on the other hand, the tidal trough which begins inside the passage, with a depth of forty fathoms, may be traced up the centre of the bay through the thirty, twenty, fifteen and ten fathom contour lines. Even the small middle passage between McMaster's and Pendleton's Islands, has produced a hollow twenty-four fathoms deep.

Centre shoals in Passamaquoddy Bay.

Opposite each of the main inlets into Passamaquoddy Bay, beyond the deep water, but immediately in front of these openings, there is a shoal corresponding to the "centre shoal" described on a previous page as produced by the ocean current of a former period. And along the straight reach of the northern shore of Deer Island a channel has been made by the tide, such as the Arctic current which threw up the gravel beds of the post-pliocene period produced at many points in southern New Brunswick, where a similar obstacle opposed its course.

At St. John, like results have been produced by the flux and reflux of the tide in the narrow passage by which that river debouches into the Bay of Fundy. Although there is only six fathoms at low water on the reef which causes the falls (or rapids) at the mouth of the river, such is the force of the current that trenches of twenty-five fathoms deep below the falls, and thirty-three fathoms deep above it, have been formed.

Troughs in the upper part of the Bay of Fundy.

In the open parts of the Bay of Fundy, especially in its upper half, there are ridges and hollows seemingly the result of tidal erosion. Thus in the center of the bay, between Quaco in New Brunswick and Margaretville in Nova Scotia, there is a depression, outlined by the forty-fathom contour line, nine miles long and three wide; it lies just between the points of two ridges, outlined by the thirty-fathom contour line, which extend outward from either shore. Up in Chignecto Passage also, off Cape Enrage, there is a trough scooped out by the tide, which is outlined by the thirty, twenty-five and twenty-fathom contour lines.

And, further up the same arm, another, in the Cumberland Channel, between Peck's Point and Boss Point; this trough is bounded by the ten-fathom line, and through it the tide runs at the rate of four knots an hour.

But it is in the eastern arm of the Bay of Fundy—Minas Channel and Basin—that the scouring action of the tide is most conspicuous. The curve of this arm to the east has thrown the weight of the current on the eastern shore; and there, under Cape d'Or, is a trough outlined by the fifty, forty and thirty-fathom lines, scooped out to a depth equal to that of the deepest part of the bay between St. John and Digby, N.S.; yet in the intervening space between St. John and Cape d'Or the soundings shoal to twenty fathoms.

Erosion in Minas Channel and Basin.

Passing Cape d'Or and going further up, the bottom again rises to twenty-five fathoms, but soon sinks into another trough forty fathoms deep. This extends to Cape Split, where a sharp barrier reef, rising to within twenty-five fathoms of the surface, again intercepts the tide. Surmounting this reef the current again plunges down into a trench fifty fathoms deep, and rushes along through the Parrsboro' Passage at the great velocity of seven or eight knots, where the passage is deepest; bnt slackens to five or six knots, where, in the more open parts of the passage, the soundings rise to thirty fathoms. Here the contour lines of thirty, twenty-five and twenty fathoms take a bilobate outline, corresponding to the two arms of Minas Basin; at ten fathoms this line is trilobed, shewing the erosive influence of the tide even in the middle of the basin; for these three indentations answer to the Cornwallis, Avon and Shubenacadie rivers, as will be seen if the shallower contour lines be traced. A similar result of tidal erosion may be detected in Passamaquoddy Bay, where two tongues of deep water extend up from the basin in front of Letite Passage, on the contour line of ten fathoms, to Harwood and Hospital islands.

Gravel banks formed in the sea bottom.

Causes similar to those which produced the gravel and sand beds underlying the Leda clay in this region now operate to prevent the accumulation of mud in the deeper parts of the Bay of Fundy. Chief among them are the strong currents which have eroded the bottom in the way described above. The great tidal wave which enters the Bay of Fundy is compressed, between the Old Proprietor Ledge off Grand Manan Island and the North-West Ledge off Briar Island in Nova Scotia, into a space of twenty-four geographical miles—of which space twenty miles has an average depth of 100 fathoms, with a sea bottom of rocks and gravel. In this strait the tide runs at the rate of from two and a-half to three knots an hour, but immediately moderates its pace when this constriction is passed. In the more open part of the bay above this passage, the bottom becomes more sandy. On the north side it is so only up to the forty-fathom line, but on the south side the bottom is sandy or gravelly up to the shore line, owing to the swifter current along this side of the bay. The violence of the current in the deep troughs of Minas Channel and Basin occasions the roughest bottom observable anywhere in the bay, for at these points rock and gravel compose the bottom over which the tidal waters run.

Gravel appears to have been gathered or exposed on the bottom by the wearing influence of these strong currents in certain parts of the bay; as, for instance, those banks which lie on each side of the deep water area eastward of Grand Manan. The bank on the New Brunswick side is of small extent, is separated from the Southern Wolf by a sinus or hollow outlined by the fifteen fathom line, and runs in an easterly direction. Scattered and irregular tracts of gravelly bottom extend along the Nova Scotian shore into comparatively shallow water, owing to the swiftness of the tide along the coast. But the most considerable gravel bank in the bay is that which begins on the eastern side of St. John Harbor and extends (mostly in soundings of twenty to thirty fathoms) nearly to Quaco Head. Along this coast the tide runs at the rate of two knots an hour, and the formation of mud-banks here has thus been prevented. A small gravel bank also extends along the western shore of Grand Manan Island, where the tide runs at the rate of three knots.

Mud and clay deposited in the quiet waters.

Conditions of the sea-bottom similar to those which prevailed over southern New Brunswick during the period marked by the accumulation of Leda clay, now exist in some parts of the Bay of Fundy, chiefly along the northern shore; and not a few of the species, the remains of which occur in the Leda clay, still maintain their existence in the bay. The north side of the Bay of Fundy having the slower run of tide, and being that along which the principal rivers enter, has in parts a muddy bottom. The only mud-bank of considerable volume, is that formed by the sediment which the St. John River carried to the sea. It begins at the harbor of St. John, and extends westward along the coast as far as the small islands called The Wolves, its outer limit coinciding nearly with the fifty fathom line. At the Wolves it connects by a narrow neck of clayey bottom with a deposit of mud in deeper water, consisting of the sediment of the St. John and the numerous small rivers west of it in St. John and Charlotte counties. This clayey deposit lies in the deepest part of the bay east of Grand Manan, having a width of twelve miles off Flagg's Cove; but it rapidly narrows to the southward and terminates at the last submerged ridge east of the Old Proprietor Ledge. To this point the Island of Grand Manan preserves it from the rush of the strong tidal current which enters the bay twice a-day south of that ledge.

Mud flats in the upper part of the bay.

Narrower mud flats spread along the sides of the bay eastward of St. John in the shallower soundings. The longest is on the north shore, and lies between Quaco Head and Cape Enrage. Another exists on the opposite side of the bay between Cape Chignecto and Sand Cove opposite Cape Enrage. These mud banks, however, are exceptional, and of small extent when compared with the whole area of sea-bottom in the bay; for elsewhere, even in the deepest part, the bottom is mostly sandy, gravelly, or rocky, the coarsest bottom being where the tide runs with the greatest violence. As a rule, where the movement of the current exceeds one and a-half knots, mud is not deposited on the bottom of the bay.

2.—*Leda Clay* (Estuarine Deposits).

Composition of the Leda clay.

The gravels or Syrtensian beds graduate upward into Leda clay in all the low-lying part of southern New Brunswick. There is a great variety of composition in these clays, from the pure "brick clay" to a mass that is composed entirely of sand beds. Near the coast it consists usually of finely laminated clay beds, with thin partings of sand; but among the higher hills of the interior is chiefly made up of sand and clay in alternate layers. At a certain height, which has not been exactly measured, but which cannot be far from 200 feet above the sea-level, this deposit in the valleys of streams is composed chiefly, sometimes entirely, of sand. Where this occurs it is difficult to distinguish between the three members of the modified Drift—Syrtensian, Leda, and Saxicava—all being composed of similar materials. The point at which the Leda deposit in the valley of the Magaguadavic becomes a succession of sand beds, is in Brockaway Settlement, on the boundary between Charlotte and York counties. The corresponding point in the valley of the St. John River will be beyond the district to which this report relates, but a similar condition of the Leda clay was observed on some of its tributaries within the district. Thus at the Welsford station on the Nerepis River, there is an excellent example of the passage of Leda clay into beds of pure sand. It was visible in a section of the clay beds south of the station on the west side of the Nerepis River, made at a time when the European and North American railway was in process of construction.

Sand beds in place of clay at the Welsford Station.

At the points where the cuttings for this railway come opposite brooks descending from hills on the western side of the Nerepis valley, the whole thickness of the Leda clay consists of sand beds. But in tracing these beds in the cuttings along the track of the railway, north or south from the ravines in which the brooks run, the sand becomes more and more interlaminated with clay until it passes again into ordinary Leda clay. The bearing of this fact upon the question of the depth of water in which the Leda clay was deposited will be readily seen.

Organic Remains of the Leda Clay.

Among the hills of the interior, organic remains are not often met with in the Leda clay, but on the lower levels near the coast a variety of fossils have been exposed by the wearing away of clay banks along the shores of the Bay of Fundy, and in cuttings on the railway lines. Among the fossils found are the following:—

Beluga sp?—*A ramus* of the lower jaw of a right whale has been found at the mouth of the Popologan River, having fallen from a bank of Leda clay, and is now deposited in the museum of the Mechanics' Institute in St. John. The bone is much worn, and has lost a great part of the gelatine once contained in its pores.

Phoca Gröenlandica Mull.—A skeleton of this species, which lacked the fore limbs and the vertebræ of the loins, was found several years ago at Hopkins' brickyard in Fairville, north of Carleton. The skull and hind limbs were nearly perfect, except that the left side was considerably worn. There were fifteen large vertebræ, with corresponding ribs; and there were also a number of caudal vertebræ. This skeleton was destroyed by the fire which devastated St. John in June, 1877. The following is a section of the beds from which it came (descending order):—

	FEET.	INCHES.	
Saxicava Sand.—Pale-brown sand, with intermingled gravel.....	2	0	Section at Fairville.
Pure pale-brown sand	8	0	
Upper Leda Clay.—Light brown sand and pale reddish clay, the sand-layers of irregular thickness.....................	7	0	
Lower Leda Clay.—Dark grey sand and reddish clay in alternate layers of one-half inch to six inches in thickness, containing remains of mussels (*Mytilus edulis**) and other small molluscs. The top of this clay was eroded before the deposition of the other clay......................	8	0	
Black sand, colored by organic matter, containg the same shells as the last, and the skeleton of the seal (*Phoca Gröenlandica*).....................................	0	6	
Red brick clay with partings about one foot apart of black sand and clay, colored by organic matter..............	4	6	
	30	0	

Another section, which exhibits clearly the relative positions of the

* A list of the remains of shell-fish and other invertebrates found in the Leda clay is given on a succeeding page.

sandy and clayey parts of the surface deposits, is that of Duck Cove, near Sand Cove, west of Carleton, viz:—

Section at Sand Cove, near Carleton.

			Feet.	Inches.
Saxicava Sand.—Stratified sand, gravelly near the top and having a few scattered stones			3	0
Leda Clay.—Red clay with the following shells: *Portlandia glacialis, Macoma calcarea, Nucula expansa, Buccinum undatum, Natica affinis,* &c			16	0
Red clay with seams of sand, viz:	Feet.	Inches.		
Brown sand	0	6		
Clay with *Portlandia glacialis, Macoma calcarea, Mya truncata,* &c	2	3		
Black sand with *Portlandia glacialis, Saxicava rugosa, Ophioglypha Sarsii,* &c	0	3		
Red clay with *Portlandia glacialis,* &c	0	9		
Black sand and clay with *Portlandia glacialis, Pandora trilineata, Lyonsia arenosa, Cryptodon* sp? a *Lacuna neritoidea* (*fide* A. S. Packard)	0	3		
Red clay	0	6		
Black clayey-sand, fossils like those of the black sand above, with bryozoa, corals, *Ophioglypha Sarsii,* and a larger Ophiuran, species undetermined	0	6—	5	0
Red clay with irregular layers of sand, bryozoa on small imbedded stones			5	0
Syrtensian or Gravel and Sand Beds.—Brown sand with lumps and irregular layers of clay			3	0
Pure, buff and greyish-brown sand, distinctly stratified, with a few layers of red clay at the base			5	0
Boulder Clay.—Coarse and sandy, with many glaciated stones			9	0
			46	0

The extremity of the gravel ridge or kame west of Sheldon Point, referred to in the section of the Syrtensian beds, presents a much thicker mass of deposits, but a similar succession.

Section at Manowagonish Beach.

	Feet.	Inch's.
Saxicava Sand.—Stratified sand and gravel	5	0
Leda Clay.—Fine red clay with a few algæ	0	0
Beds of red and black clay, and of fine, brown sand, with seams of black sand and clay. It contains algæ—three or four species, including *Rhodomela* and a narrow *Fucus;* also *Serripes Gröenlandicus, Mytilus edulis,* and a Bryozoon	0	0
Red clay and gravel in alternate layers	0	0
Red clay with some seams of grey gravel. In this clay are *Portlandia glacialis, Mya truncata, Balanus crenatus, Saxicava rugosa, Nucula expansa, Serripes Gröenlandicus, Buccinum undatum, Natica affinis,* &c.; also algæ	40	0

Syrtensian Beds.—Grey gravel with some clay; strongly marked by beach structure, the southern end of the beds being cut off. It contains beds of boulders and large rounded stones	0	0
Grey gravel beds, with few boulders; structure as the last, except that the layers are nearly horizontal	50	0
	95	0

These gravels are rounded up in the middle into a projecting ridge, which is covered by arching layers of Leda clay. The Saxicava sand is terraced on the south slope of the ridge, being a fragment of a raised beach, corresponding in height to the long beach formed on the slopes of the middle row of kames in Lancaster, referred to on a previous page. The above section exhibits the greatest thickness of modified drift so far observed in this part of New Brunswick.

Section at Enniskillen station.

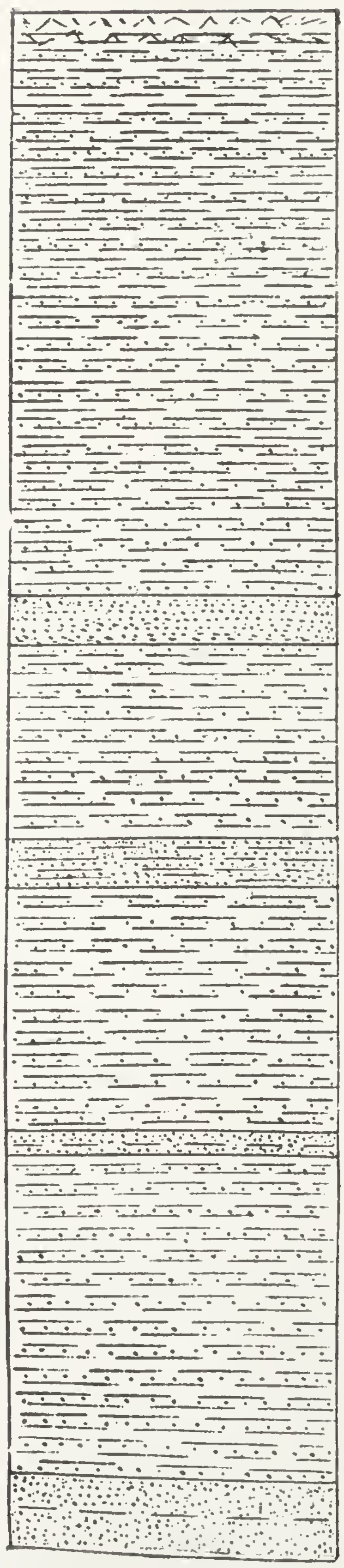
A remarkable section of Leda clay was observed at Enniskillen station, on the European & North American railway. The station is on the northern slope of land from the foot of the Nerepis Hills, and is about three miles from their base. When this cutting was fresh it was marked in a singular manner by rows of miniature columns, visible along the face of the bank. On a close inspection the columns were found to consist of small vertical pipes in the sandy layers, supporting projecting layers of clay. The pipes had been formed in the sand by the cementing of its particles around fine rootlets of small plants and trees which had grown on the surface of the clay and sand, and pushed their roots through the layers of clay, one after another in succession, till they had penetrated and mellowed the whole bank. These miniature drain pipes exhibited well the penetrating power of roots, and their utility in improving the drainage of land where the circumstances are favourable. Here they penetrated to a depth of eight or ten feet, and mellowed a soil which otherwise would have been a water-soaked sand.

Sand and clay in equal proportions.

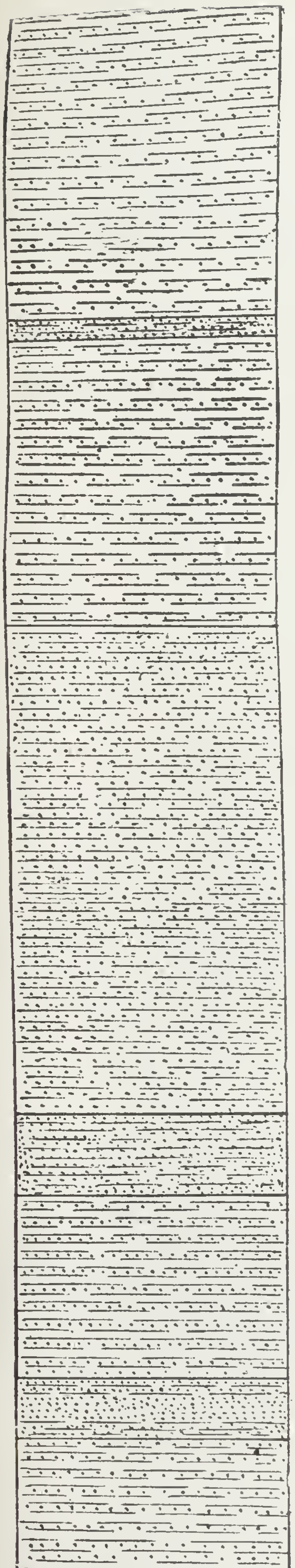
The Leda clay at this locality has been deposited in a shallow valley opening to the north, and gradually sloping to the Oromocto River. In the relative proportions of sand and clay it is intermediate between the deposits along the coast and those of Brockaway Settlement, &c., the sand and clay being in nearly equal proportions. The whole set of beds exposed consists of regularly alternating layers of clay and sand, except for short spaces at intervals in the section where there are sand beds only. These sand beds, however, have faint clayey partings, which are so spaced as to correspond to the clayey layers in other parts of the section. A sub-division into thinner laminæ may be traced in the clay-layers, especially in the upper groups, where there is an average of about eight laminæ to each layer.

Section of Leda Clay, Enniskillen.

Scale: One inch to a foot.



		Ft.	In.
a.	Loam, sand, and upper layers of clay disturbed by frost and vegetation........	2	0
	Sand bed on undulating layer	0	2
b.	Clay and sand in alternate layers, about 18 in number or $2\frac{1}{4}$ to an inch........	0	8
	Sand bed with thin clay laminæ........	0	2
c.	Clay and sand in alternate layers, about 20 in number, or 2 to an inch........	0	10
	Sand bed with thin seam of clay........	0	1
d.	Clay and sand in alternate layers, about 25 in number, or 2 to an inch (layers finer and more homogeneous than those above)...........................	1	1
	Sand with imperfect seam of clay; very little............................	0	3



		Ft.	In.
e.	Clay and sand in alternate layers, about 37 in number, or $2\frac{1}{2}$ to the inch (two layers in the middle more sandy than the rest)	1	3
	Sand bed, with faint clayey partings	0	1
f.	Clay and sand in alternate layers, about 50 in number, or $3\frac{1}{2}$ to an inch	1	2
g.	Sloping bank, where the clay was disturbed by frost and rain, clay and sand layers not clearly traceable...........	2	0
	Sand bed, with faint clayey partings	0	4
h.	Clay and sand in alternate layers, about 28 in number, or 3 to an inch	0	9
	Sand bed, with faint clayey partings near the top and bottom	0	3
i.	Clay and sand in alternate layers, about 16 in all, or $2\frac{1}{4}$ to an inch............	0	7
		11	8

This section is notable, because its regularly alternating layers appear to point to a succession of seasonal changes during the time the Leda clay was being deposited. If the sand and clay layers be associated in pairs, there will be about 150; and if to these one-tenth be added for the bands which consist wholly of sand, the number will be raised to 160, or more, of pairs of layers, representing recurring cycles of time. The thickness of Leda clay exposed in this section is about twelve feet.

Details of section.

	No. of Layers to an Inch.	Ft.	In.
Loam sand and upper layers of clay, disturbed by frost and vegetation	..	2	0
Sand beds, an undulating layer	..	0	2
Clay and sand in alternate layers—18	2¼	0	8
Sand bed, with thin clay laminæ	..	0	2
Clay and sand in alternate layers—about 20	2	0	10
Sand, with thin seam of clay	..	0	1
Clay and sand in alternate layers—about 25. (These are finer and more homogeneous than those above.)	2	1	1
Sand bed, with an imperfect seam (a very little) of clay	..	0	3
Clay and sand in alternate layers—about 37. (Two layers in the middle are more sandy than the rest.)	2½	1	3
Sand bed, with faint clayey partings	..	0	1
Clay and sand in alternate layers—about 50	3½	1	2
Clay and sand disturbed by frost, showing on a sloping bank, imperfectly	..	2	0
Sand bed, with faint clayey partings	..	0	4
Clay and sand in alternate layers—about 28	3	0	9
Sand bed, with faint clayey partings near the top and bottom	..	0	3
Clay and sand in alternate layers—about 10 large or 16 small	2¼	0	7
		11	8

A section shewing heavy denudation of the Leda clay, and its relation to later deposits, is exposed near Lawlor's Lake, on the Intercolonial railway. At the shore of the lake, where it passes beneath a bed of fresh water marl, it contains *Portlandia glacialis, Saxicava rugosa* and *Astarte Banksii.* But 100 yards east of the old lake margin, it is overlaid by peat. Here it shews the following succession:—

	Ft.	In.	Ft.	In.
Peat			1	0
Saxicava Sand.—Grey sand	0	3		
Clayey sand, with an abundance of *Mya arenaria* and *Macoma fusca.* (This is reckoned as part of the Saxicava sand here on account of its fossils; but as this section is 65 feet above the sea, it may be equivalent to the upper Leda clay of St. John.)	0	6—	—0	9
Leda Clay.—Reddish sandy clay, with small stones, *Balani*, &c	1	2		
Red sandy clay. Numerous shells of *Mytilus edulis*; also *Cardium pinnulatum*, *Serripes Grœnlandicus*, *Macoma Grœnlandica*, *Saxicava rugosa*, var. *arctica*, *Buccinum undatum*, *Natica affinis*, *Balanus crenatus*, *B. Hameri*, *Toxopneustes Drobachiensis*, &c	0	2—	—1	4
Tough red clay without fossils			1	0
			4	1

List of Marine Invertebrata of the Leda Clay.

In this list species collected by Mr. R. Chalmers in the Leda clay on the south side of Chaleur Bay, in the Gulf of St. Lawrence, are inserted for comparison with those of the southern counties of New Brunswick. The three columns indicate the occurrence of the remains at Passamaquoddy Bay (P. B.), other parts of the Bay of Fundy (B. F.), and Chaleur Bay (C. B.) respectively.

Name of Species.		P. B.	B. F.	C. B.
Corals (with stony skeleton); two species undetermined.		....	*	....
Ophioglypha Sarsii, Lutken		....	*	....
Ophiuroid starfish, larger species; undetermined		....	*	....
Lepralia hyalina, Johnston		....	*	....
Membranipora pilosa, Johnston		....	*	....
Cellepora pumicosa, Ellis		....	*	....
Saxicava rugosa, Linn	Common. (Smooth forms.)	* } 2/3	* } 4/5	* } 1/3
" " var. pholadis,				
" " Linn		*	*	*
" " var. arctica	Rugose forms.	* } 1/3	* } 1/5	* } 2/3
" " var. rhomboides		*	*	*
" " var. hiatella ...		*	*	*
Mya arenaria, Linn.; common		*	*	*
" " " var. acuta, Say; common		....	....	*
" truncata, Linn.; frequent		....	*	....
" " " var. Uddevallensis; common		*	*	*
Lyonsia arenosa, Muller; frequent		....	*	....

List of Marine Invertebrata of the Leda Clay.—Continued.

Name of Species.	P. B.	B. F.	C. B.
Pandora trilineata, Say ; scarce	....	*	....
Macoma calcarea, Chemnitz ; common	*	*	*
" fusca, Say ; common	....	....	*
" " " var. Grœnlandica ; common	*	*	*
Astarte Banksii, Leach ; scarce	....	*	....
" compressa, Linn. ; infrequent	*	....	....
" artica, Möll, var. lactea ; infrequent	*	....	....
Cardium pinnulatum, Conrad ; common	*	*	....
Serripes Grœnlandicus, Chemnitz ; common	*	*	*
Kellia suborbicularis, Montague ; rare	....	....	*
Cryptodon, sp.? rare	....	*	....
Mytilus edulis, Linn. ; common	*	*	*
" " " var. elegans ; common	....	....	*
Modiolaria discors, Linn.? rare	....	....	*
Nucula expansa, Reeve, common (rare C.B.)	*	*	*
" tenuis, Montague ; common	....	....	*
Leda pernula, Möller, var. buccata ; frequent	*	....	*
" " " var. tenuisulcata ; common	*	....	*
" minuta, Fabricius ; rare	....	*	....
" " " var. caudata ; rare	....	....	*
Portlandia glacialis, Gray (Leda truncata Br.) ; very common. Name of Leda clay is taken from this species	*	*	*
Yoldia sapotilla, Gould ; rare	....	....	*
Pecten tenuicostatus (P. Magellanicus Lam.) ; scarce	....	*	....
" " a smooth variety ; rare	....	*	....
" Islandicus, Chemnitz ; common	....	*	....
Bela harpularia, Couthuoy ; infrequent	....	....	*
turricula, Montague ; not common	....	....	*
Natica affinis, Gmelin (Natica clausa) ; common	*	*	*
Lunatia heros, Say (dwarf and distorted) ; rare	....	....	*
" " " var. Chalmersi (*Canadian Naturalist*, vol. viii., p. 108) ; rare	....	....	*
Lacuna neritoidea, Gould (fide A. S. Packard) ; rare	....	*	....
Buccinum Grœnlandicum, Chemnitz? rare	....	....	*
" glaciale, Linn. ; scarce	....	....	*
" tenue, Gray ; not common	....	*	*
" undatum, Linn. ; common	*	*	*
Tritonofusus Kroyeri, Möll ; rare	* ?	....	*
Neptunea tornata, Gould ; not common	*	....	*
Balanus crenatus, Brug. ; common	*	*	*
" Hameri, Ascanius ; frequent	*	*	....

Depth of sea inferred from fossils.

The period occupied in the deposition of the Leda clay was one of progressive shoaling along this coast. The lowest beds are of compact clay containing few organic remains, and these chiefly shells of *Portlandia glacialis*. At St. John this lower clay, which is of a dull red color, gradually passes upward into a fine dark colored clay varying in tint from dark grey and liver-brown to nearly black, owing to the organic matter disseminated through it; and here shells of *Portlandia glacialis* abound. It is this portion of the deposit which contains *Lyonsia*, *Cryptodon*, and other molluscs, also Ophioglypha, none of which indicate a depth of water less than that of the coralline zone. These dark beds are overlaid by another mass of red clay, which is generally of a browner hue than the lower red clay, and which contains such species as *Buccinum undatum*, *B. tenue*, *Mya truncata*, *Macoma calcarea and Saxicava rugosa.* A somewhat shallower sea is indicated by the occurrence at St. John of clay beds holding *Mytilus edulis* and *Cardium pinnulatum*, while a still further withdrawal of the ocean is shewn by the presence in the sands which overlaid these clays of *Mya arenaria* and *Macoma fusca.*

3.—*Saxicava Sand.**

(Terraces and Raised Beaches.)

Teraces observed in southern New Brunswick.

The shoaling of the sea in which the Leda clay was deposited was brought about by successive upheavals of the sea bottom, which, as the land rose above the sea, produced terraces at several levels along the coast. The lowest of these terraces is about fifteen or twenty feet above the present level; they are common at the mouths of small streams entering the St. John and Kennebecasis rivers. The next terrace, which is more conspicuous, varies from forty to sixty feet, and can be seen to contain the three sub-divisions of the Modified Drift—gravel and sand at the bottom, clay in the central part, and sand (Saxicava) forming the top of the terrace. A third terrace begins at the height of one hundred feet and extends to one hundred and twenty feet. Another terrace was observed at a height of one hundred and fifty feet, and a fifth at three hundred and forty-five feet. These upper terraces are more gravelly than the lower ones, and not so regular in their outline. The terraces along the coast are in some cases remnants of sloping shore flats, or beaches which have been partly cut away by the sea. The height of the sloping banks which overlook the flats also vary. The following are some of the terraced slopes seen near St. John, which exhibit the irregularities of level:

	Manawagonish Road and Beach.	Loch Lomond Road.	Mount Prospect Road.	Black River Settlement.
Raised beach..............	30	—	—	—
Terraced slope.............	—	—	—	36—60
Terraced slope.............	90—135	{ —95 { —112	—85 —	— 100—115
Slope or summit of ridge....	150—155	140—	—	—
Terraced slope	—	—	345—350	—

* This term is used for the upper member of the Modified Drift, as the conditions under which it was formed appear to have been the same as those which produced the deposit of this name in the St. Lawrence Valley. But the only molluscan remains found in it in southern New Brunswick are those of *Mya arenaria* and *Macoma fusca.*

Influence on growth of certain trees.

In general the Saxicava sand does not attain a great thickness, but being the surface deposit in many parts of the country, it has an important influence on vegetation. Some of the most valuable timber trees grow plentifully on the sandy soils of this epoch. Extensive groves of white pine once covered the heavy beds of Saxicava sand which gathered in the valleys of streams at one or other of the terrace levels noted above. Most of the barrens or plains covered with ericaceous plants are due to the presence of these sands in wide-spread flats, and where the flats are water-soaked or badly drained, there are frequently fine groves of hackmatack or larch (*Larix*).

Thickness of Saxicava sand.

The thickness of the Saxicava sand varies from two to nine feet where it has been exposed to the action of the surf when in process of formation; but at the mouths of streams banks of this sand are seen as much as twenty or thirty feet thick. Beds of bog iron ore are not infrequent in connection with this deposit, and it everywhere contains a small percentage of the oxide of iron and less frequently manganese, by which the upper layers of sand are sometimes cemented.

III.—MODERN ALLUVIUM, SHELL, MARL, PEAT, &C.

Subsidence of the Land.—The Saxicava sand was the last marine deposit formed in this region, and resulted from the wearing away of the older surface accumulations as the land rose above the ocean. This upward movement went on until the area of dry land extended considerably beyond its present limit. Since the Saxicava period peat bogs, marl beds and river alluviums have continued to grow upon the surface of the land and in the fresh water, except where their growth was arrested by subsequent subsidence. The depth of submergence cannot be shewn to have been very great, but the area affected is of considerable extent. It includes the whole of the Bay of Fundy; part, if not the whole, of Nova Scotia and Prince Edward's Island; and the south-eastern half of New Brunswick from Passamaquoddy Bay to the Miramichi River. Proofs of this subsidence in Nova Scotia and at the head of the Bay of Fundy, are given in "Acadian Geology," Dr. J. W. Dawson. In the building of the Windsor and Annapolis railway evidences of subsidence in the Annapolis valley, similar to those observed by Dr. Dawson in the marshes at the head of the Bay of Fundy, were revealed; and I shall give here the outlines of facts observed in the southern counties of New Brunswick, having a similar bearing:

Extent of the sunken area.

At Mill Cove, on Frye's Island, in Charlotte county, there is a deposit of peat, concealed at high tide mark by a gravel beach, but exposed in patches by the washing away of the sand at the lower levels in the cove. It is said that the peat has been observed to extend to low-water mark.

On the western side of St. John harbor are the remnants of a considerable deposit of peat, which is now covered daily by the tide. It underlies the mill pond in Carleton, and once extended across to Navy Island in the upper part of the harbour. When St. John was first settled it is said that a gravel beach extended along the western side of the harbour from Old Fort Neck (the site of Fort La Tour) across this peaty flat in the direction of Sand Point. Mr. F. T. C. Burpee, whose granite works are situated in rear of the line of wharves and the streets which have been built along the course of this beach, informed me that he had driven piles in the bottom of the mill pond to secure a foundation for his buildings, and found there a soft deposit ten feet deep, at which depth the piles struck a firmer bottom. Two feet from the surface a bed harder than the rest of the soft deposit was penetrated.

Buried peat beds at mill pond in Carleton.

The remnant of this deposit on Navy Island was examined by Rev. James Fowler, where, as at the mill pond, the peat occurs between high and low water marks, and contains the roots and stumps of several kinds of trees, standing where they grew. Among the stumps was a tangled mass of fallen trees of various kinds: birch, (*Betula lutea*,) spruce (*Abies nigra?*) and fir (*Abies balsamea*). These trees are such as grow in an ordinary upland soil, and appear to have been at the border of the swamp in this direction, but further west the peaty deposit consisted largely of the roots of a horsetail (*Equisetum limosum*) and other marsh plants. On the north side of the mill pond a canal for sluicing logs into the pond was cut many years ago through the marshy flat which separated Old Fort Neck from Carleton, and here also the bed of peat was found. Patches of peat have also been observed on the opposite side of the harbor in Portland, at the cove between Straight Shore and Simond's Point.

In coves along the shores of the Kennebecasis River there are submerged flats which correspond to the buried peat beds of the coast. Excavations were made in one of these flats at Harris' Cove, in Rothesay, several years ago, for the purpose of testing the value of the peat as a fertilizer. Pits were sunk at various points near the shore to depths of from four to ten feet into this deposit; throughout its whole thickness it was found to consist of marsh-mud full of the roots and stems of various sedges and grasses such as now grow on the marshes along the rivers. The marsh peat is perfectly uniform throughout the depth examined; and though compact is easily cut out, and when exposed for a week or two to the atmosphere crumbles to a fine grey powder or mud. In this property, as well as in the absence of acidity

Sunken marshes of the Kennebecasis River.

Value of marsh peat as a fertilizer.

and the abundance of fine mud mingled with peaty matter, this substance, as a fertilizer, is far superior to ordinary peat. It was used in the cultivation of root crops with the best result, the land dressed with it having given as good crops as that on which ordinary barn manure was used. It is not so lasting in its effect upon the land as the latter, for after the second year the grass which grew upon the soil where barn manue was used, was superior to that whereon the marsh-peat had been spread. If mixed with some substance which would improve its quality in this respect, the marsh-peat would no doubt prove a very valuable fertilizer. As there is such a thick mass of the peat in Harris' Cove, it is probable that all the other coves along the river, equally sheltered from the waves, and having tributary brooks, will be found to have similar beds of peat.

The roots of the marsh plants in this deposit are spread out in regular layers and support the base of the stems, shewing in the deepest pits where the old beach similar to that which forms the present shore was exposed. Besides the rooted stems of the marsh plants the peat abounds with the leaves of sedges, &c., in horizontal layers—smooth and shining leaves—with a golden gleam when first opened up, but turning black when exposed for a while to the air. Over these grassy layers were scattered leaves of hardwood trees: birch (*Betula lutea*), beech (*Fagus ferruginea*), maple (*Acer dasycarpum*), and alder (*Alnus nicana*). The peat near the shore, where there is a steep, rocky hill, contained also twigs and small fragments of various trees, such as white and yellow birch (*Betula alba* and *B. lutea*), hemlock (*Abies Canadensis*), &c.

Continued subsidence at Passamaquoddy Bay.

The subsidence of the land which gave opportunity for the slow and steady growth of this mass of peat, may not yet have altogether ceased on some parts of the coast, as, for instance, in Passamaquoddy Bay. Along the shores of this bay there are sites of the villages of a palæolithic people, similar in some of their arts and customs to the race found in this part of the continent when it was first visited by Europeans. These village-sites were probably abandoned before the white race entered the country, as no relics of European manufacture were found in the shell-heaps by which the village-sites are marked. The banks upon which the beds of shells have been heaped have been reached by the sea, and undermined by its waves, so that the shells are now scattered down the slope of the bank, and mingle with the stones of the beach below. I have not been able to learn, however, that the present inhabitants of these shores have noticed or heard of any encroachment of the sea in recent times.

Lacustrine Marl. Lacustrine marl has been reported from several places in the southern part of New Brunswick, but the only deposit which has received special attention is that of Lawlor's Lake, five and one-half miles from St. John, on the Intercolonial railway. The lake is a small, deep pond enclosed among craggy limestone hills of the Laurentian formation; it originally stood about fifteen feet higher than its present level, and discharged by a small brook flowing from the western end. Subsequently the water was drained off at the eastern end, and the marl bed exposed. Finally the cutting to the railway level laid bare a larger area of the marl and again gave the lake an outlet from the western end.

This pond has been above the sea-level since the 38-60 feet terrace of the Saxicava period was formed. It is underlaid by a thin band of Saxicava sand along the margin, and a complete lining of Leda clay beneath the sand. The clay, which is of a reddish color, contains remains of the following marine species: *Tellina, Gröenlandica, Balanus crenatus, B. Hameri, Pecten Islandicus, Saxicava rugosa,* and *Astarte Banksii.* Between the clay and the overlying marl bed is an intermediate layer of a dingy grey color, more sandy than the clay and less calcareous than the marl, but containing a few shells of the fresh water species, in which the overlying marl abounds. The marl is spread over the whole of the basin in which the lake lies, up to the original water line; but the deposit is thickest and abounds most in shells at the two extremities, especially the eastern, where it attains a thickness of two feet. The species of fresh water molluscs which are most plentiful in the deposit, are: *Planorbis campanulatus* and *Lymnæa elodes; Cyclas similis* is also common, and *Lymnæa stagnalis* and *Anodon fluviatilis* less so. A smooth variety of *Valvata tricarinata?* is common in this deposit, and assumes some unusual forms, varying from the usual close coil to an open spiral.*

Antiquity of the deposit.

Thickness of marl bed.

Fossils.

Peat. In a hollow adjoining the basin in which Lawlor's Lake is situated, and of nearly the same size, is a bed of peat which, like the shell marl of the lake basin, rests on Saxicava sand and Leda clay. The peat and marl appear to have been cotemporaneous in origin, and are still forming in their respective basins. That in which the peat lies is shallow and drained by sink-holes in limestone rock at the eastern end.

Peat beds are quite numerous in the southern counties of New Brunswick, but usually not of great extent. Either a general or special reference to many of them will be found in the Survey Reports of this region, especially that for 1870-1.

Marine and River Alluvium. The marine or salt marsh alluvium is not so extensive in the south-west part of New Brunswick as at the

* Prof. Alpheus Hyatt is now studying these peculiar forms of *Valvata.*

head of the Bay of Fundy. Musquash Marsh, the marsh east of the city of St. John, and Manawagonish Marsh, are the principal deposits. These are all dyked and converted into meadow land.

The fresh water alluvium is much more extensive. That of the St. John River covers many square miles of surface and is very fertile. The most continuous portion is on the east side of the river, between Fredericton and the outlet of Grand Lake; but there are large islands in the stream and flats attached to one side or the other of the river as far down as Oak Point, on the Long Reach, in King's county. Below Oak Point the river becomes deep and wide, and the alluvium or interval is on the tributary streams only, viz., the Nerepis and Kennebecasis.

REPORT

OF

EXPLORATIONS AND SURVEYS IN CAPE BRETON, NOVA SCOTIA.

BY

HUGH FLETCHER, B. A.

ADDRESSED TO

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The following report, section and map contain a summary of the results of the survey made in Cape Breton Island during the summer of 1877.

The area surveyed, embracing the remainder of Cape Breton county and that portion of Richmond which lies between the county line and St. Peters canal, is greater than that examined in any previous year, partly because there were fewer geological boundaries to be determined, partly because fieldwork was carried on until the end of the year, whereas in previous years it had been discontinued much earlier, but principally because, having good plans of parts of the coast and interior, less time was given to geographical and more to geological investigations. Country surveyed.

My assistants were Messrs. Hartley Gisborne, of Sherbrooke, N. S. and John McMillan, of East Bay, Cape Breton, whose devotion to their duties cannot be too highly commended. I am also indebted in many ways to Messrs. F. N. Gisborne, of Sherbrooke, Hugh R. McKenzie, C.E., and E. T. Moseley, M.P.P., of Sydney, Albert Hooper, of Fourchu, E. G. Millidge, C.E., and E. J. Barclay, C.E., of St. Peters, Rev. Archibald Chisholm, of Grand Mira, Rev. Donald Sutherland, of Gabarus, and to Mr. James H. Austen, of Halifax, for tracings of valuable plans. Acknowledgments of assistance.

Map. The map accompanying this report, including parts of the counties of Cape Breton and Richmond, is on the same scale as those of the reports of 1874-6, and with them forms a geological map of Cape Breton county. Its construction was greatly facilitated by the use of the railway plans made for Mr. Gisborne, between Lorway and Louisburg, by Mr. Albert J. Hill, C.E., and from Louisburg to the Strait of Canso, by Mr. W. H. Tremaine, C.E., the geographical features of which have generally been adopted. In other cases, the crossings of all brooks, and the position of lakes and other natural features near the roads, are from our own surveys; whereas brooks and lakes in the barrens, marshes and woods are, with some exceptions, from the crown lands plans. The Gaspereaux River is from Church's county map, and the coastline about Louisburg Harbour, Mainadieu and Scatari, from the Admiralty charts.

Section. A section drawn from Gabarus Bay to St. Andrew Channel, shows the relations of the various carboniferous and metamorphic basins to the older, underlying felsites.

Character of the country. Although the hills seldom attain a greater elevation than four hundred feet, and the shores are for the most part low, and fringed with beaches of sand, shingle and gravel thrown up by the sea, the character of the country is varied. It is evident that the whole coast was once occupied by carboniferous rocks, to the removal of which, from among the more unyielding felsite ledges, the present indentations owe their existence. Outliers of this carboniferous mantle are still to be seen between Scatari and Belfry Lake, and in traces as far as St. Peters. The trend of the hills and valleys is north-east and south-west, corresponding with the distribution of the geological formations. For the same groups described in former reports have been traced into this region, and the southern hills, like those between Middle River and Loch Lomond, are composed of rocks of the syenitic and feldspathic series.

Hills. The Mira Hills, which stretch from the mouth of Salmon River to L'Ardoise, and spread out and occupy most of the country between Loch Lomond, Saint Esprit and Framboise, form the only range of hills in the district, for although the land sometimes rises to a considerable height, it is rather in isolated knolls than in ridges.

Brooks. The brooks are long and sluggish from the nature of the country. Catalogne River, for example, rises a mile and a half from Gabarus Bay, and after running thirteen miles, discharges into Mira Bay. Mira River, the largest and only navigable stream, thirty miles in length, with many important feeders, is more properly an arm of the sea and chain of lakes. Brooks of considerable size flow into the sea at Loran, Louisburg, Gabarus, Framboise, and other places.

The shores of the lakes are wooded, often marshy, but several of great beauty occur, abounding in fish. One of these, Stewart Lake, has two outlets of equal size, flowing into Loran and Louisburg Harbours respectively. Lake with two outlets.

The country being sparsely settled and the brooks low, some ambiguity might be expected with regard to the distribution of the geological formations. This, however, is not great, nor can it affect the general features of the map. At most, there may be a few outliers not indicated within the Silurian and pre-Silurian regions, or the boundaries as drawn between the outcrops observed in the brooks and roads, may be more irregular than they appear on the map; but the descriptions in the sequel will show where and within what narrow limits the possibility of error lies. Geological boundaries.

Viewed generally, the felsitic rocks which form the foundation over which the Primordial and more recent formations have been spread, occupy two large areas, one of which constitutes the Mira Hills, whilst the other appears in a belt of variable width along the shore of the Atlantic, from Scatari Island to Marie Joseph Lakes, where it coalesces with the Mira belt. A spur two miles wide also connects the two areas at the head of Giant Lake. Two areas of pre-Silurian rocks.

Two great basins of metamorphic rock run parallel to the felsites. The first, which abounds in Primordial fossils, stretches from the head of Mira Bay to Upper Marie Joseph Lake, but is divided at Giant Lake by the felsite spur. The second, probably of Devonian age, extending from Loch Lomond to St. Peters and re-appearing on Isle Madame and in Guysborough and Antigonish counties, is characterized by more recent shells and plants. It contains masses of granitoid and trappean rocks, and the associated strata bear a close lithological resemblance to the Cordaite shales and Dadoxylon sandstones of New Brunswick. Metamorphic Silurian and Devonian rocks.

Carboniferous rocks, belonging to several denuded basins, are exposed in patches along the seaboard as far as Belfry Lake, and in the valley of Salmon River, Loch Lomond, and Grand River. They are affected at Mira Bay by the fault traced from Sydney Harbour to Black Brook (Report for 1874–5, p. 184), by which a narrow zone of millstone grit and carboniferous limestone is tilted at a high angle and overturned against the felsites of the coast. Carboniferous areas.

Details respecting these series will be presented in the following order :

1. Pre Silurian. Syenitic, gneissoid, and other feldspathic rocks. Classification.
2. Lower Silurian rocks.
3. Devonian ? Metamorphic rocks.
4. Carboniferous conglomerate and limestone.
5. Millstone grit.

1. Pre Silurian.

The rocks of this series in the Mira Hills and on the sea shore are more like the Coxheath porphyritic and fragmental felsites, than the schists and gneisses of the hills of St. Annes and Boisdale. Similar schists and gneisses occur, however, in the White Granite Hills and at Capelin Cove.

Salmon River.

Mira Felsites.—From the mouth of Salmon River, where the syenite of the Mira Hills underlies fossiliferous strata of the millstone grit, carboniferous limestone and Lower Silurian formations, it extends along the Mira road, and is seen between this road and Mr. John McInnes', and on the path from his house to Salmon River, as far as the contact of the millstone grit. Above the bridge on a brook about half a mile south of the McInnes road, is an outcrop of greenish compact felsite and mottled volcanic rock, apparently of this age, succeeded higher in the brook and on its banks by quartz-felsite and syenite. The eastern boundary of this formation twice again crosses the Mira road, passes to the Black road, and thence to the Caledonia road, which it follows for a great distance. Near the school at Kelvin Brook is an outlier of buff-coloured compact felsite, containing a few minute grains of vitreous quartz, and cells filled with a soft black mineral or empty. Up stream, a cliff of coarse reddish felsite, associated with greenish and red, mottled, soft serpentine, is in immediate contact with reddish coarse grit and conglomerate along an irregular line which runs N. 9° E. At one point the felsite appears to overlie the conglomerate, the first layer of which is so friable as to be readily ground up by the fingers. Lines of bedding are wanting in the felsite mass, of which much of the grit seems to be made up. In the bank to a height of seven feet is the sandstone, overlaid by a light-coloured clay-rock, with bright-red spots. On ascending about a mile further to the confluence of a brook from a small lake and hay-marsh, a coarse Lower Silurian conglomerate is found sticking to the surface of a reddish and greenish Coxheath felsite, of which it is composed.

Volcanic rock.

Felsite of Kelvin Brook in contact with Silurian strata.

Serpentine.

Felsite, quartz-felsite and syenite of Loch Lomond and Framboise.

Felsite, buff syenite and coarse quartz-felsite with imperfect crystals of quartz alternate with millstone grit and carboniferous limestone on the Salmon River road as far as Loch Lomond. Near the lake, they are well displayed on the Framboise road in large barrens underlaid by syenite, mottled white and green finely granular diorite and dark-green, porphyritic, compact, epidotic felsite, containing much disseminated hornblende; and on Angus W. Morrison's farm-road, blocks of syenite, granular quartz-felsite, diorite and epidotic felsite occur.

A striking similarity to the rocks of Watson and Grantmire Brooks is presented by the red syenite, greenish, pyritous, compact and crystalline felsite, and finely speckled crystaline diorites exposed between Morrison's road and that to James McLeod's. The greenish compact quartz-felsite and diorite and bluish, coarse, granular quartz-felsite with a few grains of hornblende, which are first passed over on McLeod's road, are succeeded by Lower Silurian grit, and again by coarse, granular, speckled white and black syenite, diorite and felsite.

Diorite.

Aluminous shales of Hooper's mill.

Hooper's mill stands on a greenish, soapy, aluminous shale, striking N. 56° E., with bottle-green felsite-breccia, and light-coloured, compact felsite and quartz-felsite; whilst on the Mira road, where these rocks give place to whitish and red quartzo-feldspathic sandstone and grit, and greenish coherent slates, their strike is north, that of the Lower Silurian rocks being N. 55°–68° E. Barrens here occupy most of the country between the Framboise and Fourchu roads, and here also the Mira felsites coalesce with those of the coast. Nearer the post-road at Framboise, blocks of syenite and conglomerate are curiously intermingled, but outcrops of conglomerate are alone seen.

Felsite of the Blue Mountains

The Blue Mountains and White Granite Hills appear to constitute bosses of this formation in the Lower Silurian area; but the boundaries of these, owing to the impenetrable nature of the country, have not been well defined. On the Blue Mountains, in the neighborhood of the copper mine mentioned in the Report for 1876–77, p. 451, the prevailing rock is a felsite, in layers a foot or less in thickness, dipping N. 56° W. $<$ 80°, sometimes globular, and occasionally resembling an altered argillite. It is of various colours, often black and glistening from the presence of minute particles of quartz. The felsite at the copper mine is bluish, greenish, whitish and gray, chloritic and compact, with conchoidal fracture, dipping N. 64° E. $<$ 30°. Light-coloured felsite occurs in globular, concretionary masses in the darker varieties, several spheres often uniting to form an agatoid concretion, the nuclei of which contain granular feldspar or quartz. The greenish rings in the agatoid layers may be epidote.

Copper mine.

Globular structure.

A line run by Mr. Tremaine through the woods and over the great blueberry barrens at the head of Hardy Lakes, crosses bluish fine quartzite, conglomerate and other Silurian strata, succeeded by compact or slightly crystalline bluish felsite. Externally it is whitish, with rusty-brown prominences, often globular, in concentric strongly coherent layers, composed of crystalline, granular felsite not unfrequently mixed with quartz. The rock is veined in every direction with this crystalline matter as well as with quartz; chlorite and hornblende are also present, and iron pyrites and manganese oxide coat the joints. Although occasionally obscurely granular, and sometimes a quartzite, the mass is essentially a compact felsite like that of the copper mine, of gray, bluish, and other colours. The strike is doubtfully N. 34° E.

Another outcrop, twenty-four feet long and nine wide, of blackish compact felsite of obscurely globular structure, is met with in the fields near the school, at the source of a feeder of Trout Brook, north of the French road. These rocks are in proximity to Primordial slates, but as there is no evidence that they are contemporaneous, and since they resemble the coastal rocks of Gabarus Bay, they have been classed with the latter.

White Granite Hills.

At the most northerly point reached on the White Granite Hills, are large blocks of whitish and reddish granite, with black and golden mica, and occasionally hornblende; and of bluish finely granular felsite. Farther south, where the hills approach the French road, they rise in rugged, woody slopes, down which flow rills issuing from springs above. Ascending one of these to a small fall, we find jagged cliffs of reddish and whitish, fine and coarse granite, quartz-felsite and felsite, containing a minute quantity of iron and copper pyrites. Of hornblende there is little or none; mica is often sparingly present, and quartz sometimes absent, but generally quartz, feldspar and mica are well mixed. The mica is generally black, sometimes in small hexagonal plates, and at times arranged in waving, gneissoid layers, especially in the finer varieties. The bluish compact or slightly crystalline felsite, seen in large blocks on the road nearer Grand Mira, probably belongs to this series, but the country is too thickly wooded and the brooks too insignificant to be of use to determine this point. The White Granite Hills approach the clearings again behind Ronald Gillis' house.

Copper pyrites.

On the post-road to Gabarus near the French road, compact and coarsely crystalline black hornblende-rock, pink and green, compact, porphyritic felsite, felsite-breccia and indian-red fine porphyry with light spots, striking apparently N. 64° E., and closely resembling certain Coxheath felsites, are associated with and probably underlie the coarse quartzose Silurian conglomerate of the vicinty.

Scatari Island.

Coastal Felsites.—The cliffs of Scatari are composed of felsites like those of Coxheath, East Bay and Louisburg, and the character of the island corresponds generally with that of most of the region in which these rocks occur. At the western light, bottle-green, porphyritic, fine-grained, and fragmentary felsite and diorite are blotched with quartz and epidote and stained in the joints with hematite. To the northward of the lighthouse, felsite and felsite-breccia present the greatest variety in the colour of the fragments, some of which are six inches in diameter, although often indistinguishable in a fresh fracture. The strike is about N. 79° E., coinciding with the trend of the coast, the dip, when not vertical, being northerly.

Variegated felsite-breccia

Quartz pervades these rocks, sometimes in the form of veins, but more frequently in blotches and streaks; and calcspar abounds in the joints.

Concretionary felsite.

Near Gull Cape are displayed compact and splintery or finely vesicular and fragmental felsite, usually of some shade of bottle-green, but also purple and indian-red, in thick layers or papery shales, with a well-marked northerly dip. Many concretions occur in these beds, consisting of single and united spheroids, the concentric layers of which may be removed like the coats of an onion. This does not extend to the stratification of the beds, but only to the internal structure of certain layers. Joints break the rock lengthwise and across into small pieces, and quartz veins run in the bedding. The vesicles are of every shape and size, being sometimes formed by the disintegration of light-coloured films of the concretions, but generally deep and more or less cylindrical. Similar rocks continue, with changing strike, as far as the eastern light.

Carboniferous outlier.

Not far from Eastern Harbour, felsites of various colours strike S. 88° E., which is also the course of a conglomerate, probably carboniferous, seen at low water. The felsite that follows is darker than those seen on the north shore, and contains much chlorite and hematite. Bright indian-red and bottle-green, quartz-veined felsites, associated with purple amygdaloid strike S. 82° E. at the next prominent headland; whilst near the fishing station of Howe Point, the dip is N. 39° E. $<$ 45°. Purple, red and green felsite-breccia extends as far as the head of Tin Cove, where light-greenish and gray felsite-breccia dips N. 46° E. $<$ 35°. At Pigeon Point, a pink splintery felsite occurs.

Amygdaloid

Moque Head.

Purple, red, pink, cream-coloured and greenish, often compact felsite, full of small veins of quartz which run generally in the bedding, form rocky cliffs between Moque Head and Neil Cove, dipping in a northerly direction at a high angle. They pass under the belt of carboniferous rock in this cove, but appear on the road within this belt, on the Clarke road as far as Louisburg, and on the road from Neil McRury's to Catalogne Lake.

Calcspar vein.

Barrens and marshes of Loran and Louisburg

Between Mainadieu and Cape Breton every variety of felsite is met with. At Cape Breton it is quartz-veined, greenish and reddish, fragmentary and compact, with lines of vertical jointing or bedding, which run N. 39° E. and S. 76° E. At Little Loran the felsites are spotted with hornblende and characterized by an abundance of calcspar, a lenticular mass of which, about six feet thick, is associated with them. At Gooseberry Cove laminated greenish-gray, white-weathering felsite dips at a high angle S. 13° E. On the road between Loran and Little Loran similar rocks form bake-apple barrens and marshes full of broken ponds; and the rocky, indented coast from Loran to Louisburg is equally sterile. The rocks of this district have been fully described in the Report for 1875-6, p. 379, and in that for 1876-7, p. 425, but in addition to these felsites, quartz-felsites, diorites, and soft, soapy shales, a mixture of feldspar, quartz and chlorite may be cited.

The Louisburg railway displays in several cuttings between the pier and the crossing of the Loran road the bright-coloured felsite-breccias seen at the lighthouse, as well as greenish pyritous diorite and other Coxheath rocks. These continue both on the post road and railway as far as Catalogne Lake, where a laminated variety strikes N. 64° E. Below the post road, on the left side of Catalogne Lake, a similar felsite is exposed; at the road, on the upper side of the bridge over Catalogne River, a beautiful mottled felsite-breccia is in place, whereas on the lower side carboniferous limestone occurs. Hills of felsite follow, giving place nearer Sydney to fossiliferous Primordial rocks.

Contact of carboniferous limestone at Catalogne.

Louisburg.

At Rochford Point, Louisburg Harbour, gray, greenish and reddish, quartz-veined, porphyritic, compact, granular and fragmental felsite and quartz-felsite strike N. 74° E. The fragments are of every shape and sometimes exceed an inch in length. When a large proportion of quartz is present the rock assumes a distinctly granular texture.

Gray, granular, pyritous, epidotic, laminated quartz-felsite is traversed by irregular dykes of porphyritic diorite and dips S. 35° E. at Kennington Cove. The Seal Cove felsites are dark, compact and obscurely fragmentary, and, with more hornblendic and chloritic varieties, extend to Eagle Head (Report for 1875-6, p. 379). Pre-Silurian rocks are well developed between Eagle Head and Cape Gabarus, except where concealed by beaches and carboniferous rocks. At the Cape, gray, greenish, purple and red compact and fragmentary felsites, porphyritic and sometimes indistinctly granular, with blotches of quartz, strike N. 46° E. The Shore and French roads from Louisburg to Gabarus also exhibit these rocks, which in a hill near John Matheson's consist of greenish and red, mottled, compact, porphyritic felsite, full of quartz veins. South of the Lower Silurian slates, at the McLeod road, felsite and diorite everywhere crop out on the road to Gabarus.

Cape Gabarus.

On the Bengal road, the felsites at their most northerly outcrop are light-purplish, fragmentary, porphyritic and epidotic; and a vesicular breccia resembling the altered felsite referred to in the Report for 1875-6, p. 423, appears on the Bengal hills south-east of McInnes Lake. Near a mill on the Catalogne road, at the road to D. McDonald's, immense blocks of fine yellowish-green epidotic felsite are met with, covered with prominences like those found on weathered surfaces of serpentine limestone. Many of these are of quartz, others of decomposed feldspar in a framework of quartz; they often resemble pebbles, but

Quartziferous felsite.

sometimes contain cavities lined with crystals. This rock is associated with quartz-felsite and granular and fragmentary calcareous felsite containing a few scales of mica. Being veined with quartz and banded like the sandstone and grit with which they are in contact, they often bear a striking resemblance to them.

Near the fork of the Catalogne and Bengal roads, pink, reddish and green felsite-breccia, cut by small veins of quartz, is associated with pieces of red sandstone and conglomerate, sometimes hardly distinguishable from it, but generally having the pebbles distinct.

Around the Belfry Lakes, and between these lakes and Fourchu, red syenite, felsite, diorite and quartz-felsite are often seen, the country being for the most part barren. On the road to the shore between Belfry and Mulleuish Lakes whitish, greenish and light-pink felsite, quartz-felsite and syenite also occur. The felsite is compact, the quartz-felsite of every degree of fineness, the grains being occasionally as large as marbles. Hornblende is sparingly present, appearing in the finer varieties as small porphyritic fibres, in the coarser rocks, as small scattered grains.

Near the Framboise school-house more or less slaty felsites and greenish, soft, finely laminated, pearly fragmental rocks dip S. 56° E. with a slight deviation from the vertical. It is unnecessary to characterize in detail the numerous exposures of felsite and diorite, quartz-felsite and syenite seen on the shores and roads about Fourchu, Framboise and Marie Joseph, the attitude and distribution of which are shown on the map. Those, therefore, which present features of special interest will alone be described.

The road from the post-road to Donald McAskill's passes over Louisburg felsites with a westerly dip, followed by allied rocks of great variety of colour and texture. On the west side of the road these rocks are intimately associated with a conglomerate containing pebbles of quartz-felsite, which seems to pass into them, the paste being bluish compact porphyry with small bright grains of quartz, or bluish quartzite like the pebbles. Argillite, sandstone and felsite of doubtful character succeed, associated in the neighbouring barrens with purple grits.

Capelin Cove exhibits an interesting series of rocks which, near the fishing hamlet at the beach, comprise reddish and greenish granitoid felsite and quartz-felsite, diorite and syenite, in which the lines of bedding display less foliation than some of the gneisses of St. Annes and Boisdale, and could not always be detected except for the long reefs, in which, however, they are distinct. The rocks are rather friable, show in places an approach to a fragmentary and porphyritic structure, and occasionally resemble the obscurely granular syenite and felsite of

Gneissoid rocks of Capelin Cove.

Shenacadie and Escasonic. Blotches and veins of quartz penetrate in all directions, and dykes of bottle-green granular rock run in the bedding and across it, entangling wedges of the syenite. Syenitic gneiss on the road from Capelin Cove to the post-road displays on weathering the ridged aspect referred to in the Report for 1875-6, p. 379, and alternates with Coxheath felsite, the country being barren. From the fork of these roads, for a considerable distance towards Framboise and Saint Esprit, syenite is the prevailing rock.

Gneiss, diorite, finely laminated quartz-felsite and bluish, soft, pearly, feldspathic shales occupy the rocky coast between Capelin Cove and Saint Esprit. Here, however, the shore becomes low, and the ponds and beaches, together with the slates seen on the post-road, afford unmistakable proof of the former extension of Silurian strata in this vicinity.

Porphyritic felsite.

In beauty and variety of colour the compact and fragmentary, porphyritic felsites of the coast near Murdoch Matheson's and towards Grand River may vie with those of Louisburg and Scatari.

Bluish and reddish coarse felsite, diorite and syenite are intermixed with compact and fragmentary felsite and diorite on the Fourchu road near McLean's, and underlie the barrens that stretch towards Framboise and Loch Lomond.

Contact of carboniferous conglomerate at Grand River.

In a large brook near the Kemp road is a greenish and reddish, compact, splintery, porphyritic felsite, with soft unctuous matter in the joints. At L'Archevêque a similar rock rises into low hills. Near Grand River Bridge greenish, rough, coherent, pearly slates strike N. 64° E., which is also the attitude of a band of chloritic, calcareous felsites, near the schoolhouse at McLeod's. The latter are reddened by the colouring matter from the carboniferous conglomerate with which they lie in contact.

The coast between Grand River and L'Ardoise is composed chiefly of felsite, but the beaches and lowlands often show traces of newer rocks. At Point Michaux, laminated syenite, diorite and light-coloured, waving, papery, slightly granular feldspathic shales dip N. 37° W.

Hay Cove.

Breccia and amygdaloid.

An outcrop of felsite in one of the brooks above the Loch Lomond road, near Hay Cove, is interesting because of its proximity to the newer dioritic series, from which it is separated by a zone of carboniferous conglomerate, lying nearly horizontal, and composed of the underlying felsites. It consists of a purplish, slaty, friable, soft, calcareous, minutely fragmentary or compact feldspathic rock, dipping N. 54° W. $< 70°$, associated with an irregularly cleft, obscurely brecciated rock, sometimes an amygdaloid with pea-size amygdules of quartz, but also precisely similar to the mottled felsites of McKeagan Brook (Report for 1875-6, p. 372) and the pearly shales of Big Pond.

2. Lower Silurian Formation.

The general distribution of this formation was sketched at page 3 of this report, and a section of part of it given in the Report for 1876-7, p. 437. Reference was also made to the probable connection of the red shales on the Louisburg railway with the gray sandstone in which *Obolella* was found near Marion Bridge, and Mr. Billings' opinion of the Primordial age of this fossil, in the Report for 1875-6, p. 393. Mr. Billings' opinion has since been confirmed by a much larger fauna obtained near the same place; and from the shales between Mira and Catalogne specimens of a similar *Obolella* were found last autumn by Mr. Gray, one of the engineers of the Cape Breton Company. The thickness of this formation is no doubt considerable, but the crumpling to which it has been subjected renders the determination difficult, and details are still wanting. Fossils.

Mira Basin.—This area, to which most attention has been given, stretches from Mira Bay to Upper Marie Joseph Lake. On the road from the railway down the left side of Catalogne Lake no rocks except pre-Silurian and carboniferous were seen in place, but numerous blocks denote the proximity of the Silurian belt. Farther west, many outcrops occur, showing reddish and greenish, soft, shaly argillite, gray sandstone similar to that of the Caribou Marsh road, red sandstone, quartzite and quartzose grit. The boundary between this formation and the millstone grit on the Caribou Marsh road is somewhat indefinite, exposures being rare. Caribou Marsh road.

On the Sydney road, greenish, purple and reddish, soft, feldspathic, micaceous, arenaceous shale and sandstone, quartzite, quartzose grit, nut and pea-conglomerate with pebbles of quartz, reddish limestone, and greenish and gray argillite full of quartz veins strike S. 59° E., extend nearly to Albert Bridge, and occupy the old Louisburg road to the mill on the outlet of McMillan Lake. South of the mill, ledges of reddish fine shale and thick-bedded sandstone dip S. 16° E. $< 60°$, and are succeeded by greenish, soft, pearly shales, dipping S. 16° W. beneath carboniferous limestone. Albert Bridge.

Proceeding westward, we find these rocks exposed in many places along an irregular line of contact with the felsites on the Catalogne and New Boston roads; and near the school on the Bengal road, dark reddish sandstone and argillite, with greenish, soft, white-weathering feldspathic shales, in thin, rippled layers, contain thread-like quartz veins at right angles to the strike, which is N. 20° E. South of the large lake on this road, quartzite and quartzose grit appear with bluish-gray, black-spotted, laminated, rather coherent argillites, and reddish micaceous, nearly compact quartzo-feldspathic sandstone, Catalogne. Quartz veins.

running N. 10° E. Farther south, reddish, micaceous, arenaceous shale and sandstone, dip S. 69° E. < 80°, containing, at their contact with the pre-Silurian felsites, pebbles of quartz and red feldspar, apparently derived from that series.

Trout Brook.

Red sandstone forms the rocky bed of a small tributary of Trout Brook flowing from the Bengal road. In the main brook below the confluence, bluish-gray and red, quartz-veined fine sandstone and argillite, with scales of specular iron ore, dip N. 69° E. < 43°. This brook, a favorite resort of anglers, flows in a narrow, picturesque valley on whose banks grow Indian pears and hazel-nuts, whilst multitudes of blueberries occur on the barrens above. The dip varies in descending the brook to the South Mira road. The argillites are contorted, soft and crumbling, silky and slaty, resembling those of Boisdale, like which they break into pieces, nine inches long and a quarter or an eighth of an inch wide.

Fossils of McNeil Brook.

No fossils were found in Trout Brook, but on the road near McKay's, impressions of *Obolella* appear on a fine whitish feldspathic sandstone, and in McNeil Brook, shells and trilobites are abundant. On the road at McNeil's mill, argillite and sandstone dip S. 16° E. < 45°, whereas, above the mill pond the dip is N. 54° W. < 40°. Higher up, the direction remains the same, while the angle is much lower. The shales include a nodular bed of bluish-gray and black, bituminous, often granular limestone, full of fossils, among which were recognized *Orthis*, *Obolella*, and the head of a trilobite. Above the bridge on the Trout Brook road, black and bluish argillite, in layers quarter of an inch thick and under, dips S. 83° E. < 15°–60, crumbling into knife and needle-shaped fragments. Cliffs formed of these shales abound in impressions of trilobites including *Agnostus* and an *Olenus* (or *Sphaerophthalmus*) allied to *O. alatus* of Boeck. Large layered blocks of bluish, pyritous, veined limestone, sometimes a foot thick, which occur among the shales, are wholly composed of the heads, tails and spines of trilobites, as the corresponding limestone of Macintosh Brook (Report for 1876-77, p. 432) is of *Lingula* and phosphatic nodules. Concretions of iron pyrites in the shales, which vary from the size of a pea to that of a hen's egg, produce by their decomposition a considerable quantity of bog iron ore.

Limestone.

Black shales.

Concretions.

Beyond the crossing of the Caribou Marsh road the detritus in McNeil Brook and in the road consists of whitish and brownish sandstone and greenish-gray argillite. Near the school the former is covered with shells.

The southern part of the Bengal road displays blocks of bluish plumbaginous rock, weathering like a limestone and not unlike an argillite seen on the same road near Mira; together with bluish, black-spotted slates and quartzose conglomerate, sometimes resembling a Coxheath felsite. At Allan McDonald's, coarse quartzose conglomerate and whitish grit contain flat, angular fragments of felsite, and are associated with whitish porphyritic felsite and blocks of bluish sandstone and purplish argillite. Not far from James McIntyre's, felsite-breccia is found with bluish spotted slates and quartzite, with a vertical trend of about N. 7° E.

In Lynk's old clearing on the left side of a lake at the end of a wood-road, a twisted, compact felsite or altered argillite shows waving lines of lamination on the surface, although within it is quite homogeneous and of a dark-bluish colour. Blocks of highly altered quartzose conglomerate and grit abound in the fields, so that the felsite also is perhaps Lower Silurian, although the exposures are insufficient to determine with certainty the position of this and other rocks of the neighborhood. Similar bluish rocks extend to Murdoch McDonald's, near whose house is a white quartzite and hard laminated argillite, somewhat resembling a schist. Conglomerate

Light-coloured, compact quartzose grit and quartzite occur constantly on the French and McLeod roads, to the outlet of the second Hardy Lake; and in the vicinity of McCormack Lake, purplish and greenish, silky and coherent, arenaceous and argillaceous shales, together with a conglomerate composed of quartz, felsite, porphyry and green argillite, are associated with blocks of felsite-breccia. The Silurian and pre-Silurian rocks are here in contact, and on the borders of the String Lakes sometimes the conglomerates, sometimes the felsites, break the surface of the ground, their irregular distribution probably giving rise to this beautiful chain of lakes. French Road

Black and bluish spotted slates, resembling those of Long Island, occur frequently on the French road. Near its junction with the Gabarus post-road, Silurian and pre-Silurian strata are again in contact. The former consist of light-purple and gray, close-grained pea and nut-conglomerate, containing pebbles of quartz and feldspar, and striking apparently N. 13° W. Near the highest of the String Lakes, at Angus McDonald's (Big Angus), is a fine reddish micaceous sandstone; and in the fields, blocks of bluish, micaceous, arenaceous and argillaceous shale, whitish, reddish and purple conglomerate and grit prevail as far as the hill at the copper mine. Lower Silurian rocks also cover the Grand Mira end of the French road, and the farm-roads of Ronald, John and Donald Gillis. On the South Mira road to the eastward, black and gray argillaceous shales, and greenish-gray feldspathic sandstone appear in many of the brooks.

Canoe Lake Brook flows from Canoe Lake to Mira River along a chain Canoe Lake Brook.

of marshes, interrupted by stretches of rapids with small falls, keeping its course among the Silurian rocks, with the coastal felsites and White Granite Hills on either hand. There is no great variety in the character of these rocks, which comprise bluish argillite, bluish and red, fine, micaceous sandstone and grit in shaly layers, and, near the lake, nut-conglomerate underlaid by quartz-veined, Coxheath felsite.

On the old road between Belfry and Canoe Lakes, indian-red, compact and indistinctly granular felsite, spotted with quartz and veined with epidote, is succeeded by reddish quartzose sandstone and slate detritus.

In Easg Brook, reddish, greenish and bluish argillite and quartzite overlie pre-Silurian felsites, as shown on the map. At Victoria Bridge, laminated argillite strikes N. 70° E.; and on the road round the head of the Mira lakes, rocks like those of String Lake contain masses of milky quartz and dip S. 69° W.

Interesting displays of Lower Silurian strata are also found on the roads and brooks of the western side of Mira River. Good sections are exposed in a series of falls on the brook which runs along Rory Curry's road, the rocks consisting of reddish micaceous grit and conglomerate. At Curry's house these rocks are also met with, and near Hugh Walker's, a reddish argillite dips N. 57° W. On the road to Caledonia from Victoria Bridge, conglomerate, composed chiefly of quartz and felsite, is associated with a light-reddish grit, striking S 52° W. with a vertical dip. Near J. McDougall's, on the road back to the shore, gray grit is encountered.

Felsite of McEachern Brook.

The greenish-gray laminated argillite of the Mira road at McEachern's gate strikes northeast, and in McEachern Brook, just above the road, is succeeded by a bank of gray, friable, flaggy, micaceous sandstone and arenaceous shale. Above the fork is a fine development of buff-coloured compact felsite, with grains of quartz, presumably belonging to the syenitic series, beyond which is a reddish and gray, fine, calcareous sandstone. Near the road, the Silurian rocks strike N. 6° W., at the junction the dip is N. 76° E., while immediately down stream from the felsite and quartz-felsite, a compact, red and greenish, mottled, splintery, micaceo-arenaceous argillite dips N. 89° E. $< 60°$.

Mira road.

At the Mira road, near the crossing of Kelvin Brook, is an outcrop of red argillite and greenish, fine, feldspathic sandstone, dipping S. 86° E. Nearer Victoria Bridge this is followed by light-reddish felsite, holding a few grains of quartz. Most of the road from this outcrop to the bridge is occupied by blocks of bluish quartzose conglomerate, grit and fine sandstone. The conglomerate contains pebbles of felsite, quartz-felsite, syenite and related rocks, as well as others which may be red argillite or fragments like those of the Louisburg breccias. Not far from Kelvin Brook, on the shore of Mira River, is an outcrop of bluish, greenish and gray fine argillite, interstratified with shaly, micaceous, nearly compact, feldspathic sandstone, full of quartz veins like those of St. Andrew Channel, and striking N. 9° E. with a dip alternately to east and west.

Kelvin Brook.

Kelvin Brook, one of the most beautiful streams in the region, was surveyed from the shore to the marshes above the Caledonia road. Succeeding the felsite at the Mira road is a light-green, compact or fine-grained, micaceous, feldspathic sandstone, with a well-defined dip N. 85° E. < 44° ; next to which lies a red and green, blotched, friable, micaceo-calcareous sandstone. Up stream, shaly and flaggy argillite dips S. 81° E. <45°, succeeded by a coarse, pebbly, quartzose, feldspathic grit, dipping vertically N. 76° E., and by a pea-and-nut conglomerate, with a dip N. 70° E. < 47°. Above the felsite outlier, a red clay rock dips N. 85° E. < 40°. The conglomerate contains pebbles of the buff-coloured quartz-felsite of the outlier, and the grits appear to be in great part of similar composition. Higher up is another nut and egg-conglomerate, containing large blocks of red, bluish and greenish, obscurely granular aad porphyritic felsite and quartz-felsite. Every pebble is a felsite; the paste is a nut and egg-conglomerate in which the large, round and well-worn boulders are imbedded. Whitish, nearly compact, fine conglomerate or coarse grit follows, dipping S. 79° E. < 45°, and associated with layers of red and purple calcareous sandstone, grit, conglomerate and argillite, which extend to the lake and farm road at McDonald's. Above the Caledonia road, Kelvin Brook flows over reddish, purple, gray and bluish, quartzose, feldspathic sandstone and grit, which appear in contact with greenish and reddish, soft, fine-grained or compact, epidotic rocks of trappean aspect, like those of Long Island and Gregwa Brook, and with unbedded, jointed felsites. This may be an intrusive series, but more probably represents the fundamental rocks. Still proceeding up the brook we meet with indian-red fine argillite, dipping N. 47° E. < 42°, underlaid by coarse reddish syenite, diorite and felsite, seen only in small exposures.

Silurian conglomerate composed of pre-Silurian detritus.

Obolella of Salmon River.

To the southward of Salmon River on the Mira road, whitish, fine-grained or nearly compact micaceous sandstone, full of impressions of *Obolella*, in flaggy layers with red sandstone, conglomerate and greenish argillite, seems to be unconformably underlaid by the red felsite and syenite of the Mira Hills.

Framboise Basin.—Separated from the foregoing by a spur of older rock, about a mile and a half in width, are the metamorphic deposits of Framboise and Marie Joseph. Unlike those of the Mira basin, with which they were probably once continuous, these deposits have as yet yielded no fossils; but presenting in the lithological characters and succession of the beds a perfect correspondence with their equivalents in that basin, they stand, with the outliers at Five Island Lake, on the shore of Framboise Bay and at Saint Esprit, as a monument of the immense amount of denudation undergone by this area since their deposition.

Sandstone, grit and conglomerate.

On the Mira road between Angus McKinnon's and the Fourchu road, gray and reddish, quartzose and feldspathic sandstone, grit and conglomerate are in contact with the felsites in many places. The nut-and egg-conglomerate of the Framboise road is composed of well-rounded pebbles of quartz and felsite in a paste of fine quartzose grit or highly crystalline felsite, the latter giving it the appearance of a Coxheath felsite, notwithstanding the shape of its pebbles. Outcrops of fine, whitish, quartzose grit and conglomerate occur near the path to Framboise church, and of red and greenish argillite, in Framboise River, on the opposite side of the road. Similar strata are found on all the roads in the vicinity; near Widow McLeod's is another display of greenish shale; and from the Mira road between the Framboise road and Neil Morrison's a spur of Lower Silurian rocks runs westward up the valley of a large brook.

The conglomerate so characteristic of this formation generally contains pebbles, as large as a hen's egg, of quartz, quartz-felsite and felsite of variable texture; and apparently also of fine quartzose grit. On the Fourchu road near McAskill's road it is associated with feldspathic, close-grained grit and sandstone, underlaid by syenite, the country being uncultivated and covered with strawberry and raspberry plants with a few small spruces and tamaracs. On the road to Hector McDonald's, Silurian and pre-Silurian deposits are also in juxtaposition, and on a cross road to the backlands, the former are represented by light-lavender and lead-gray, close-grained, quartzo-feldspathic grit, fine in texture and cut by small streaks and veins of quartz. Pre-Silurian felsite, syenite and quartzite succeed near Angus Strachan's house, and between McAskill's and the main road. Near Blue Lake, Saint Esprit, is an outlier of sandstone and bluish-gray, soft, crumbling, pearly slate, probably of this age.

3. Devonian? Metamorphic Rocks.

A great development of igneous and altered sedimentary deposits occupies an irregular area between Loch Lomond and St. Peters. Outcrops are everywhere presented in the brooks, lakes, shores and roads; but so contorted that no continuous section is accessible, and any estimate of the thickness must be uncertain. The characteristics of the lower members of this group will be understood by reference to the following enumeration of the exposures seen on the seashore between L'Ardoise and St. Peters. It must be remembered, however, that these outcrops are frequently separated by large intervals of concealed strata :

Coast-section between l'Ardoise and St. Peters.

1. Greenish and bluish coherent grit and sandstone, with layers of blackish, finely laminated, friable, areno-argillaceous shale, and patches of conglomerate. Quartz and calcspar veins and blotches run in every direction, giving the rock a meshed aspect, and small cross joints also occur. These rocks at low water near L'Ardoise chapel dip S. 15° E. $<$ 30°, and in the next cove to the westward N. 5° W. $<$ 30°.

Veins.

2. On the western extremity of L'Ardoise Head, light-coloured quartzo-feldspathic grit and sandstone, coherent and close grained, veined, and not unlike the *whin* of the gold fields, dip S. 64° E. $<$ 40°.

L'Ardoise Head.

3. In the following, cove greenish and blackish crumbling argillite dip S. 25° E. $<$ 25°.
4. On a headland 400 yards farther north a bluish coherent sandstone, wrinkled across the beds by lines of jointing and cleavage, and full of minute veins and blotches of quartz and calcspar, dips S. 26° E. $<$ 60°.

Beyond St. Peters Island and the lobster factory is the following descending sequence :—

St. Petors Island.

5. Greenish and light-coloured, veined, somewhat shaly, cleft arenaceous rocks, including greenish-gray, nacreous, argillaceous shales.
6. Light emerald-green argillaceous shale.
7. Greenish veined argillite.
8. Light-bluish sandstone in layers one to six inches thick, waving, and veined with calcspar.
9. Light-coloured quartzo-feldspathic sandstone in thick beds. The dip of the beds from 5 to 9 is S. 20° E. $<$ 50° ; their aggregate thickness 230 feet.
10. White-weathering quartzo-feldspathic grit, dipping S. 38° E. $<$ 60° seems to underlie the shore as far as Pothier Point, where the angle of dip is lower and the direction more nearly south.

Pothier Point.

11. Red and greenish conglomerate, represented only by large blocks on the shore, but well seen in the fields and on the post-road. The pebbles are seldom larger than a hen's egg, and are chiefly quartzites of various colours, but sometimes sandstone and felsite. It is rough, coherent and differs greatly from the carboniferous conglomerate.
12. Reddish, purplish and bluish sandstone and grit, dipping S. 56° E $<$ 20°
13. Greenish and bluish sandstone, sometimes stained with hematite.

Hematite.

14. Measures concealed.
15. Red conglomerate mixed with coarse and fine red sandstone, underlying the coast as far as Three Island Cove, and stretching over rocky clearings towards the road.

Three Island Cove.

16. Traces of sandstone and pieces of soft, crumbling, bluish argillite.
17. Measures concealed in a deep, wide bay, with sand and pebble beach and gravel bank.

18. Long reefs of blackish and gray, crenulated arenaceous shale and whitish close-grained feldspathic sandstone and impure limestone, crossed by veins and blotches of quartz and calcspar, in some of which are specks of copper and iron pyrites. Lenticular layers of bluish limestone, not bituminous, but veined and twisted, often concretionary and folded round a core of soft argillite or of iron pyrites. Dip S. 12°—30° E. < 45°—60°.

Copper pyrites.

19. Greenish conglomerate, pebbles of light-coloured quartzo-feldspathic sandstone embedded in a fine paste of similar composition. Dip S. 20° W.

Godie Point.

20. Drab and reddish argillo-arenaceous shale seems to strike S. 55° W. at Godie Point, but if this is the attitude, the colours pass abruptly into each other across the line of strike. Here the rocks are nearly vertical; but at the extreme point, where the next bay begins, similar shales dip N. 45° W. < 45°, running thence as far as the pond in the bay.

Mark Point.

		FEET.
21.	Measures concealed by the pond and beach.	
22.	Red and green shales, often nacreous and slaty	50
23.	Thick-bedded sandstone with patches of a brecciated rock, veined with quartz, calcspar and ankerite	10
24.	Quartzite or quartzo-feldspathic sandstone in rolls, covered with rusty blotches derived from the weathering of streaks of pyrite. Markings of carbonized plants one-eighth of an inch wide; thin streaks of coaly matter. (*Coal.*)	30
25.	Measures concealed	32
26.	Quartzite or sandstone like 24	50
27.	Measures concealed	100
28.	Greenish fine sandstone or quartzite	135
29.	Measures concealed	95
30.	Black and greenish shale, containing an obscure *Cypris* and carbonized plants. (*Shells and plants.*)	40

31. Drab, cleft, shaly sandstone, not well seen. Here a roll repeats the measures, which are, however, soon concealed.

32. Between Mark Point, where the foregoing section was obtained, and Jerome Point few exposures occur on the shore. Blocks of quartzite, sandstone and shale cover the fields about Kavanagh Creek, and on one of the brooks flowing into this inlet is a greenish argillite crumbling into knife and needle-shaped fragments. Between Kavanagh Creek and Jerome Point are many blocks of greenish-gray, close-grained sandstone, with fragments of carbonized plants, *Sphenophyllum*, ferns and *Cordaites*.

Plants.

Encrinal limestone containing galena.

33. Limestone, bluish and gray, compact, crystalline and concretionary, massive or slaty, contorted and variable in dip; seen on the eastern side of Mount Granville and in many places on the Bras d'Or as far as McNab Cove. At St. Peters it is full of small specks and strings of galena; and chloritic matter is found between the layers; contains here only a few doubtful encrinites.

St. Peters diorite.

34. Diorite of Mount Granville and St. Peters Canal.

Rocks similar to those described above are present on the L'Ardoise, Salmon Creek, Soldier Cove, Ferguson Lake and other roads between the Atlantic Ocean and Bras d'Or Lake; and some of the L'Ardoise brooks exhibit a great thickness of conglomerate, quartzite and red argillite, indistinguishable from those of the Primordial series except by the fossils which they contain.

Whether in direct contact with the traps and diorites or far from them, the limestone is highly altered—in places to such a degree as to lead to its being quarried for marble. Fossils are rare. At Robinson Cove, where it has been largely quarried, small shells appear on weathered surfaces, and *Conularia, Streptorhynchus,* stems of plants and other organic forms may sometimes be obtained from the more shaly layers. Its attitude here is nearly vertical, but at the mouth of the brook the vertical beds seem to be overlaid by another limestone in horizontal bedding, an appearance due to a small fault, for, a short distance up the brook, the contorted, horizontal layers turn up and dip steeply like the others. The concretionary limestone is blackish, with white spots; it includes irregular, cross and bedded veins of white calcspar, sometimes three feet thick, in which the crystals are often an inch in length. Several small caves, one of them ten feet high and seven feet deep, occur in this limestone.

Crystalline limestone.

Fossils.

Fault.

Veins.

Caves.

Masses of diorite and trap are intruded among the sedimentary rocks, and rise into conspicuous hills in the neighborhood of St. Peters. The St. Peters canal is excavated for nearly its entire length in a rock of this kind, which forms the western slope of Mount Granville, and consists essentially of a greenish, gray, bluish and light-red mixture of hornblende and feldspars, intersected by veins of quartz and feldspar, and holding specks of quartz, mica, hematite, copper and iron pyrites. In one place a band of soft, crumbling, calcareous clay-rock, of variable thickness, full of imperfect compound crystals of pyrite, crosses the excavation nearly at right angles from bank to bank. At Jerome Point, the extremity of this hill, is a compact, rusty, calcareous felsite, fragmental and vesicular, or mixed in globular structure with greenish diorite so as to resemble a conglomerate.

Trappean hills.

St. Peters canal.

Campbell Hill is a diorite surrounded by limestone, reddish, greenish and purplish argillite and sandstone. This argillite is cleft, and contains small, twisted lenticular veins of quartz, with cavities full of iron rust. Several beautiful little brooks flow down from these hills, between high, woody banks, in small cascades. One of these is met in its course by a high bank of limestone, under which it passes to emerge, farther down, as a spring. On the western shores of Soldier Cove and Salmon Creek, and on the Indian Reserve, the sedimentary rocks are again broken through by gray and greenish, compact and granular diorite and pyritous, epidotic felsite, traversed by veins of light-coloured calcspar.

Campbell Hill.

Indian Reserve

A dyke of coarse, greenish diorite intruded among fine, glistening

Diorite dyke.

sandstone, coarse grit and nut-conglomerate, alters the sandstone into quartzite, but its influence extends only a few feet. Compact porphyry and trap are on the beach to the eastward, resembling the trappean rocks of Gregwa Brook (Report for 1876-7, p. 413). The crystals of the porphyry are long and whitish, often crossing one another. A short distance beyond, a limestone is cut by fine-grained diorite and felsite, beneath which it apparently dips.

Porphyry and trap.

Cliff-outcrops of black, bluish, greenish and purplish, compact or granular, rusty-weathering trap, passing into felsite or diorite, occupy the eastern and outer shores of Alick Island. The trap is sometimes porphyritic, or assumes the globular structure seen at Jerome Point; it has vugs containing a canary-yellow, crystalline mineral; and traces of hematite, calcspar, chlorite and radiating zeolites are disseminated throughout the mass. Moonac Island is probably carboniferous, blocks of plaster being strewn along the shores. Two small islands lie nearer Chapel Island. The easternmost is merely a mussel-bed, but the second is covered with blocks of purplish, fine, calcareous, amygdaloidal trap. This latter is separated by a shallow bar from Chapel Island, at the western point of which, hematitic amygdaloid is in contact with greenish and reddish conglomerate associated with veined and wrinkled limestone and friable sandstone.

Minerals of the trap.

The continuity of the volcanic series on the mainland in this vicinity is often doubtful, but exposures occur in many places.

Near the millbrook, at the foot of Loch Lomond, is an outcrop of greenish and gray felsite and friable diorite which may belong to this series. The outcrop is singular. No other rocks are seen, the exposure is only a few feet wide, and nearer the brook pieces of sandstone occur. An interesting junction is displayed on the left side of Grand River, not far above the bridge, where felsite and diorite, apparently intrusive but strikingly resembling the coastal series, are in close connection with highly altered quartzose sandstone, grit and conglomerate, along a very irregular line of contact, It is possible that this belongs to the older series. On the other hand, it is not impossible that some of the rocks in the immediate neighborhood, coloured on the map as pre-*Silurian*, may be newer.

Grand River

The quartzite and sandstone of the Loch Lomond and Grand River barrens are more coherent and compact than those of the Bras d'Or Lake and L'Ardoise. In the brook to the southward of the millbrook at Loch Lomond they are bluish, gray and whitish, with a tinge of red, micaceous, full of minute rusty specks, compact or fine grained, cleft and broken, massive, thick-bedded or shaly; and are associated with occasional beds of soft, rippled argillite, in thin laminæ with polished surfaces.

Quartzite.

From the outlet of Loch Lomond (Report for 1876–7, p. 424)* to the L'Ardoise road, and at the end of the road at the church, syenitic detritus prevails. Whitish and reddish quartzite, quartzo-feldspathic sandstone and grit, not unlike those of the Caribou Marsh road, then appear, and are also displayed at Benjamin McLeod's point and the vicinity. At Grand River mouth and on the road up the left bank to the bridge at the head of tidewater, the only rocks seen in place are felsites, but many blocks of gray, whitish, reddish and purplish quartzite, quartzo-feldspathic sandstone, grit and conglomerate are met with, as well as on the beaches between Grand River and L'Ardoise. Above the bridge, quartzites alternate with carboniferous conglomerate and limestone, while they entirely cover the barrens of the right bank. Near the small lake at A. McLennan's and on Widow McKay's road, whitish sandstone, veined and streaked with quartz and hematite, without evident bedding, also underlies the rocky barrens which extend to and beyond the river, and to Loch Lomond. Loch Lomond. Grand River. Quartz and hematite.

Following these strata from the foot of Loch Lomond, on the road to McNab Cove, through woods and rocky quartzite barrens, and past lakes and marshes, we find them again represented in McNab Brook by red and gray contorted sandstone and argillite full of quartz veins. Near McNab Lake reddish sandstone and shale form good soil, resembling that derived from the lower carboniferous formations, and the land is, consequently, cultivated. McNab Brook.

In Tom's Brook the limestone occurs in a series of folds, lying generally at a high angle, and apparently overlaid unconformably by gypsum in almost horizontal bedding. In one of these folds the following ascending sequence is presented : Tom's Brook.

	FEET.
1. Gray, bluish and black, contorted, concretionary limestone, in regular, flaggy and shaly layers, cut by minute calcspar veins and abounding in vugs lined with crystals of calc-and dogtoothspar. A plumbaginous film invests many of the planes. Fossils : *Conularia*, *Streptorhynchus*, a whorled shell and markings of plants. The limestone is cut intó gorges and small caves. One of the latter is about three feet high and about the same width at the mouth, but rises to five feet inside : it is waterworn and apparently at times the passage for a brook.... (Fossiliferous limestone; Caves.)	75?
2. Gray micaceous sandstone covered between the layers with broken, carbonized plants. Dip S. 84° E. at a variable angle	11
3. Purplish and reddish argillaceous shale with green streaks	20
4. Measures concealed	6
5. Gray and white fine sandstone or quartzite, like that of the barrens of Grand River	11

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* These rocks were at first doubtfully referred to the Lower Silurian series, which they greatly resemble.

FEET.

6. Gray sandy and argillaceous shale, full of minute, blackened fragments of plants. 10

Plants.

7. Gray and whitish, sometimes rusty sandstone, shaly, flaggy and massive, fine-grained and coherent or coarse and crumbly: carbonized impressions of large *Calamites* and other plants.......... 150
8. Purplish and greenish, cleft, coherent, calcareo-micaceous, areno-argillaceous rock. Dip S. 70° E. < 45°.......... 104
9. Bright-red, soft, indefinitely bedded marl.......... 12
10. A rock similar to No. 8.

Carboniferous rocks.

The rocks now turn and dip N. 3° E. < 10°—75°. But before the limestone reappears, a coarse diorite is seen in the brook, beyond which are softer rocks, brighter in colour, associated with a gray and yellowish limestone-breccia, and probably carboniferous.

McNab Brook.

In the western branch of McNab Brook, above the road to Loch Lomond, similar strata, repeated again and again by folds, form barrens producing a few birch and spruce trees, white and yellow mosses, blueberry and wintergreen plants; and exhibit, in the brook, picturesque cascades and linns. They comprise:

1. Bluish, reddish, purplish, greenish and whitish, fine-grained or compact, massive quartzo-feldspathic sandstone and quartzite, in rough, white-weathering knobs, with blotches and veins of milky quartz and vugs containing crystals of the same mineral. The surface of the sandstone has a sparkling appearance from the presence of innumerable minute particles of quartz.
2. Gray, smooth, argillaceous rock, in thick, irregularly cleft and jointed beds.
3. Red marl, with green spots, cleft and jointed.

When the highland is reached the rocks give place to willows, grass and moss.

St. Peters road.

On the St. Peters road not far north of McNab Cove, red and purple micaceous sandstone and argillite, and grayish-white and greenish, fine, quartzo-feldspathic sandstone, with a purplish or rusty tinge, dip S. 81° E. < 30°, and nearer the cove S. 76° E. at a high angle. South of the cove, an interesting section on the shore displays

1. Grayish-white and mottled red and gray, micaceo-calcareous, shaly sandstone and quartzite, like those of the Caribou Marsh road and Young Point (Report for 1875-6, p. 388), and like them arched and crumpled.
2. Greenish, purplish and indian-red, soft, crumbling argillite, in a rusty bed of which, traces of coaly matter were detected.
3. Limestone, blackish, bluish, grayish yellow-weathering, often arenaceous, drused with hematite and seamed with calcspar, shaly, wrinkled or rippled, full of cone-in-cone concretions. Sometimes it dips into the water at a low angle, but frequently runs vertically or dips inland. It holds dark-purple fluorspar and small spiral shells.

Fluorspar: shells.

Metamorphic Devonian rocks of this character have been examined in many brooks between McNab Cove and the Indian Reserve where they are cut by masses of felsite and diorite. West of the Salmon Creek chapel, red sandstone and argillite are again associated with diorite, epidotic felsite and syenite in the road; and succeeded by black and bluish, shaly and slaty, argillaceous, crystalline limestone, with a silky surface lustre, full of calcspar and cone-in-cone concretions, and dipping S. 86° W. Markings often occur in the limestone which simulate corals but are probably the result of crystallizing or concretion-forming agencies, which also give rise to cones three inches in diameter, with a central, radiating nucleus. Cone-in-cone concretions.

Similar rocks were observed at Cape Porcupine on the Strait of Canso, unconformably overlying the felsite and slate series of the mountain. The latter seem to be of pre-Silurian age. Cape Porcupine

4. Carboniferous Conglomerate and Limestone.

It is impossible to doubt the former continuity of the carboniferous strata, of which scattered patches alone indicate the existence in the district to which this report refers. A single outcrop of coarse conglomerate of somewhat doubtful character is found in the eastern part of Scatari Island, nor are others met with until we reach Neil Cove, on Mira Bay, where a similar conglomerate caps the pre-Silurian felsites. This is succeeded by a limestone, from which the French are said to have burnt lime for Louisburg, overlaid in turn by millstone grit. On the shore beyond, conglomerate and variegated limestone dip about north at a low angle. At Catalogne Point, millstone grit strikes southeast vertically, but is immediately succeeded by a thick limestone, dipping N. 13° W. < 60° in a reef underlaid by red rocks. Immediately to the south of these carboniferous rocks come the coastal felsites of the shore road, which also emerge from beneath them north of Catalogne Lake, on the railway and on the Old Louisburg road. From the railway to the Sydney post-road the felsites are in several places overlaid by impure, pebbly limestone and conglomerate with a moderate northwesterly or southeasterly inclination. Scatari Island. Mira Bay.

On the Atlantic coast between Mainadieu and Cape Breton traces of red soil and sandstone are exhibited on the broad beach of fine sand fringing Mainadieu Bay, over which this road passes, and also at the head of Baleine Cove; but nowhere east of Loran (Report for 1876-7) were carboniferous rocks found in place. In the northeast angle of Louisburg harbour, reddish coarse conglomerate is exposed, and doubtful traces extend as far as McAlpine's store. In Gabarus Bay and around Lever and Belfry Lakes, several outliers of conglomerate rest upon the coastal felsites; and gray and yellowish shaly limestone was pointed out to us at several places on the shore of Upper Belfry Lake by the Rev. Donald Sutherland, of Gabarus. Loran. Louisburg. Belfry Lake.

Morley road. On Lamond's farm, about a mile west of the Mira end of the Morley road, blocks of carboniferous limestone lie scattered about the fields, and the ground is riddled with pits. Salmon River. On the right bank of Salmon River, below Ball's mill, another outcrop of limestone runs N. 26° E. vertically. It seems to overlie whitish Lower Silurian sandstone, and again appears on the Mira road, as well as on the farm of Mr. J. Huntington, at the mouth of the river. Ten miles higher, on the Salmon River road, a gray bituminous limestone, with a moderate northwesterly dip, contains specks of galena. (Galena.) In a millbrook close by is a fine exposure of red felsite and syenite, overlaid by a conglomerate formed of their debris.

Several outliers appear in the valley of Grand River and at L'Ardoise, two of which afford workable beds of limestone of the usual character. Grand River falls. In Grand River, a reddish friable conglomerate, in thick beds, sometimes fine and approaching limestone, gives rise to falls of great beauty and interest. The water from the Loch Lomond chain of lakes and many considerable brooks leaps down a height of twenty-six feet in three cascades, sixteen, four and six feet high respectively, in a distance of one hundred and thirty-five feet. It is proposed to erect a fish-ladder to surmount the falls and allow salmon to ascend to the lakes and streams above. Red sandstone and conglomerate, probably carboniferous, composed of various felsitic rocks, are displayed in contact with pre-Silurian felsite, diorite, quartz-felsite and granite on the Ferguson Lake road, and in two brooks flowing from it to Grand River; and on the L'Ardoise road, above the Grand River bridge, are interstratified with limestone. The dip, unlike that of the quartzite series, is always low; the rocks, earthy, crumbling, and quite unaltered.

Plaster. Pieces of gypsum are strewn along the shore near McNab Cove, and outcrops are frequent in Tom's Brook and the vicinity of Hay Cove. At the northern end of Wilson Island, red and gray calcareous sandstone in thick and shaly beds dips S. 61° E. $<$ 15°; and half a mile farther south, reddish, flaggy and shaly, rippled sandstone dips S. 69° E. $<$ 5°. These outcrops probably belong to this formation, but long clam-flats conceal the strata and render this somewhat doubtful.

5. Millstone Grit.

Succeeding the limestone of Catalogne Gut, which dips seaward at a low angle, are cliffs and reefs of bluish and yellowish-gray, false-bedded sandstone, in nearly vertical beds, some of which are shaly and flaggy, others thick and fit for building purposes. Mira River. Above Albert Bridge on the South Mira road, a gray, rusty-weathering, pea-and-nut conglomerate is mixed with gray sandstone and coarse grit, containing fragments, principally of quartz but also of feldspar, syenite and mica;

and rests unconformably upon Lower Silurian slates and sandstone. On the Mira road near Salmon River, millstone grit, carboniferous limestone, Lower Silurian and pre-Silurian rocks occur together, the southern boundary of the millstone grit running thence along the Salmon River road to Loch Lomond. In Alfred Huntington's fields, ledges of gray and reddish sandstone dip S. 46° E. < 80°.

A seam of coal is said to have been found in these rocks near Catalogne Gut, but was not seen by us, and the report may have arisen from traces of this substance derived from carbonized plants in the sandstones. Coal.

SUPERFICIAL GEOLOGY.

The general characteristics and agricultural capacities of the districts underlaid by the different series of rocks described above have been frequently adverted to in the course of this report. The remarkable paucity of carboniferous deposits accounts for the somewhat tame and monotonous character of the scenery, the metamorphic rocks alone producing little diversity of hill and dale. As a whole, the country is better adapted to fishing than to agricultural pursuits, and is chiefly inhabited by a seafaring population, even in those parts where attention to the soil could not fail to be productive of wealth equal to that derived from the ocean, combined with comfort to which the fisherman is a stranger. The settlements are indeed thriving, but a season of scarcity—and the cod, mackerel and herring are said to be less plentiful than of old—leaves the inhabitants wholly indigent or dependent on the wrecks that strew the coast. For, no more appropriate epithet than "shipwrecking" can be applied to the sea in this region. Few years pass without their record of vessels on the rocks and loss of life or property, notwithstanding the many lighthouses on the coast to warn them of its dangers.

The Indian Reserve at Salmon Creek vies with Escasonie in the natural beauty of its scenery. The charming view from the Indian hill is perhaps the finest on the Bras d'Or Lake. The islands opposite are grassy or woody, and alive with birds; their shores rocky or covered with bright pebbles; the water clear and quickly deepening. On the largest is the Indian chapel, to which, in the month of July in every year, Indians throng from all parts of Nova Scotia to the great religious festival of St. Annes. A haze hangs above the islands and the light breeze plays around them, leaving calm spots on the deep blue surface of the water. In the distance are the purple shores of McKinnon's Intervale with fringing cliffs of plaster, the Grand Narrows, East and West Bays, backed by ranges of hills. The land of the reserve is good but little cultivated: the Indians subsist chiefly Indian Reserve at Salmon Creek.

on eels and other fish caught in the lake, and inhabit the primitive wigwam to which a small log cabin is sometimes attached.

Game.

The otter and mink are trapped on the lakes of the interior; ducks and wild geese abound at certain seasons on all the coasts; and seals and porpoises often visit the bays and harbours. One hundred and fifty seals were killed in Gabarus Bay in the first week of April 1878.

Salmon River near its mouth flows through plains of great fertility; and Mira, Catalogne, Grand River, Framboise, and other districts contain land capable of supporting a large agricultural population.

Villages.

The principal villages on the shore are Mainadieu, Baleine, Little Loran, Loran, Louisburg, Gabarus, Fourchu, Framboise, Saint Esprit, L'Archevêque, Grand River, L'Ardoise, and St. Peters. Of these, Louisburg, the site of the historical French town of that name, now a shipping-port of the Cape Breton Coal Company, boasts one of the finest harbours in Nova Scotia.

Scatari Island.

The shores of Scatari consist alternately of rocky headlands and sand and gravel beaches, guarded by reefs, and inclosing ponds. Mossy barrens, full of holes, bordered and sometimes interrupted by clumps of scraggy spruce, and covered in their season with bake-apples and other edible berries, line the shore, while the interior is occupied by barrens, rocky knolls and lily-ponds, among which gulls have built their nests, since the foxes were driven from the island. Small fishing hamlets nestle in the coves, thronged during summer by fishermen from all the surrounding country; but not more than eight or ten families spend the winter here. The road between the eastern and western lights is a mere footpath, on which the sum of sixty dollars was expended some years ago for the removal of the trees from the dangerous, crumbling cliffs. The soil is light, and it is doubtful whether there are ten acres of land under cultivation. A few goats, six milch cows, and perhaps as many small horned cattle, fifty sheep, and innumerable dogs—grown fat and lazy by feeding on fish offal—are the principal domestic animals.

The description given of Scatari applies equally well to most of the region of the coastal felsites. On the Catalogne, Old Louisburg, and McLean roads the farms are scattered among lakes, rocky knobs and felsite ridges. The land on the uplands appears good, and the crops excellent, but barrens, marshes and small lakes are alone met with on the lowlands.

Between Louisburg Harbour and Kennington Cove the coast is barren; few bushes occur near the shore, but beaches inclosing ponds, rocky cliffs, reefs and small islands abound. The whole shore from Cape Gabarus to Fourchu is low and covered with rough beaches. Reefs lie outside, within which it is dangerous for a vessel to approach. About Fourchu and Framboise and between the latter and Loch Lomond much of the country is marsh and barren; and the same may be said of that between Grand River and St. Peters, fertile spots intervening on the highlands and in the neighborhood of several of the brooks and lakes.

The barrens owe their origin to bush fires, which have several times devastated the country and destroyed the timber. They are of two general kinds, being either wet and rocky or dry and stony. The wet barrens are covered with moss and marsh plants, and are characteristic of pre-Silurian areas; whilst the dry barrens, producing small trees, bushes, raspberry, strawberry, and other plants, indicate the presence of blocks of white sandstone and quartzite of the higher metamorphic series, the red sandstone, limestone and shales of which usually yield land capable of cultivation. The reason of this difference is probably to be found in the unequal resistance to atmospheric disintegration, offered by the felsites and quartzites, the former crumbling to a clay easily removed by rain and streams, the latter breaking into angular blocks, which encumber the surface. On some of the hills among the barrens, patches of good land occur, and it has sometimes happened that settlers have deserted clearings, because only winter roads could be made to their houses. Barrens.

The great length of the brooks compared with the slight elevation of their sources above the sea, interruptions to their flow and surface inequalities give rise to the marshes and lakes which characterize a great part of this region. Some of these afford hayland of great fertility. Brooks and lakes.

Sand-beaches are numerous and often of great length, the most important being those of Mainadieu and Point Michaux. The fine, rusty, rippled sand of the latter, studded with a few small pebbles and frequently holding grains of magnetic iron ore, is beautifully displayed at low tide. It is skirted just above high-water mark by a ridge of blown sand. Magnetic sand.

Two remarkable moraine like accumulations of sand, gravel and boulders occur at Middle Hardy Lake and Upper Marie Joseph Lake. The former, near McLeod's, encircles the lake with a mound, as if artificially raised to confine the water. The latter is higher and farther from its lake, resembling a railway embankment. Sheep and cattle have a path along the top. Raised beaches

Glacial striæ were observed near Cape Gabarus, running N. 60° E., crossed by finer ones in a direction N. 40° E., the rocks being finely smoothed, polished and rounded. On the path from Framboise road to the church, striæ rocks seemingly in place, run N. 22° E. and N. 7° E., the latter being the most recent. Glacial striæ.

At the outlets of many of the lakes, blocks of stone have been accumulated by the breaking up of the ice in spring. In many cases these have been thrust forward many yards in the soft mud of the Action of ice in lakes.

bottom to form long deep grooves, at the end of which lies the boulder, with a pile of smaller stones and mud in front. This was well displayed at the foot of the Barren Lake, near Loch Lomond.

ECONOMIC MINERALS.

Coal.—A seam of this mineral is stated to have been seen at low water in the gray sandstone at Neil Cove, Mira Bay, but the rumor was not verified.

Le Cras seam.

The Le Cras seam has been again opened by the energy and perseverance of the Messrs. Cossitt, 36 chains northeast of the road from Sydney to Louisburg, quarter of a mile southeast of the piece of old road near Sydney, apparently on the line of fault, as it dips S. < 67°. Although reported to be in one place four feet thick, it does not seem generally to have improved much in thickness or quality (Report for 1874–5, p. 191).

Fluorspar.

Traces of coaly matter were also found in the limestones of McNab Cove associated with fluorspar.

French Vale.

Iron Ore.—Red hematite similar to that found at Lauchlin Curry's (Report for 1875–6, p. 414, and Report for 1876–7, p. 449) was developed by Mr. Moseley in a pit on Widow Campbell's land on the French Vale road, two miles and a half to the northward of Curry's pits. It resembles in apearance and surroundings the ore at Curry's, being also mixed with scales of chlorite, talc and mica. The limestones in which it is found are of every variety of colour and texture, sometimes graphitic. Red carboniferous rocks are seen at no great distance. The occurrence of the iron ore at this locality is interesting as tending to prove that it probably exists as a bed in the George River limestone rather than as a local contact-deposit between this formation and the overlying carboniferous rocks, a point, which, however, cannot yet be considered as conclusively established.

Loran.

Trial pits were put down on the deposit of iron ore at Loran (Report for 1876–7, p. 449) by Mr. Ranson, of Louisburg, which prove that the ore does not exist in workable quantity in this locality, but occurs in a very hematitic carboniferous conglomerate.

Gabarus Bay.

Blocks of hematite mixed with calcspar were found in Seal Cove, Gabarus Bay; but their origin is uncertain. Strings and veins of hematite of no economic value penetrate the Devonian quartzite and sandstone of the barrens of Loch Lomond and Grand River.

Loch Lomond.

Bismuth Glance.—Specimens of this ore are found in the veinstone of the Eagle Head copper mine, as pointed out by Professor How, of Windsor, N. S.

Arsenical Pyrites is also said to have been found in minute quantity at Eagle Head.

Copper Ore.—The occurrence of copper pyrites in quartz layers at Eagle Head, Gabarus Bay, was described in the Report for 1875–6, p. 415. It is also met with, at the same place, in a light-coloured felsite containing vugs lined with crystals of quartz. A band four feet in width has been worked in the old shaft, and new openings have been made in several places; but the prospect of finding a valuable deposit does not seem greatly improved. Associated with the feldspar and quartz, a band of whitish green soapstone was found in shaly layers by Mr. Angus Campbell, of Sydney, with arsenical pyrites, bismuth glance, iron pyrites, molybdenite and traces of gold. Eagle Head.

Yellow copper pyrites also occurs on the farm of Angus McDonald (Big Angus) on the French road (Report for 1876–7, p. 451) in eye-shaped blotches and films in a compact felsite. A large portion of the rock is impregnated with the ore, but nowhere is it revealed in paying quantity. French road.

The so-called copper-mine of the Gillis Lake road is a development of the outcrop indicated in the Report for 1875-6, p. 374. An excavation made by Mr. John McKenzie, of Sydney, disclosed a greenish, soft, sectile, soapy rock, impregnated with calcspar, drused with a talcose hematite, and holding traces of iron and copper pyrites with green carbonate. Gillis Lake road.

Magnetic Iron Ore occurs in grains in the sand of some of the beaches on the coast.

Limestone.—The position of the principal beds of this material fit for burning is shown on the map. Quarries have been opened to supply local demand at Catalogne, Salmon Creek, L'Ardoise, McNab Cove, and other localities. At Marble Mountain, West Bay, a deposit of bluish crystalline limestone, about one hundred feet thick, which burns to a very good white lime, suitable for mortar as well as for agricultural purposes, is wrought by the Cape Breton Marble Company. An analysis of a sample of this stone gave Professor How:— Marble Mountain. Professor How's analysis.

Carbonate of lime	94·31
Carbonate of magnesia	·75
Oxide of iron and alumina	·45
Water	·14
Phosphoric acid	decided traces.
Silicious residue	4·35
	100·00

Every facility for burning and shipping lime exists at this place, where in connection with the quarrying and cutting of marble it is believed a profitable business might be done.

Gypsum.—Plaster occurs only in small quantity on the shore of the

Bras d'Or Lake, near McNab Cove, and has not been applied to any useful purpose.

Mira brick-works.

Clay.—An excellent deposit of stiff blue clay, overlaid by a gray variety, has been for many years somewhat largely wrought for the manufacture of bricks by Mr. Caleb Huntington, of Mira River. It has been dug to a depth of twenty feet without being exhausted, and is said by Mr. Huntington to exist on the opposite side of the river. At one time 400,000 bricks were made annually, but of late years the demand has so fallen off that operations are continued only one or two months, and fifteen men employed. Three kinds of bricks are made—hard, medium and soft—which are said to be of remarkably good quality.

Steatite.—Soapstone or steatite has already been mentioned as occurring in thin layers among the felsite and quartzite of Eagle Head.

Scatari.

Ornamental Stone.—The felsite-breccias, near the west light of Scatari, yield a great variety of bright coloured pebbles, and a polished block is on exhibition at the Provincial Museum, Halifax. But the planes of joints and cleavage, combined with those of bedding, break the rock, and apparently render it unfit for the uses to which, on account of its great beauty, it might otherwise be applied.

The granite of the White Granite Hills is said to have been used in the neighborhood for building hearths and chimneys; and, if the Louisburg railway were built, might become of economic importance as a building and ornamental stone.

Salmon Creek.

Marble.—At Stephen McLean's, near Salmon Creek, a cliff of bluish-gray, somewhat crystalline, Devonian limestone was quarried for marble in a deep excavation, but soon abandoned.

Marble Mountain.

The finest deposit of workable marble yet developed in Nova Scotia is that of Marble or North Mountain on the West Bay of the Bras D'Or Lake, which was discovered by Mr. N. J. Brown in 1868, but has attracted less attention than it deserves, owing to the difficulties which beset a new enterprise, the occupation of the Canadian market by older quarries, more favourably situated, and the exclusion of Canadian marble from the United States by a duty of fifty cents per cubic foot imposed on all foreign marbles. Still, there can be little doubt that this will ultimately become a source of profit to its owners.

Quality.

Distribution.

In variety of colour and tint this rock is like the crystalline limestone of the George River series, of which it forms a part; but it contains little or no admixture of the foreign minerals that elsewhere render them unfit for use, is more uniform in texture and in unequalled abundance. It has been traced by means of natural outcrops and by trial pits from the shore of the lake to a height of five hundred feet or more, on the side of a steep hill, with a nearly vertical southerly dip; and its extension on the strike appears to be considerable.

Professor How in a report* addressed to the Cape Breton Marble Company speaks highly of the extent and quality of the marble; and his opinion is corroborated by Professor Hind, Mr. Poole,† inspector of mines, and practical quarrymen, who have visited the place. Samples have been sent to marble cutters in England the United States and Canada with the most gratifying results. Its texture and quality are excellent; it works freely, takes a good polish, stands the weather well, and is especially adapted for monuments and ornamental work. According to Professor How, the rock while somewhat similar to the Vermont and New York marbles is tougher, and takes a much sharper cutting. In blocks it has greater resistance to crushing power than any rock except granite. Professor How enumerates the following varieties: Comparison with U. S. marble.

Varieties.

1. Fine white statuary marble.
2. Fine white building marble.
3. Coarse white building marble.
4. Blue and white, clouded or Brocatello, marble.
5. Brocatello marble mixed with some six varieties of coloured marbles.
6. Fine flesh-coloured marble; changing to darker marbles, often striped and variegated.

Quarries.

Several quarries have been opened. The "Grand Quarry," about four hundred and fifty feet above the lake and three hundred yards from deep water, is in the centre of the very best pure white and variegated rock, which is found over about two or three hundred acres and exposed in the quarry to a height of sixty feet. A tunnel, one hundred and twenty feet long, driven from a point about two hundred yards from the margin of the lake, runs through bluish and white crystalline limestone and strikes the solid rock at the bottom of this face. A bed of yellowish crumbling rock, eight feet thick, overlies the marble and greatly facilitates its removal. At the upper part of the face the rock is very much broken, but the cracks diminish in number and extent in depth, and for some distance around the tunnel the rock is white, solid and free from flaws; and as the beds here are from four to five feet thick, immense blocks can be removed. Another tunnel has been driven from a point half-way between the first tunnel and the shore, to strike the wall-face 170 feet below the surface, where the marble is clear white and free from flaws.

The facilities for mining, drainage and shipment could hardly be surpassed. A short tramway has been laid to a shipping-place, from which Canso light is but a few hours' sail. The buildings and plant are in good repair. Mr. Underhill, of West Rutland, Vermont, a

* Many of the details here presented are extracted from this report.

† Report of the Nova Scotian Department of Mines for 1876, p. 67.

marble worker of thirty years experience, estimates "that $5,000 will put the Grand Quarry in good working order and build a mill sufficient to commence with." It is hoped that the reopening of St. Peters canal will add a fresh stimulus to this undertaking, and develop a new industry and source of wealth in Cape Breton.

Building Stone.—Some of the metamorphic sandstones make good flags, but generally they are too soft and friable or too hard and compact to be used in building. Good stone is found in the millstone grit of Neil Cove, Mira Bay, but the quantity is limited. The crystalline diorite of Blackrock Point was largely used by the French in the fortifications of Louisburg. The walls of the first St. Peters canal were built of the shaly limestone quarried on the road to the eastward of the village and at Robinson Cove.

Mira Bay.

Louisburg.

St. Peters.

GEOLOGICAL SURVEY OF CANADA.
ALFRED R. C. SELWYN, F.R.S., F.G.S., DIRECTOR.

REPORT

ON THE

MINERALS OF SOME OF THE APATITE-BEARING VEINS

OF

OTTAWA COUNTY, Q.,

WITH

NOTES ON MISCELLANEOUS ROCKS AND MINERALS

1878

BY

B. J. HARRINGTON, B.A., PH. D.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

Montreal:
DAWSON BROTHERS.

1879

GEOLOGICAL SURVEY OFFICE,

MONTREAL, June 6th, 1879.

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

Director of the Geological Survey.

SIR,—Herewith I beg to hand you my report on the minerals of some of the apatite-bearing veins of Ottawa County, Quebec, and on miscellaneous rocks and minerals from other regions.

I have the honour to be,

Sir,

Your obedient servant,

BERNARD J. HARRINGTON.

REPORT

ON THE

MINERALS OF SOME OF THE APATITE-BEARING VEINS

OF

OTTAWA COUNTY, QUEBEC,

WITH

NOTES ON MISCELLANEOUS ROCKS AND MINERALS.

BY

B. J. HARRINGTON, B.A., PH.D.

The numerous openings which have been made in search of apatite since the spring of 1876 in Buckingham, Templeton and other townships of Ottawa County, comprising what is sometimes known as the North Ottawa Phosphate Region, have afforded excellent opportunities for the study of many of our Laurentian minerals and their mode of occurrence. With the object of making such a study, two visits were paid to the region during the past season, one in June and the other in September; and although they were both of short duration, many minerals were collected for examination, and numerous facts obtained bearing upon the character of the deposits from which they were taken. Most of the time was spent in the township of Templeton, as the apatite veins of that township were known to afford a great variety of minerals; but a number of mines in Buckingham and Portland were also visited. North Ottawa Phosphate Region.

My grateful acknowledgments are due to Mr. J. G. Miller, of East Templeton, Mr. Gerald C. Brown, of Buckingham, and other gentlemen, for much information, and also for most substantial assistance. Mr. Miller, who takes a lively interest in mineralogy, has been a most industrious collector, and generously placed at my disposal quantities of interesting material from his own collections. Acknowledgment of assistance.

Some of the observations which follow concerning the apatite region of the Ottawa are new only as regards that region, similar statements relating to the North Burgess district having long ago been published by Dr. T. Sterry Hunt; but, at the same time, many entirely new facts worthy of being recorded are given here, and the general similarity of the two regions is established. The interesting paper of Messrs. Brögger and Reusch on the occurrence of apatite in Norway, published in the journal of the Geological Society of Germany,* has also enabled me to institute occasional comparisons between the deposits of that country and our own, and to add to the many analogies already pointed out by Hunt, Macfarlane and other writers.

Facts published by Dr. Hunt.

Occurrence of apatite in Norway.

In Norway the more important deposits of apatite are stated by Brögger and Reusch to occur either in or in the immediate vicinity of a rock which they term "spotted gabbro," (*gefleckten gabbro*), and which they regard as eruptive. The term gabbro, however; is not used by them in its ordinary sense, but applied to a rock consisting of brown, lustrous hornblende and white to greyish-white labradorite—an aggregate commonly called diorite. Except in the colour of the hornblende, it would appear to resemble what has been termed by Mr. Vennor "blotched diorite,"† and which consists of dark green to black hornblende, with labradorite or oligoclase, and sometimes a little mica. Veins containing apatite have also been observed in these diorites, but, so far as I am aware, are not of any economic importance. Judging from the localities visited by me last summer in Ottawa County, however, there is evidently there, as in the Burgess region, an intimate connection between the apatite veins and certain pyroxenic rocks which, on account of this connection, may be looked upon as representing, in one sense at least, the so-called spotted gabbro of Norway. These pyroxenic rocks, which have been called by Hunt pyroxenites,‡ vary considerably in their characters. Sometimes they consist almost exclusively of pyroxene, though more commonly quartz and orthoclase are present. Mica, too, is of frequent occurrence, while minute garnets may occasionally be seen. The frequent presence of disseminated grains of apatite is also an important fact. When pyroxene is the principal mineral the rock commonly shows little or no trace of bedding, but is often a good deal jointed. Its aspect when the pyroxene is of a dark colour is often that of a massive eruptive rock.

Gabbro.

Diorite.

Pyroxenite.

Frequently the fresh fracture of some of the "pyroxenites" would not lead one to suspect the presence of more than very small quantities of quartz, in cases where the weathered surface shows that it is present in considerable abundance and marks the lines of stratification. Large

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* Vorkommen des Apatit in Norwegen. *Zeitsch d. deutsch geol. Ges.* Heft III., pp. 646-702.

† Report of Progress, 1874-75.

‡ Geology of Canada, 1866, p. 185.

lenticular patches and veins of a coarsely crystalline aggregate of orthoclase and quartz, with more or less pyroxene, or sometimes hornblende, may often be observed, and appear to have been separated out from the mass of the rock by some process of segregation.

Of other rocks met with in the Ottawa phosphate region the most important are the gneisses, quartzites, and crystalline limestones. The gneisses vary much in character, but the predominating variety consists of more or less reddish orthoclase and greyish or white quartz, with little or no mica, and sometimes with garnets.* It is usually coarse or granitoid in texture, and the bedding often obscure, though in other cases it contains numerous beds or layers of quartzite from half an inch to a foot or more in thickness, which render the strike of the rock plainly visible. Gneiss with these quartzite layers may be seen on the twelfth lot of the twelfth range of Templeton, where it forms the peak overlooking McGregor Lake at the "Fidelity Mines." In other cases mica is abundant, and the gneiss assumes a marked foliated texture. It is then sometimes grey, and at others reddish. Many of the gneisses, however, which appear reddish, are only so from weathering, and on fresh fracture the feldspar is seen to be white or pale grey. The micaceous gneisses are sometimes garnetiferous, and occasionally exhibit the texture of the so-called *augen-gneiss* or eye-gneiss. Grey hornblendic gneisses also occur, and in some instances contain epidote.

Gneiss.

Quartzite has already been referred to as forming thin beds interstratified in some of the gneissic strata; but independent beds of considerable thickness also occur. A good example of one of these may be seen in the hill behind the little village of Perkins' Mills, in Templeton. It is white and glassy, and in places contains a little orthoclase. The quartzite and adjoining orthoclase rock and hornblendic gneiss are here traversed by a dolerite† dyke more than a hundred feet thick, the course of which is N. 75° W. and S. 75° E., while the strike of the quartzite is about north-east and south-west. At the time of the intrusion of the dyke the quartzite has been curiously split up into numbers of sheets or layers in a direction approximately parallel to the course of the dyke, and the dolerite has filled the spaces between the layers, thus producing a series of small dykes parallel to the main mass, but of much finer texture, owing, no doubt, to more rapid cooling. The accompanying

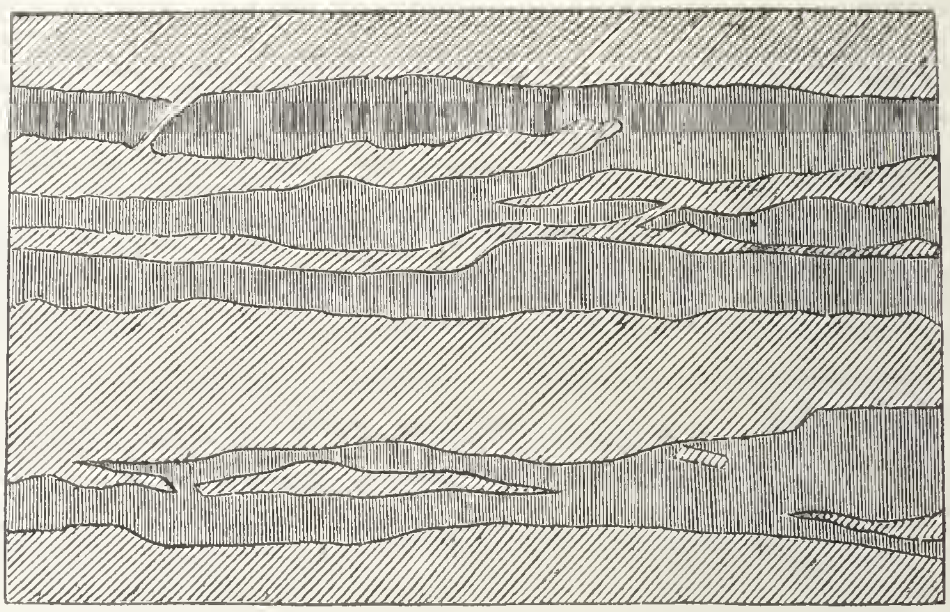
Quartzite and dolerite.

* By some writers many of these rocks would be termed granulite, but we prefer to class them here under the general name of gneiss, with the more typical forms of which they are often intimately associated, and into which they pass by insensible gradations.

† By many lithologists the rocks spoken of here as dolerite would be called diabase on account of their freedom from "glass," and their antiquity. It is, however, deemed advisable to retain here the name dolerite, by which they have hitherto been designated in the Reports of the Survey.

sketch shows the appearance presented on the surface by the alternating layers of quarzite and dolerite. The portion with diagonal shading is the quartzite, with the strike of which the diagonal lines coincide, while the dolerite is indicated by the vertical shading. The dolerite, it will be seen, occasionally includes angular fragments of the quartzite. The area represented in the sketch is twelve feet long and nearly eight feet wide.

Fig. 1.



Dolerite Dykes Cutting Quartzite.

Series of dolerite dykes.

The dyke just described is but one of a series which are known to traverse the Laurentian strata in the counties of Ottawa and Argenteuil. By some they have been supposed to have influenced the character of the apatite deposits, and it has even been suggested that rich apatite veins were most likely to be found in proximity to the dykes. This, however, does not seem to be the case. The dykes cut all the Laurentian strata of the region indiscriminately, and considering the abundance of the apatite deposits, and also that they were probably formed before the dykes, it would be strange if the latter did not occasionally pass either through or close to some of them. Dykes apparently of similar character occur in the apatite region of Norway, but have not, so far as I am aware, been supposed to be in any way connected with the apatite deposits.

Microscopic character of dolerite.

Analyses of specimens of some of the Grenville dolerites were made many years ago by Hunt,* and descriptions of their microscopic characters subsequently published by me in the *Canadian Naturalist.*† Quite recently, also, microscopic sections of dykes from Templeton and Wakefield have been studied, but have not been found to offer any

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* Geology of Canada, 1863, p. 653.

† New Series, Volume VIII., Number 6, p. 315.

essential differences from those of the oldest set of dykes in Grenville. With the microscope the rock shows, in thin sections, a perfectly crystalline texture, being made up of a network of striated blades of triclinic feldspar, brownish augite, black. opaque grains of magnetite, and commonly small quantities of a green chloritic mineral. The relative proportions of these constituents vary a good deal, and in the case of the dyke near Perkins' Mills, described above, the proportion of augite appeared to be much larger in the main dyke than in the fine-grained portions between the layers of quartzite. In the latter a green serpentinous mineral was observed, which is probably pseudomorphous after olivine.

Messrs. Brögger and Reusch state that limestones rarely occur in the regions where they studied the Norwegian apatite deposits; but with us the case is different, and a number of bands of crystalline limestone are known to exist in the apatite regions of both Ontario and Quebec. Those seen by me in Templeton were highly crystalline, and often serpentinous. In a few localities they were noticed to contain concretionary balls of serpentine several inches in diameter, sometimes enveloped by a single layer, or containing several more or less concentric layers, of white fibrous calcite. Large masses of serpentine also occur in the limestone, consisting of the ordinary yellowish-green variety, traversed by numerous veins of beautiful chrysotile. Small quantities of this have been mined as asbestus on the eleventh lot of the seventh range of Templeton. Limestones. Chrysotile.

In the Geology of Canada the apatite deposits of the Burgess region were described as beds. Subsequently, however, it was stated by Dr. Hunt that although the apatite did occasionally occur in beds the workable deposits were, "with few if any exceptions, confined to the veinstones."* Limestone beds were described by him as containing disseminated grains or crystals of apatite, the proportion of which amounted in some cases to two or three per cent., or even much more, and the pyroxenites were stated to contain disseminated grains or small masses of apatite marking the stratification. (Loc. cit., p. 204.) Dr. Hunt's reasons for regarding most of the deposits as concretionary veinstones are fully given in the report just referred to, and also in his *Chemical and Geological Essays.* They depend upon such facts as banded structure, the presence of drusy cavities, the manner in which various minerals surround or encrust each other, and the rounded forms of certain crystals—indicating "a process of partial solution succeeding that of deposition." Beds or veins of apatite.

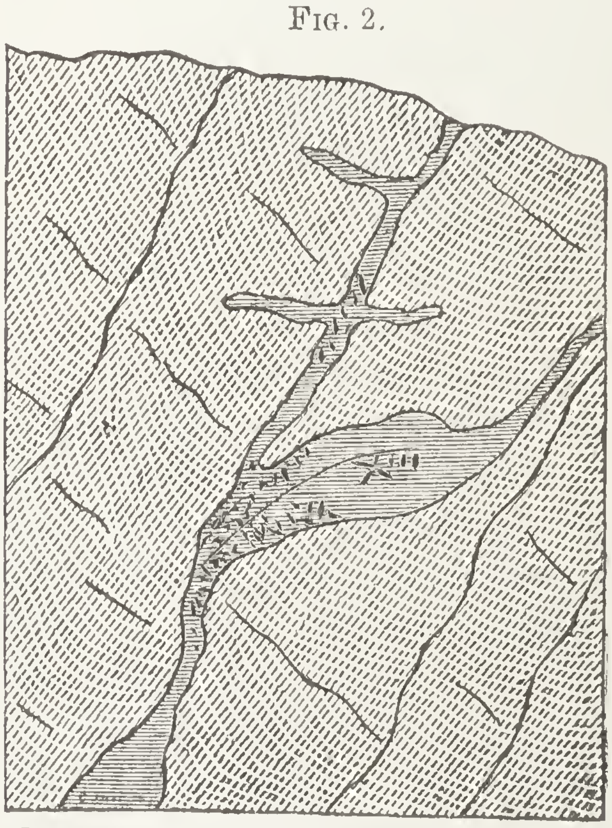
As many of the facts obtained last summer in Templeton and

* Report of Progress, 1863–66, p. 188.

adjoining townships bear upon these points, some of them may now be stated. That many of the apatite deposits of this region are not beds is plainly shown by the manner in which they cut across the strike of the rocks containing them. As examples of this, may be mentioned an important vein on the seventh lot of the first range of Portland, the course of which is N. 15° W., while the strike of the country rocks is N. 45° E. On the nineteenth lot of the ninth range of Templeton the rocks strike N. 40° E., and are traversed nearly at right angles to their strike by a vein of apatite.* Again, on lot fifteen of the eighth range of Templeton, there are three veins whose courses are, respectively, N. 40° W., N. 60° W., and N. 67° W., while that of the country rocks is N. 20° W. In some instances deposits which look like interstratified beds in places, are here and there seen to give off lateral branches, which cut directly across the strike of these rocks. An example of this was noticed at Mud Bay, on the twelfth lot of the eleventh range of Templeton, in the case of an apatite vein occurring in garnetiferous gneiss.

Examples of veins.

FIG. 2.



BRANCHING APATITE VEIN IN PYROXENITE.

Branching apatite vein.

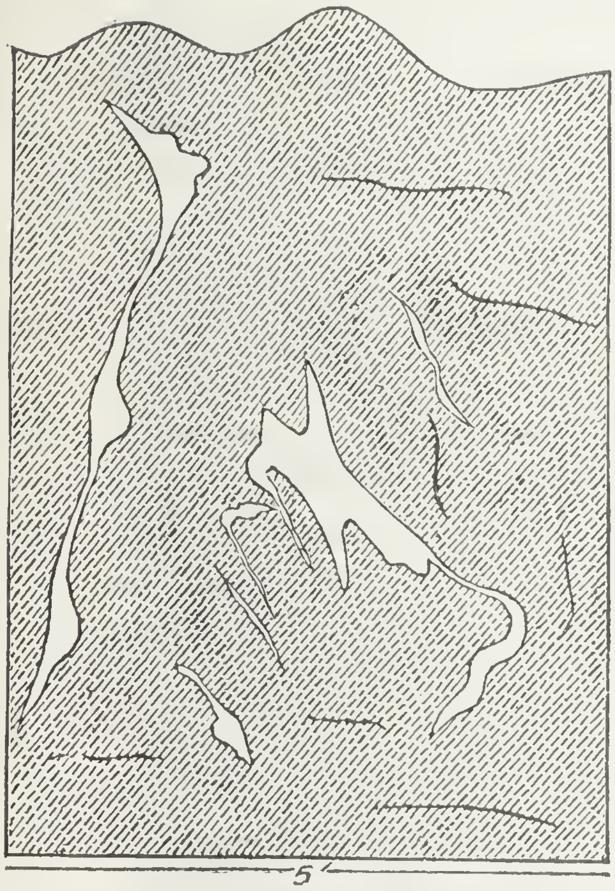
Figure No. 2 is a vertical section across a branched vein occurring on the same lot in massive pyroxene rock. The latter shows what are probably joints, though possibly planes of bedding. In either case, however, the only possible conclusion, as regards the apatite, is that it forms a vein. The pyroxene rock is indicated by broken diagonal lines, the apatite by horizontal. Plates of mica are seen to be numerous in places, especially at the points where the vein forks. The thickest portion of the vein represented is about two feet.

Figure No. 3 shows a number of small irregular veins of apatite cutting a light greenish-grey "pyroxenite," on the surface of which

* Owing to the great irregularity of the apatite veins and the limited extent to which they have been worked, it is often difficult to obtain their courses very accurately. The following twenty, however, were ascertained as carefully as possible under the circumstances. The first fifteen are the bearings (mag.) of veins in Templeton, the succeeding four in Portland, and the last in Buckingham:—

E. & W.	N. 78° E.	N. 35° E.	N. 60° W.	N. 30° W.
E. & W.	N. 45° E.	N. 17° E.	N. 40° W.	N. 15° W.
E. & W.	N. 45° E.	N. 67° W.	N. 40° W.	N. 5° W.
N. 85° E.	N. 35° E.	N. 60° W.	N. 55° W.	N. 45° E.

Fig. 3.



Apatite Veins in Pyroxenite.

quartz and feldspar weather out and mark the stratification of the rock. The apatite looks as if it had been drawn out or squeezed into the curious forms which it now presents, during the folding or crumpling of the enclosing rocks.

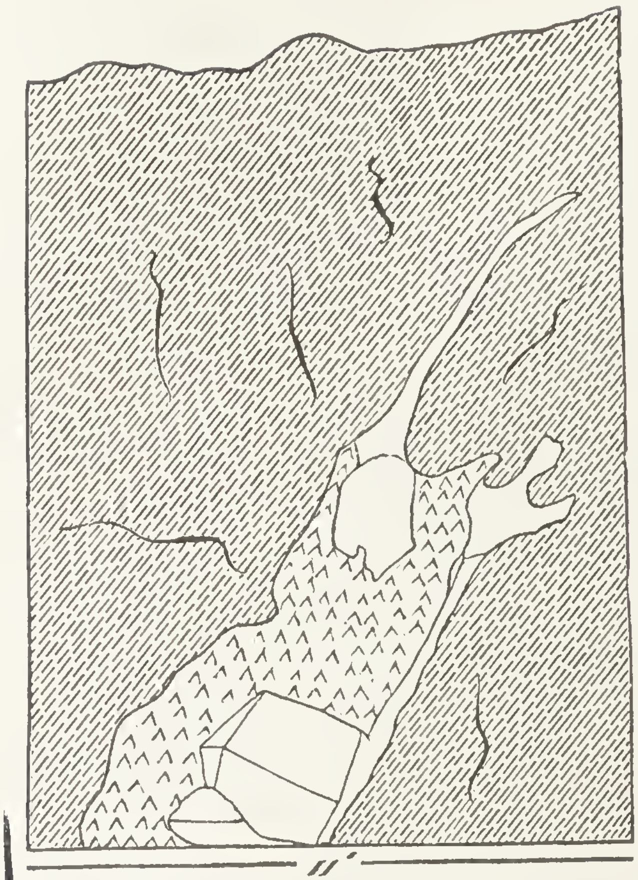
Drusy cavities.

Drusy cavities do not seem to be so abundant in the veins of this region as in those of Burgess, but are now and then met with, lined with crystals of quartz, calcite, apatite or pyroxene. Among other localities, they were observed at the Grant Mine in Buckingham and on lot seventeen in the ninth range of Templeton. In a vein at the latter locality, a cavity lined with pyroxene crystals is said to have occurred, in the centre of which there stood, like a statue in a niche, a crystal of apatite several feet in height. This was no longer visible at the date of my visit, but numerous smaller cavities were observed, mostly lined with different varieties of quartz. The *vein* at this locality is a most interesting one. It occurs in the so-called pyroxenite, and has a course of N. 78° E. and S. 78° W., with an underlie of about 70° to the south. Last summer it had been exposed for a distance of about 125 feet on its strike. Some mining had been done, but what quantity of apatite had been removed was not ascertained. Parts of it are made up almost entirely of a confused aggregation of gigantic apatite crystals, which have grown from the walls of the crevice, and many of which are several feet in length and a foot or more in diameter. The top of one, which had been broken off and was lying on the ground, had the pyramidal planes entire, and was eighteen inches long and eighteen and a-half inches in greatest diameter. Towards its eastern end, a section of the vein, in a cutting, showed it to be largely composed of calcite holding a few large crystals of apatite, and having a thin layer of the latter mineral adjoining the foot-wall. One rude crystal of apatite, which projected from this layer of apatite into the calcite, was two feet nine inches long, and also in diameter. It is shown in the accompanying cut (Fig. 4), in which the diagonal shading represents the country rock, the arrow-head markings calcite, and the white, apatite. In another opening west of the first, the vein

Interesting vein.

Large apatite crystal.

Fig. 4.



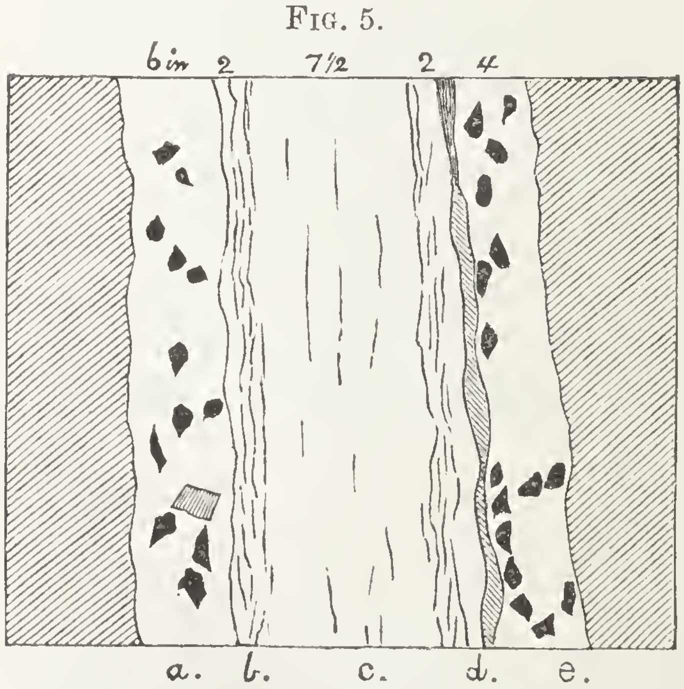
Vein showing large Apatite Crystal.

showed much less calcite and a good deal of dark green hornblende, pyroxene and mica—the last sometimes in plates a foot across, and most abundant along the foot-wall, while the hornblende occurred in greatest quantity along the hanging-wall. At the surface the vein showed nearly six feet of solid apatite, partly consisting of large crystals; but at a depth of eighteen feet the total width of the vein was only four feet, and of this only one foot consisted of apatite. This vein has afforded interesting examples of mineral envelopment and of broken and re-cemented crystals, some of which will be noticed further on.

Banded structure of veins.

As a rule, the apatite-bearing veins of the Ottawa region are characterised rather by a want of regularity or order in the arrangement of their constituents than by any degree of symmetry. Occasionally, however, instances are met with where the veins show a distinct banded structure. An excellent example of this was observed at Mud Bay, on the twelfth lot of the eleventh range of Templeton. The vein was twenty-one and a half inches thick, and occupied a well-defined fissure. A section of it is shown in the accompanying figure (Fig. 5).

Fig. 5.

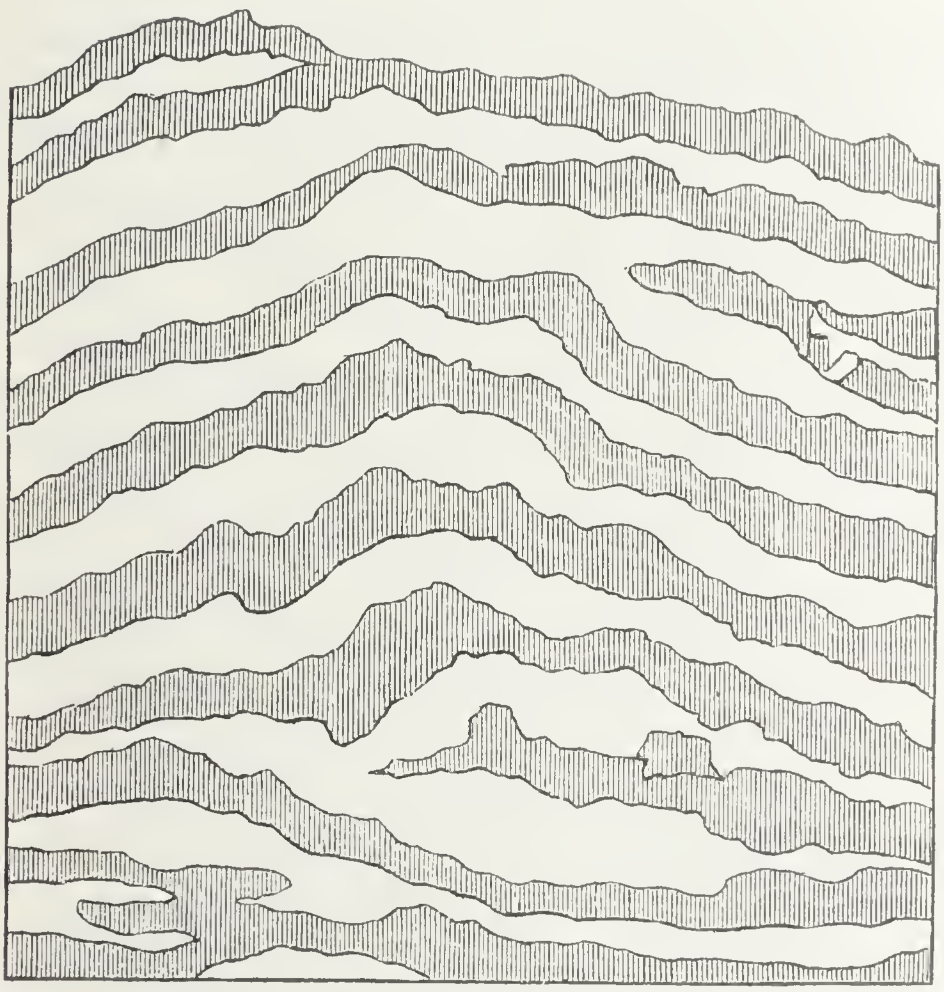


a. Calcite and mica.
b. Fine-grained mica in wavy lines, with pyroxene and a little apatite.
c. Pyroxene, granular apatite, and a little mica, in fine scales, arranged in wavy lines in the direction of the vein.
d. Mica, pyroxene and thin layers of apatite.
Calcite and mica.

The Grant Mine, on the eighteenth lot of the twelfth range of Buckingham, has also afforded an interesting illustration of the alternate deposition of minerals in a vein. The minerals are pyroxene and apatite, and they occur in layers averaging about a quarter of an inch in thickness, alternating one with the other with wonderful regularity for very considerable thicknesses, like the laminæ of Eozoon. In

Fig. 6, which is a tracing froman actual specimen the shaded portion represents the pyroxene and the white apatite. In the original the lines are scarcely as sharp as indicated by the drawing. In some cases the apatite has been dissolved away, leaving the layers of pyroxene.

FIG 6.



VEINSTONE SHOWING ALTERNATE LAYERS OF APATITE AND PYROXENE.

Veins with sharply-defined walls, such as are common in the case of metalliferous lodes, are rarely seen, the constituents of the vein and country rock rather merging into one another. According to Dana, "such a blending of a vein with the walls is a natural result, when its formation in a fissure takes place at a high temperature during the metamorphism or crystallization of the containing rock." * Sharply-defined walls not common.

Figure 7 is an illustration of the irregular manner in which the various minerals occur in some of the apatite deposits. It is a vertical section on a scale of approximately one foot to an inch, sketched in an opening from which considerable quantities of apatite had been extracted. The uncertainties of mining deposits of this character are evident. Irregular character of apatite deposits.

Such examples as those which have been given prove incontestably that there are true apatite veins in the region in question ; and as to their mode of formation, we concur with Hunt in regarding many of them as

* Manual of Geology, 1875, p. 733.

fissures or cavities which have been filled by the deposition of materials derived from the adjacent strata. At the same time, however, we believe that in many cases there has been a segregation of apatite and other minerals which accompany it from the surrounding rock into irregular or lenticular masses, without any true cavity or crevice

Segregated masses.

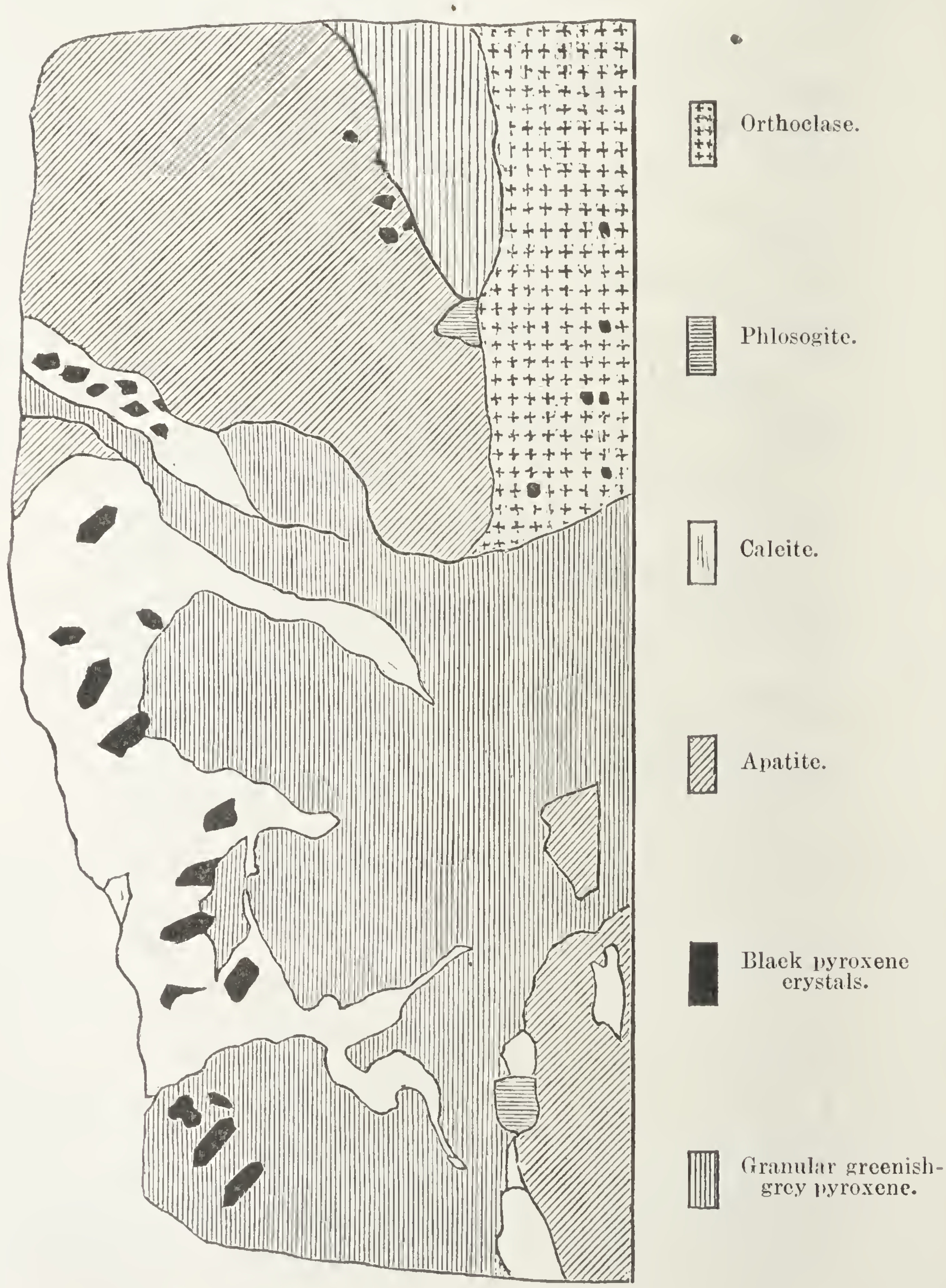


Fig. 7.

having ever existed. This, it is true, implies that the particles have possessed a degree of mobility which it may be hard to understand: but, nevertheless, there are many of the apatite deposits whose formation it does not seem possible to explain in any other way. The tendency which phosphate of lime exhibits to accumulate in concretionary masses, as well as in veins, in rocks of later age is well known.*

The conclusions arrived at by Messrs. Brögger and Reusch concerning the apatite veins studied by them in Norway, are that they are of eruptive origin, and that there is "no definite relation between the minerals of the veins and those of the country rock." The veins are stated to traverse indifferently both eruptive and sedimentary strata—gabbro, granite, hornblende slate, hornblende gneiss, mica-schist and quartzite; but neither apatite nor any other mineral containing phosphoric acid is known to occur in the country rock. The banded arrangement which they have observed in some of the Norwegian veins, they assume to be due to the conditions under which the "magma" has cooled. Often, too, the veins are said to be fine-grained near the walls and coarse in the centre, a phenomenon regarded as analogous to what is observable in many trap dykes. The crumpled and broken crystals of mica and other minerals are considered as best explained by assuming the eruptive nature of the veins. After the formation of the crystals a portion of the vein-matter still remained in a plastic state, and by its movements the crystals were bent and broken. The rounded crystals are supposed to have been rounded not by solution but by partial fusion. Still another ground of the eruptive origin of the veins is that in several cases they have been found to contain angular fragments of rock, which in one instance were different in character from the country rock, and supposed to have been brought up from beneath by the liquid vein-matter. Lastly, the fact that apatite is known to crystallise out from certain materials rendered liquid by fusion, and its occurrence in certain igneous rocks, is appealed to.

Eruptive origin of apatite veins

This idea of an igneous origin cannot be adopted for our veins. With us, as we have seen, they occur chiefly in the pyroxenic strata, but they also traverse or occur near to other rocks which seem, to a greater or less extent, to influence their mineral character. Veins, for example, which occur near to beds of limestone are liable to be calcareous, and to hold the apatite in the form of crystals imbedded in the calcite. We have also seen that the pyroxenites often contain disseminated grains of apatite, and no doubt they are the strata from which the apatite of the veins has been chiefly derived. If, as has been suggested, the apatite of these ancient strata represents material accumulated by organic agencies,† then the connection of the pyroxene and apatite may be that the material of the former constituted an

Veins of this country not eruptive.

* In connection with this subject see an interesting paper by M. Daubrée on the occurrence of phosphate of lime in France. *Comptes Rendus*, 1871, LXIII. p. 1020.

† See in connection with this subject, a paper by Dr Dawson in the *Canadian Naturalist* (N. S. Vol. VIII., p. 162,) entitled, "Notes on the Phosphates of the Laurentian and Cambrian Rocks of Canada."

oceanic bottom particularly suitable for the life of the creatures which secreted the phosphatic matter.

The fine-grained character of the veins near the walls, regarded by Brögger and Reusch as an evidence of eruptive origin, is observable in some of our apatite veins, but quite as frequently they are coarser in texture near the walls than in the centre. The phenomena of bent, crumpled and cracked or broken crystals are apparently quite as common here as in Norway, and certainly remind one of the similar phenomena in eruptive rocks, but are nevertheless explicable upon other grounds than those stated by Brögger and Reusch. The same is true of the numerous instances of mineral envelopment, for some of which, no doubt, striking parallels may be found if eruptive rocks are studied microscopically, but for many of which no analogy can be given. The very different character of the apatite of igneous rocks from that of such deposits as we are now considering, is certainly a strong argument against the eruptive origin of the latter. In the igneous rocks the apatite, which has usually been the first mineral to solidify and penetrates all the other constituents of the rock, is characterised by the sharp outlines of its crystals, though they are, for the most part, exceedingly minute,* while in the apatite veins crystals with sharp angles are comparatively rare. How, we may ask, have the enormous crystals of apatite in the veins suffered so from fusion, while the acicular prisms of the igneous rocks preserve their form intact?

Character of apatite in igneous rocks.

Depth of apatite deposits

The statement is commonly made that our apatite deposits are very limited as regards depth; but such a statement certainly seems premature when we remember that no mining operations have as yet been carried on to a depth of more than 150 feet. It, however, is evident that the depth to which the true fissure veins will be found workable will often depend largely upon the thickness and attitude of the pyroxenic strata in which they occur, and upon the course and inclination of the veins themselves as compared with the strike and dip of the enclosing rocks. A vertical or nearly vertical vein, for example, traversing a highly inclined bed of pyroxenite, is likely to be workable to a greater depth than a similar vein cutting a pyroxenite bed of slighter inclination and underlaid by other rocks, such as gneiss and limestone, in which the veins are less likely to be remunerative. As regards the irregular or lenticular masses referred to on page 10, their working must, of necessity, be to a greater or less extent of uncertain character, but it does not follow that when one of these masses is worked out another may not occur near it.

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* Zirkel, *Mikroskopiche Beschaffenheit der Mineralien und Gesteine*, s. 223.
Rosenbusch, *Mikroskopische Physiographie der petrographisch wichtigen Mineralien*, s. 216.

THE MINERALS OF THE APATITE DEPOSITS.

Mineral associates of apatite.

Leaving now such questions as the origin of our apatite deposits, we pass to the consideration of the minerals which they have been found to contain in the region visited last summer. Their names are given in column I., while, for the sake of comparison, those enumerated by Brögger and Reusch, as occurring in the apatite-bearing veins studied by them in Norway, are given under II.

I.	II.
Apatite.	Apatite.
Calcite.	Calcite.
Fluor-spar.	——
Quartz (several vars.).	Quartz.
Pyroxene.	Pyroxene.
Hornblende.	Hornblende.
Phlogopite.	Phlogopite.
Garnet.	——
Epidote.	——
Idocrase.	——
Tourmaline.	Tourmaline.
Titanite.	Titanite.
Zircon.	——
Orthoclase.	Orthoclase.
Albite.	Albite.
Scapolite.	Scapolite.
Wilsonite.	——
Talc (Steatite)?	Talc ?
Chlorite.	Chlorite.
Prehnite.	——
Chabazite.	——
Hematite.	Hematite.
Rutile?	Rutile.
Pyrite.	Pyrite.
Pyrrhotite.	Pyrrhotite.
Chalcopyrite.	Chalcopyrite.
Galena.	——
Sphalerite.	——
Molybdenite.	——
Graphite.	——
——	Kjerulfin.
——	Tschermakite (oligoclase).
——	Esmarkite (anorthite ?)
——	Enstatite.
——	Aspasiolite.
——	Titanic Iron Ore.
——	Magnetite.

It will thus be seen that of the thirty species given in our list, no less than eighteen, or nearly two-thirds of the entire number, are identical with those in the Norwegian deposits. The Norway list, however, contains several minerals not represented in ours; but one of these, magnetite, occurs in apatite-bearing veins in Ontario. Enstatite, though carefully looked for, has not yet been found here, although a mineral supposed to be an altered enstatite* is one of the most frequent accompaniments of the Norwegian apatite.

Enstatite.

Apatite.

The varieties of this mineral ocurring in the Ottawa region are so numerous that no attempt will be made to describe them all in detail, but simply to give a few general statements with regard to some of their more important characteristics.† Crystals of the mineral are of common occurrence, and sometimes attain to large dimensions, measuring a foot or more in diameter and several feet in length, and weighing hundreds of pounds. The form, like that of the so-called moroxite from Arendal in Norway, is a hexagonal prism terminated (often at both ends) by a hexagonal pyramid (∞ P.P.); and in no case, so far as I am aware, has the basal plane oP., so common in crystals from many regions, been observed. The edges of the crystals are sometimes sharp, but more frequently rounded. The specific gravity varies slightly in different varieties; but that of a dark green, glassy crystal from the Grant Mine in Buckingham was found to be 3.2115. The colour of the mineral varies greatly, including green of various shades (sea-green, olive-green, grass-green, asparagus-green, greyish-green, &c.), sky-blue, red and brown of different shades, yellow and white. The lustre varies from vitreous to resinous or fatty, and while the mineral in its more glassy forms is subtransparent, it is more frequently subtranslucent and often opaque.

Large apatite crystals.

Though at some localities the apatite occurs chiefly in crystals, at others it is wholly or almost altogether massive, varying from compact or crypto-crystalline to coarse granular. Frequently, also, it

* It is green or greenish-grey in colour, and sometimes occurs in very large crystals. The hardness is only 2-3, and the specific gravity 2.7-2.8. In fine splinters the mineral fuses to a black glass. The following are two analyses cited by Brögger and Reusch:—

	Oedegarden.	Snarum.
Silica	57.63	59.51
Alumina	1.02	0.97
Magnesia	30.37	30.89
Ferrous oxide	4.99	2.95
Lime	....	0.37
Water	7.21	6.01
	101.22	100.70

After examining a large number of crystals, the conclusion of these gentlemen is that the mineral is rhombic, although the crystals are very near to pyroxene in form, and had previously been described as pseudomorphs of steatite after augite.

† For fuller particulars, as well as for detailed analyses of a number of Canadian apatites, see Mr. Christian Hoffmann's Report.

exhibits a distinct lamellar texture. A friable, saccharoidal variety is very common, and often termed "sugar phosphate." When white, it is sometimes difficult to distinguish by the eye from some forms of quartz sandstone. On account of its friability it is, no doubt, much easier to grind than some of the more compact forms, but, at the same time, it is more apt to undergo loss in the operations of mining and transportation. Crystals are sometimes imbedded in this granular apatite, and frequently also rounded masses of apatite of all sizes up to many inches in diameter. Similar masses of pyroxene, as well as crystals, are also sometimes imbedded in the apatite. Good examples of the fine granular or saccharoidal apatite occur at several of the openings on the twelfth lot of the twelfth range of Templeton. On this lot also, at Mr. Miller's "Doctor Pit," a curious translucent variety occurs, somewhat resembling serpentine in appearance. "Sugar phosphate."

At the Ritchie Mine, on the seventh lot of the seventh range of Portland, a beautiful example of the vitreous sea-green variety was seen. The mass, *as exposed*, measured nearly twenty feet across, and in the whole of this thickness was apparently free from other minerals, with the exception of a few crystals of pyroxene and mica.

As already stated, apatite crystals are sometimes found imbedded in the granular form of the same mineral; the best crystals, however, usually occur in calcite—as at Mr. Miller's "Crystal Pit." Other minerals in which they have been found are pyroxene, hornblende, phlogopite, orthoclase, scapolite, steatite and pyrite. Like the crystals from other regions, they frequently enclose other minerals, among which are calcite, pyroxene, phlogopite, zircon, sphene, fluor-spar and pyrite. So far as known the apatite of this region, like that of Burgess, is always fluor-apatite. Fuor-apatite,

Calcite.

In addition to its occurrence in the form of beds of limestone, calcite frequently forms veins which may or may not contain other minerals, and is also one of the most common constituents of the apatite-bearing veins. In the veins it is, as a rule, much more coarsely crystalline than in the beds, but this is not invariably the case. Sometimes it is white, blue or green, but more frequently pink, flesh-colour or salmon-colour. Occasionally, also, it is colourless and transparent. Though usually massive, crystals of dog-tooth spar, nail-head spar, and other more complicated forms, are now and then found in cavities. Calcareous veins.

Calcite is frequently enclosed in other minerals, as apatite, pyroxene, phlogopite, zircon, &c.; and still more frequently contains other minerals, as apatite, pyroxene, phlogopite, hornblende, tourmaline, sphene, zircon, quartz, chalcopyrite.

Fluor-spar.

Fluor-spar.

Specimens of this mineral have been found at several of the apatite openings, as, for example, at the "Trusty Pit," on the twelfth lot of the twelfth range of Templeton, the fifteenth lot of the third range in the same township, and the tenth lot of the fourteenth range of Hull. Usually, however, the quantity found at any one locality is small. The colour of the fluor is sometimes bright green, at others purple, violet or occasionally blue. A specimen from the township of Hull shows minute octahedra of purple fluor-spar associated with scalenohedral crystals of calcite.

Interesting vein-stone.

Specimens of a vein-stone from the augmentation of Grenville, further down the Ottawa, consist of an aggregate of dark green pyroxene, grass-green apatite, purple and wine-coloured fluor-spar, white orthoclase, calcite, black tourmaline, sphene and small prisms of zircon. Sometimes the fluor is imbedded in apatite, while at others the apatite occurs in the fluor.

In some cases fluor-spar has been observed in drusy cavities with quartz.

Quartz.

Varieties of quartz.

Quartz is a common mineral in the apatite deposits, sometimes being imbedded in the apatite, calcite or other constituents of the deposit, or lining drusy cavities. The quartz in these cavities is sometimes colourless, at others smoky or amethystine, and occasionally red or brown, and more or less opaque from included oxide of iron. The amethystine quartz is commonly pale, but fairly coloured crystals have been found on the seventeenth lot of the ninth range of Templeton. At this locality chalcedonic quartz has been deposited in crevices in the vein, producing agate when there has been an alternation of different colours. In some specimens, layers of vitreous quartz alternate with the chalcedony. The surfaces of the agate are often covered with little scalenohedral crystals, which are apparently pseudomorphs of quartz after dog-tooth spar. Most of them are under an eighth of an inch in length, and frequently they are hollow. Occasional grains of copper pyrites are imbedded in the chalcedony, while zinc blende occurs in vitreous quartz at the same locality.

Mountain leather.

In a specimen said to have come from the Grant Mine in Buckingham, glassy quartz was imbedded in a mass of mountain leather. In one or two instances also, veins of pale blue subtranslucent quartz were observed cutting a mixture of granular apatite and pyroxene.

The occurrence of quartz in some of the stratified rocks of the region is elsewhere referred to.

Pyroxene and Uralite.

Of all the mineral associates of apatite in the Ottawa region, pyroxene is the most constant and the most abundant. In one form or another it is probably present in all the apatite deposits, excepting, perhaps, some of the calcareous veins with imbedded apatite crystals. The most common variety appears to be an aluminous sahlite or lime-magnesia-iron pyroxene, but a light-coloured variety, probably diopside or malacolite, is also common. Less frequently a beautiful black kind may be observed, excellent examples of which have been obtained from the thirteenth lot of the eleventh range of Templeton. It is here associated with green apatite, white orthoclase, scapolite, graphite and small grains of titanite. The pyroxene crystals often contain little round or irregular masses of the orthoclase as well as scales of graphite, and their surfaces are sometimes coated by broad plates of the last-named mineral. The crystals differ from those of the more ordinarily occurring sahlite not only in colour, but also, to a certain extent, in chemical composition and form, having the faces of the inclined rhombic prism usually much more fully developed than the clinopinacoid, and presenting rather different pyramidal terminations. The observed planes are those of the inclined rhombic and rectangular prisms ∞ P. ∞ P∞ . [∞ P∞], combined with the pyramidal faces P. 2 P.–P. and the clinodome [2 P ∞]. The faces of the rhombic prism are often developed almost to the exclusion of the ortho- and clinopinacoid. In some crystals the pyramidal planes are pretty equally developed, but in others much distorted. In the specimens examined the basal plane oP. is absent, but there is a very distinct basal cleavage. The fracture varies from uneven to conchoidal. The colour is mostly black, but in some specimens blackish-green. On the edges or in thin splinters the mineral is translucent, and by transmitted light appears deep bottle-green. The lustre is vitreous, and sometimes almost splendent. The hardness is about six, and a crystal, of which the following is an analysis, was found to have a specific gravity of 3·385:

Varieties of pyroxene.

Analysis of black pyroxene

Silica	51·275
Alumina	2·821
Ferric oxide	1·317
Ferrous oxide	9·164
Manganous oxide	0·329
Lime	23·344
Magnesia	11·612
Loss on ignition	0·174
	100·026

The analysis shows that this is an aluminous lime-magnesia-iron pyroxene, and its composition and other characters seem to connect it with the variety sometimes called fassaite.

Examples of other varieties of pyroxene may be met with at almost any of the apatite mines. They vary much in colour, usually being of some shade of green or grey, but sometimes white or brown. Lower down the Ottawa, in the augmentation of Grenville, a beautiful lilac pyroxene occurs, the crystals of which are sometimes imbedded in a pale lemon-yellow scapolite.

Lilac pyroxene in yellow scapolite.

Large crystals.

Now and then crystals of large dimensions are obtained. One, for example, from the township of Templeton is eleven and a half inches in circumference, nine inches long, and weighs eight and one-third pounds. Large crystals have also been found on the sixth lot of the first range of Portland township, and a portion of one now in the museum of the Geological Survey weighs about twelve pounds. Some of them, though dull outwardly, are glassy within, and of a pale bottle-green colour.

Forms of crystals.

The simplest forms observed are crystals of sahlite showing the following combination: $\infty P\infty$. ∞P. [$\infty P\infty$]. $P\infty$. P. Other planes are, however, frequently present, and among them 2 P. 3 P.–P. and oP. Sometimes the crystals of sahlite are striatied longitudinally, and they are often much flattened in the direction of the orthodiagonal. One, for example, having a width of an inch and eight-tenths, measured only seven-tenths of an inch in thickness; another, an inch and a half wide, was five-eighths of an inch thick, while a third measured two and a quarter inches by eight-tenths of an inch—giving an average width of over two and a half times that of the thickness.

In the township of Templeton well crystallised pyroxene is often found in veins unaccompanied by apatite, for which mineral, however, it has frequently been mistaken. As affording a good example of this, a vein occurring on the twenty-fourth lot of the ninth range may be mentioned. Good crystals of more or less glassy, subtranslucent green pyroxene are here imbedded in a pale flesh-coloured calcite. They vary in length from a couple of inches downwards, and are often well terminated at both ends. They are almost invariably flattened in the direction of the clinodiagonal, and show the following planes: ∞ P. [$\infty P\infty$]. $\infty P\infty$. $P\infty$. P. 2 P.–P. oP., and sometimes [2 $P\grave{\infty}$]. The specific gravity of a crystal was found to be 3·232. Scales of mica sometimes coat the crystals, or are enclosed in them.

Flat crystals.

On lot thirteen in the eighth range of Templeton a white to greyish-white or greenish-white pyroxene occurs, small quantities of which were at one time mined under the supposition that the mineral was apatite. The crystals exhibit the same planes as those just described, but are less frequently flattened in the direction of the clinopinacoid.

The enclosure of mica in pyroxene crystals, which has already been alluded to, may frequently be observed, and in some instances the scales or crystals of mica may be seen to be more or less symmetrically arranged with reference to the planes of the pyroxene. On the seventeenth lot of the ninth range of Templeton large crystals were observed, showing a central portion of dark green pyroxene surrounded by a zone of minute scales of mica, while the outer portion of the crystal was pale green pyroxene. Other inclusions also are common, and among them calcite, apatite and orthoclase. Not infrequently also pyroxene crystals are rounded as if by the action of some solvent, but this is much less common than in the case of apatite. Sometimes they have been cracked or broken in two, and the spaces between the pieces filled up with calcite, apatite, or some other mineral. In one case, a crystal four inches in diameter was observed which had been fractured and re-cemented with apatite. Mica in pyroxene.

The most interesting peculiarity observed, however, is the tendency which the pyroxene in some localities exhibits to become altered into a kind of uralite. This name was long ago given by Gustav Rose to crystals possessing the form of pyroxene but cleavage and other characters of hornblende, and first observed by him in certain rocks from the Urals, which he termed uralite porphyries. The larger crystals were found to freqently contain a kernel of pyroxene, which in the smaller ones had entirely disappeared. In the case of pyroxene from Arendal in Norway also, Rose observed a perfect transition from lustrous crystals showing no apparent trace of hornblende within to others with drusy surfaces, in which no trace of augite could be detected.* Uralite.

Crystals of pyroxene from Traversella afford another example of a change of this kind. The unaltered crystals are described as transparent and glassy, but on being altered become opaque, and often assume a silky lustre. In this opaque portion fine fibres running parallel to the principal axis begin to be developed, and, as the change advances, distinctly recognizable individuals of hornblende are formed, also parallel to the principal axis and looking like actinolite.†

Of late years, by the aid of the microscope, it has been demonstrated that the development of uralite has taken place in many crystalline rocks, not only in Europe but on this side of the Atlantic. In the case of diabase, the change of this kind has been described by Rosenbusch as follows: ‡—"The alteration processes to which the augite of

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* Bischof, *Lehrbuch der Geologie*, 1864, pp. 623, 624.

† *Lehrbuch der Geologie*, Bischoff, 1851, p. 539.

‡ *Mikroskop. Physiogr. d. massigen Gesteine*, 1877, p. 330.

Uralite in diabase.

diabase is subject is one of most varied character. Ordinarily, they begin with the formation of a vertical fibrous structure. At the same time the fibres often take the form of well-defined uralite, and in this case the process commonly begins from the entire periphery of the augite, and proceeds thence towards the centre, in general more rapidly in the direction of the vertical axis than at right angles to it. So long, then, as the process is not wholly completed, there remain in the interior portions of augite with irregular outline. Less frequently, or rather only in exceptional cases, the formation of uralite does not begin along the whole circumference, but attacks only single narrow strips in a vertical direction, so that thin columns of augite and uralite, parallel to the vertical axis, alternate with one another. The uralite itself passes on still further alterations of the rock into chlorite, and this finally into a mixture of brown iron ore, quartz and carbonates.*

Uralite of Templeton.

The above facts have been cited because of interest in connection with what now follows concerning the alteration of certain pyroxenes in the apatite region of Quebec. The best examples were observed at the mines of Mr. Breckon, on the twenty-third lot of the thirteenth range of Templeton, where crystals have been obtained showing perfectly the transition from pyroxene to what may be called uralite. The crystals are mostly flattened in the direction of the orthodiagonal, and while some of them are apparently quite unaltered, others have been converted into hornblende for a greater or less depth from the surface; others, again, are entirely changed to hornblende, and show no trace of pyroxene even when sliced and examined microscopically. In the first stage of alteration the pyroxene, which in its original condition is glassy and of a grey colour, becomes more or less dull and greenish or greyish-white, still, however, retaining the cleavage of pyroxene. In this pale portion acicular prisms of green hornblende begin to be developed, gradually increasing until, in some cases, all trace of pyroxene is obliterated. The change appears to have always begun at the surface of the crystals, extending inwards more rapidly in some parts of the crystals than in others, but although the hornblende prisms at the surface appear to be mostly parallel with the principal axis, within they are seen to run in every direction, or in some cases to be arranged in radiating groups. Intermingled with the hornblende prisms a little calcite occurs in places.

Even when the crystals have been entirely changed to hornblende the pyroxene angles remain perfectly distinct, and one crystal with

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* For other interesting details concerning uralite see Zirkel, *Mik, Beschaff, d. Min. u. Gest.* p. 178. Also Rosenbusch, *Mik. Physiog. d. Min.*, p. 316.

In the case of an "augite syenite," from Jackson, N.H., Mr. G. W. Hawes has observed an alteration of augite into compact brown hornblende instead of into the usual fibrous green uralitic mass.—*Geology of New Hampshire*, Part IV., 1878; p. 205.

terminal planes shows the following combination: ∞P∞. ∞P. [∞P∞]. P∞.–P. 2P. The crystal is an inch and seven-eighths wide and a little over half an inch thick. The remaining portion of another crystal, which has lost its terminal planes, is three inches wide and an inch thick, and apparently wholly uralite. The crystal which supplied the material for the following analyses was about an inch and three-quarters wide and an inch thick. The centre consisted of glassy grey pyroxene, surrounded, however, by the dull and pale material described above, and this was surrounded in turn by an aggregation of hornblende prisms. These three portions may be called respectively A., B. and C. A. resembled in appearance much of the ordinary pyroxene of the region, from which also it probably does not differ much in composition. The specific gravity was found to be 3·181, and it gave on analysis the following results:— Analyses of pyroxene and uralite.

A.

Silica	50·868
Alumina	4·568
Ferric oxide	0·970
Ferrous oxide	1·963
Manganous oxide	0·148
Lime	24·438
Magnesia	15·372
Potash	0·497
Soda	0·218
Loss on ignition	1·439
	100·481

This is the composition of an aluminous diopside or malacolite, and, except in the larger proportion of iron, resembles that of pyroxene from Grenville and Bathurst.* The following analysis of B., the white portion of the crystal, shows that, chemically, no great amount of change had taken place. The specific gravity (3·205) was also about the same as that of A:—

B.

Silica	50·898
Alumina	4·825
Ferric oxide	1·741
Ferrous oxide	1·358
Manganous oxide	0·152
Lime	24·392
Magnesia	15·268
Potash	0·150
Soda	0·076
Loss on ignition	1·200
	100·060

* See analysis, Report of Progress, 1874-75, p. 302, and Geology of Canada, 1863, p. 467.

It will be observed that although the total amount of iron in A. and B. is almost identical, more of it exists as ferric oxide in B. than in A. The quantity of alkalies is also only about one-third of the amount found in A.

If now we pass to C., the uralitic portion of the crystal, the changes are much more striking, as will be seen from the following analysis:

C.

Silica	52·823
Alumina	3·215
Ferric oxide	2·067
Ferrous oxide	2·709
Manganous oxide	0·276
Lime	15·389
Magnesia	19·042
Potash	0·686
Soda	0·898
Loss on ignition	2·403
	99·508

The specific gravity in this case was only 3·003. Comparing C. with A. and B. we find that the lime is diminished by about nine per cent., while there is a gain of about four and a half per cent. of magnesia. The ratio of loss and gain, however, is not that of the molecular weights of lime and magnesia; that is to say, for a molecule of lime lost a molecule of magnesia has not been gained. A portion of lime has been lost without its place being taken by magnesia. At the same time there is a slight increase of silica relatively to the other constituents, and, as would be expected, a decrease in density.

Differences in composition of pyroxene and hornblende.

It is well known that pyroxene commonly contains more lime and less magnesia than hornblende, and in the present case loss of lime and gain of magnesia would appear to be the principal cause determining the change to hornblende. The larger proportion of alkalies in the uralitic or hornblendic proportion of the crystal is also worthy of note, because hornblende is commonly richer in alkalies than pyroxene. On the other hand, it is interesting to observe that there is less alumina in the hornblendic product than in the original pyroxene, for, as a rule, hornblende is apt to contain more alumina than pyroxene. This subject has recently been discussed by Mr. G. W. Hawes in his valuable report on the mineralogy and lithology of New Hampshire. He there gives some interesting analyses to illustrate the differences in the composition of pyroxene and hornblende, and seems to regard preponderance of alumina as the principal cause determining the formation of the latter species. At the same time, however, he does not loose sight of the fact that pyroxene usually contains more lime and less alkalies than hornblende.

In the following table the analyses of A., B. and C. are included together with analyses of pyroxene from Grenville (D.) and Bathurst (E.), and also of hornblende from the High Falls of the Madawaska, in Ontario (F.), and from Edenville in New York State (G). E. and F. are by Hunt, and G. by Rammelsberg. D. is from the Report of Progress for 1874-75, p. 302 :— Analyses of pyroxene, &c.

	A.	B.	C.	D.	E.	F.	G.
Silica	50·868	50 898	52·823	51·27	51·50	55·05	51·67
Alumina	4·568	4·825	3·215	4·00	6·15	4·50	5·75
Ferric oxide	0·970	1·741	2·067	0·10	0·35	..	2·86
Ferrous oxide	1·963	1·358	2·709	..	..	5·85	..
Manganous oxide	0·148	0·152	0·276	..	..	..	..
Lime	24·438	24·392	15·389	25·27	23·80	13·44	12·42
Magnesia	15·372	15·268	19·042	17·46	17·69	20·95	23·37
Potash	0·497	0·150	0·686	0·14	..	..	0·84
Soda	0·218	0·076	0·898	0·62	..	..	0·75
Ignition	1·439	1·200	2·403	1·63	1·10	0·35	0·46
	100,481	100·060	99·508	100·49	100·59	100·14	98·12

The uralitic portion of the crystal, it will be seen, does not differ greatly in composition from the hornblende (pargasite) of the High Falls of the Madawaska, nor from the so-called edenite of Edenville. The pyroxene, too, somewhat resembles the aluminous diopsides (D. E.) of Grenville and Bathurst.

The formation of uralite is spoken of by some writers as though it were an example of paramorphism, but I have been unable to find analyses proving that this has anywhere been shown to be the case. That in the above instance, at least, we have an example of true pseudomorphism, cannot reasonably be doubted. For, in some cases, we have not so much as a nucleus of pyroxene whose "crystallogenic force" might be supposed to induce the hornblende prisms to arrange themselves in the form of a pyroxene crystal, and without such a predisposing cause it is hard to understand why hornblende prisms should adopt such an arrangement. Paramorphism.

Other examples of supposed alteration of pyroxene to hornblende were observed on the seventeenth lot of the ninth range and the twenty-first lot of the twelfth range of Templeton, and also on the sixth lot of the first range of Portland. One crystal, from the first of these localities, was no less than a foot in circumference. It exhibited the prismatic angles of pyroxene, and on being broken in two was seen to consist almost entirely of a greyish-green fibrous mineral, which is evidently hornblende. Rude crystals from the Grant Mine in Buckingham appear to be pseudomorphs of asbestus after pyroxene. Asbestus.

Hornblende.

Hornblende, as an original constituent of the apatite-bearing veins, is of far more common occurrence than the pseudomorphous minerals described above, and is occasionally one of the principal constituents of the veins, often occurring near to the walls. It does not, however, appear to be nearly as abundant as in the Norwegian apatite districts, where some of the veins are characterised by Brögger and Reusch as "apatite-bearing hornblende veins." With us pyroxene usually takes the place of the hornblende. The latter varies in colour from pale green to deep olive-green. As yet none of it has been analysed, but while it may in some cases have the composition of actinolite, most of it is probably the aluminous variety known as pargasite. Much of it resembles in appearance the uralite, of which an analysis has been given on page 22. Crystals with terminations were not seen, but beautiful blades with the characteristic angle of hornblende are common, penetrating calcite, or more rarely apatite, quartz, &c. Among the minerals imbedded in hornblende, mica and apatite are, perhaps, the most common, but calcite, titanite and others also occur.

Actinolite and pargasite.

An interesting specimen from the Grant lot in Buckingham apparently consists of the so-called mountain-leather, which is usually regarded as a variety of hornblende. At the same locality asbestus occurs, but in some cases at least, as stated above, appears to be an alteration product of pyroxene.

Mountain leather.

Phlogopite.

According to Brögger and Reusch, phlogopite is an exceedingly abundant mineral in the veins of Oedegarden, in the Bamle district, Norway, and, judging from their description, its mode of occurrence is in many respects very similar to that of the mica found in the apatite regions of this country. They state that "a brown magnesia-mica is in many veins almost the only mineral, but frequently accompanied by green enstatite, together with small masses of apatite. As the quantity of mica decreases and that of the apatite increases, the character of the veins changes. The richer veins are distinguished by the fact that mica almost exclusively occupies the sides of the veins and apatite the centre." Adjoining the wall-rock the mica is said to occur mostly in small scales, while in the middle of the veins it is in large plates. The veins in which mica is the predominant constituent are termed by Brögger and Reusch "apatite-bearing mica veins." Few, if any, of the veins which I have seen in the Ottawa district could properly have this designation applied to them, notwithstanding that phlogopite is one of the most common of the minerals accompanying

Abundance of phlogopite in Norway.

Phlogopite of Ottawa district.

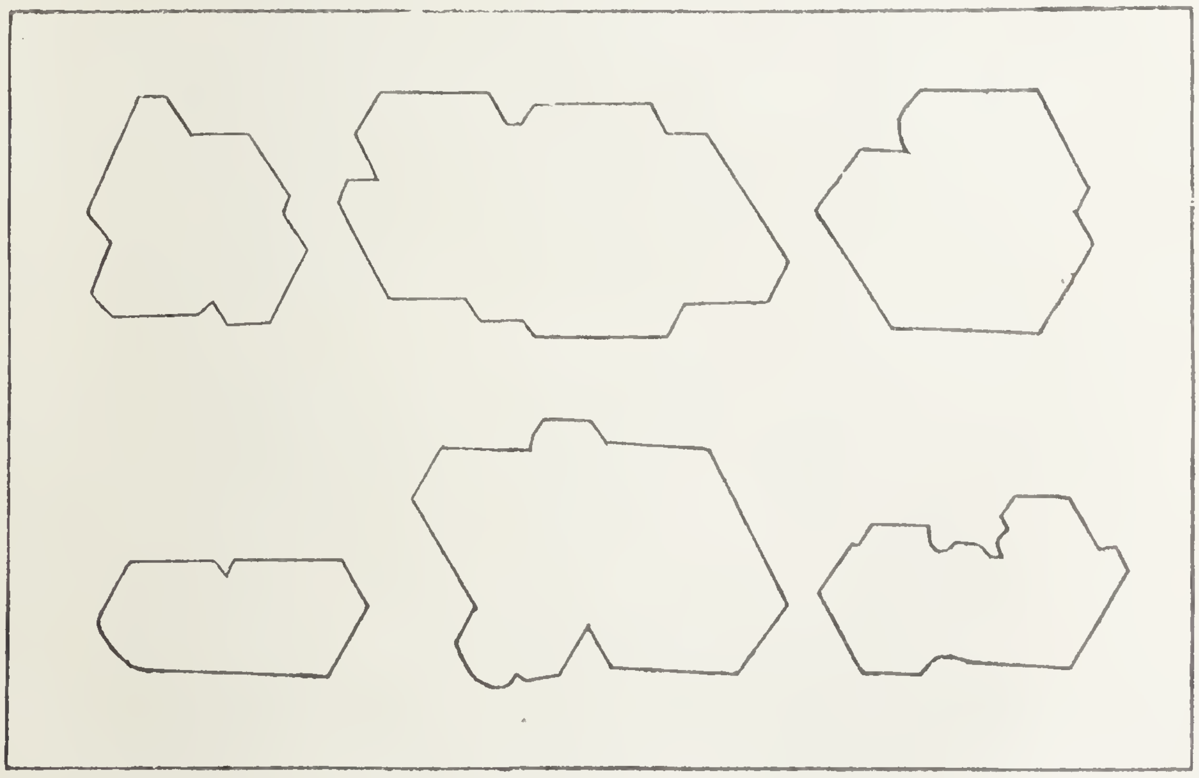
the apatite; but as an example of one which is very largely composed of mica, may be mentioned a vein in the first range of Portland township. It is about twenty-four feet thick, and contains numerous lenticular masses of apatite, sometimes several feet in diameter, imbedded in phlogopite and pyroxene. The mica is partly in fine scales, but sometimes in plates more than fifteen inches wide. From an opening at this locality, about thirty-five feet deep, several hundred tons of very fine apatite have been extracted.

In some instances mica lines the walls of veins, while the centre is filled with apatite. As in Norway also, mica in fine scales is sometimes found adjoining the walls, while large crystals occur in the central portions of the vein. Large crystals are, however, quite as often found near the walls, and in some cases are scattered indiscriminately through all parts of the vein.

Minerals accompanying phlogopite.

Among the minerals in which phlogopite is found imbedded are apatite, calcite, pyroxene, hornblende, scapolite, and zircon. On the other hand, the phlogopite often contains calcite and apatite, these minerals occuping cavities whose forms frequently have some relation to the prismatic faces of the mica crystals. Or the calcite, and more rarely the apatite, may form thin films between the layers of mica. In a few instances, small prisms of apatite were observed penetrating phlogopite crystals.

Fig. 8.



Outlines of Phlogopite Crystals.

The phlogopite crystals* from many localities in Templeton and the adjoining townships are, as in the Burgess region, often of great beauty.

* According to the latest observations on the subject, phlogopite is monoclinic in crystallisation.

They vary in lustre from pearly to almost metallic, and in colour from yellowish or reddish-brown to almost black, The prisms are usually tapering, and the lateral planes often perfectly smooth or polished. Compound crystals are common, and often have curious outlines, such as are shown in the accompanying figure. (Fig. 8. Outlines traced from the crystals themselves and reduced to one-fourth natural size.)

Bent and corrugated crystals.

Remarkable examples of bent and corrugated or wrinkled crystals are very common, and crystals have been found with beautiful markings parallel to the prismatic faces.

Muscovite.

Though large plates of mica occur in many of the apatite veins, they are rarely of economic value owing to unevenness, the presence of calcite or other impurities, and too dark colour. In some cases, also, they are said to exfoliate on heating. Muscovite is not known to occur in any of the apatite deposits of the region in question.

Garnet.

Almandine and essonite.

Several varieties of garnet have been met with in the apatite-bearing veins of Ottawa County, although, so far as known, they are by no means common. A dark red specimen from lot twelve in the twelfth range of Templeton is probably almandine or common garnet. It was imbedded in orthoclase. In the townships of Wakefield and Portland specimens of essonite or cinnamon-stone have been found, and in some cases mistaken for apatite. This variety is found both massive and crystallised in rhombic dodecahedrons. Among the minerals immediately associated with it, besides apatite there are quartz, feldspar, calcite, and idocrase—prisms of the last being imbedded in the garnet. A more or less smoky amber-yellow garnet has been found in the township of Hull, but whether associated with apatite or not I am unaware. The crystals are highly lustrous, and show planes of the dodecahedron and trapezohedron.

Chrome-garnet?

A beautiful emerald-green chromiferous mineral occurs in the township of Wakefield, associated with apatite, pyroxene and tourmaline. In colour and lustre it closely resembles ouvarovite or chrome-garnet. Although one specimen seems to exhibit prismatic structure, another shows faces apparently of a rhombic dodecahedron—three planes meeting at 120°. As the presence of chromium does not seem to have been hitherto recognised with certainty in any of our Laurentian minerals, this one must be regarded as of particular interest, and a quantitative analysis of it will shortly be made.

As we have already seen, garnets are common in some of the gneisses of the region, and have also been observed, though rarely, in the pyroxenites.

Epidote.

In addition to its occurrence in some of the stratified rocks of the region, epidote has, in a few cases, been met with as a constituent of the apatite deposits. One locality is on lot nine of the tenth, another on lot twenty-three of the thirteenth range of Templeton. At the former it is associated with dark green pyroxene, pyrite and calcite; at the latter with hornblende, pyroxene, orthoclase, scapolite, pyrite and calcite. In both cases the mineral is yellowish-green, and fuses with much intumescence to a black slag. In the closed tube it gives, as is usually the case with epidote, a little water. Epidote.

Idocrase or Vesuvianite.

Beautiful crystals of brownish-red idocrase, nearly an inch in diameter, have been found in the township of Templeton, but whether from one of the apatite veins I have been unable to ascertain. Small prisms of green idocrase imbedded in cinnamon-stone have also been obtained from the township of Wakefield, being in this case associated with apatite. Idocrase.

Tourmaline.

The only variety of this mineral noticed in any of the apatite-bearing veins is the ordinary black tourmaline, but this is of quite common occurrence. The best crystals are usually imbedded in calcite, but they are brittle and not often obtained with terminations. In one case a triangular prism, about an inch and a half long and nearly half an inch across the faces of the prism, had been broken in two, and the space between the parts filled with calcite. Other minerals besides the calcite in which tourmaline occurs are apatite, pyroxene, quartz, scapolite and orthoclase, and in one instance small prisms were observed imbedded in fluor-spar. The tourmaline prisms are sometimes aggregated into radiating groups, and this is the case not only in some of the apatite veins but also with tourmaline which sometimes occurs in joints in the quartzites. Black tourmaline. Radiating prisms.

Titanite or Sphene.

As in the Burgess region, so here this is one of the most common of the mineral associates of apatite, and occurs both in the veins and in some of the stratified rocks of the region. In the veins the crystals of sphene are imbedded in various minerals, among which are apatite, pyroxene, hornblende, orthoclase, calcite and scapolite. The crystals are of various shades of brown, and commonly subtranslucent. They vary in size from merely microscopic ones to others measuring several inches across. As a rule, however, they are very brittle, and difficult to obtain in a perfect condition. Many of them contain rounded grains of calcite like those found in crystals of apatite and pyroxene. In composition they probably resemble the sphene of Grenville, an analysis of which—made many years ago, but never published—gave me the following results:—

Analysis of sphene.

Silica	32·09
Titanic acid	37·06
Ferrous oxide	1·16
Lime	28·50
Loss on ignition	0·66
	99·47

Specimens of sphene may be found at almost any of the apatite mines, but the largest which I have seen occur at Breckon's Mine on lot twenty-three of the thirteenth range of Templeton. They were here, however, very brittle, and no good specimens were obtained. In the museum there are fairly good crystals collected by Mr. Frank Adams on the south-east half of lot eight in the fourteenth range of Hull.

Zircon.

This interesting mineral is one of frequent occurrence in the apatite veins of Templeton and the adjoining townships, and is sometimes found in crystals of great beauty. The crystals almost always consist of a square prism terminated by planes of two square pyramids and a zirconoid or octagonal pyramid (∞P. P. 3P. 3P3.), and, so far as observed, the faces of the secondary prism, ∞ P∞, are always wanting. Crystals which have been found on lot twenty-one of the twelfth range of Templeton present a simpler combination than the above, consisting only of the square prism ∞ P. combined with the unit octahedron P.* They differ, too, not only in form but in colour, and in having a lower specific gravity.

Forms of zircon crystals.

Through unequal development, especially of the terminal planes, the zircon crystals are often much distorted. Occasionally, also, they are aggregated in groups parallel to the vertical axis. In size the crystals vary greatly, but one from the twenty-third lot of the thirteenth range of Templeton (belonging to Mr. Miller, of Templeton,) is four and a

Large zircon crystals.

* This is the form of all the crystals which I have seen from Grenville. Small crystals from the sixth range of North Burgess, Ontario, said to come from a granitic vein, show the combination ∞P. 3P. P. 3P3., and occasionally have faces of the secondary prism ∞P∞. Many of them have 3P. developed to a much greater extent than P., and therefore have a curious pointed or tapering appearance.

half inches in length and an inch across each of the faces of the prism. This is, however, only part of the crystal, and how much longer it was originally is not known. A crystal fifteen inches long is also reported to have been found at the same locality by a miner, who was unfortunately unaware of its value and broke it in pieces with his hammer. A crytal presented to the museum of the Geological Survey by Mr. F. W. Henshaw is over an inch long and about half an inch square, and shows the ordinary combination ∞ P. P. 3P. 3P3. Another, presented to the museum of McGill College by Mr. Miller, is an inch and three-quarters long. It is flattened prismatically, so that while it measures half an inch one way, it is only a quarter of an inch thick.

The best zircons are hyacinth-red to cherry-red in colour, but others are reddish-brown and more rarely greyish. A crystal from the "Bishop Pit," on the twenty-first lot of the thirteenth range of Templeton, resembles somewhat in colour the greyish crystals from Buncombe County in North Carolina, but has a pinkish tinge at the extremity. Its specific gravity is only 4·482, while that of one of the dark red crystals from lot twelve in the twelfth range was found to be 4·614.* Many of the crystals are subtransparent, but they range from this to almost opaque. Though they commonly have a high lustre, few, if any, could be used as gems, for they are usually brittle and full of flaws. They are also apt to contain inclusions of other minerals, among which are apatite, calcite and mica, the last being probably the most common. The calcite occurs in little rounded masses analogous to those which are so common in the apatite and pyroxene crystals. The minerals in which the zircons have been found imbedded are apatite, calcite, orthoclase, pyroxene, phlogopite, black tourmaline, and prehnite. The apatite containing the zircons is usually a fine-granular variety, but in one instance a small prism of zircon was found imbedded in a large crystal of green apatite.

Specific gravity of zircon.

Zircon is now known to be a far more widely diffused mineral than was formerly supposed, its presence having been detected in many crystalline rocks both in Europe and America.† The crystals are sometimes macroscopic, as in the so-called zircon syenite of Norway, but more frequently can only be seen with the microscope. Among

Frequent occurrence of zircon in crystalline rocks.

* This is almost exactly the density of the Grenville zircon, which, according to Hunt, is 4·625-4·602.

† See Rosenbusch, *Mik. Physiog. d. Min.*, p. 189. Also the magnificent reports on the Geological Exploration of the Fortieth Parallel, published under the direction of Mr. Clarence King, Volumes I., II. and VI. In Volume I. (p. 397) of this series, Mr. R. W. Woodward, Chemist of the Exploration, describes a new method for the detection of small quantities of zirconia due to the presence of zircon in rocks. It is based upon the fact that zircon is but slightly acted upon by hydrofluoric acid.
The occurrence of zircon in some of the granites and gneisses of New Hampshire is described by Mr. G. Hawes in his report on the Geology and Lithology of that State.

the rocks in which it has been observed are granite, syenite, gneiss, mica-schist, felsite, eklogite, basalt, hypersthenite, &c.

Orthoclase.

Orthoclase.

We have already referred to orthoclase as a constituent of the gneisses and pyroxenites; but in addition to its occurrence in these stratified rocks it is also common in veins cutting them, including many of the apatite-bearing veins. The orthoclase of these veins is very often white, but at other times flesh-coloured, grey, lavender, green and other colours. The green has been found in both Templeton and Hull; in the latter township in masses of considerable size. Orthoclase crystals are sometimes found in cavities, but more frequently the mineral is massive and often coarse-crystalline in texture. Masses with broad cleavage surfaces are often imbedded in a ground-mass of paler colour and finer texture, also consisting of orthoclase or orthoclase and quartz. Rude crystals and masses presenting broad cleavage surfaces have been found by Mr. Miller on lot thirteen of the eleventh range of Templeton, which appear to have been acted upon by some solvent which has eaten the feldspar into curious corrugated channels or cavities, while the black pyroxene accompanying the feldspar has been but little affected. Among the minerals imbedded in the orthoclase of many of the veins, besides quartz, there are apatite, pyroxene, hornblende, sphene (very common, and sometimes in large crystals), zircon, mica, tourmaline, and calcite.

In a few cases granitic veins, or possibly true dykes, were observed cutting sharply across the apatite veins, and therefore of more recent origin. One of them, occurring on lot twelve in the twelfth range of Templeton, is eighteen inches thick, and bears S. 18° E. Another, on lot eight in the tenth range of the same township, is two feet thick, and bears north and south.*

Albite.

Occurrence of albite.

This species of feldspar has been found in a few localities in the township of Templeton, associated with apatite, sphene, pyroxene, &c. Cavities or crevices in the last-named minerals have drusy linings of albite crystals, which, on analysis, have been found to contain—

Potash	2·75
Soda	8·96
	11·71 p.c.

*For analyses of orthoclase from Buckingham township,—associated with graphite, but similar in appearance to much of what occurs with the apatite—see Mr. Christian Hoffmann's Report published last year.—*Report of Progress*, 1876-77, p. 511.

SCAPOLITE.

This name is now made by many mineralogists to include a group of closely related minerals, all of which are tetragonal in crystallisation, and consist of silicates of alumina and lime, with, or in some cases without, soda. The most important member of the group is wernerite, and to this species much of our scapolite probably belongs, but until more analyses have been made the general term scapolite must be used. *Scapolite group of minerals.*

Scapolite is a common mineral in the Laurentian, and has hitherto been observed at a number of localities, including Hunterstown, Grenville, Calumet Island, Golden Lake (Renfrew County), &c.* In the region more particularly referred to at present, it has been found as a constituent of the apatite-bearing veins in many localities, among which the following may be mentioned: *Scapolite localities.*

Templeton—Lot	13, Range	XI.	Templeton—Lot	21, Range	XII.
" — "	12, "	XII.	" — "	23, "	XIII.
" — "	14, "	XII.	Portland — "	6, "	I.

Hull—Lot 8, Range XIV.

The best crystals which I have seen are from lot fourteen in the twelfth range of Templeton. Very large ones (sometimes more than a foot in length), but of rude form, have been found on the twenty-third lot of the thirteenth range, where an enormous vein of massive scapolite occurs.

The crystals from the different localities are, on the whole, very similar, but occasionally present points of difference. Usually they are short and thick, but sometimes slender. The simplest forms observed consist of a combination of the two square prisms—the faces of the secondary greatly predominating—with the unit octahedron or square pyramid (∞ P∞ . ∞ P. P.). Good examples of these were seen at a small opening on the twenty-third lot of the thirteenth range of Templeton, the crystals being unusually long for their thickness. The more commonly occurring crystals, however, exhibit a much larger number of planes. Some of those, for example, from the fourteenth lot of the twelfth range of Templeton show the following: *Form of scapolite crystals.*

Prismatic	∞ P∞ ∞ P. ∞ P 2.	Pyramidal.......	3P. P∞ . 3P3.

Basal, oP.

All these are sometimes found in single crystals, but ∞ P2 and 3P3, as is frequently the case with crystals from other regions, are hemihe-

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* See Geology of Canada, 1863, p. 473. Also Chapman, Minerals and Geology of Central Canada, Toronto, 1871, p. 113.

dral in arrangement. Occasionally the faces ∞P. are more fully developed than ∞P∞, but the reverse is usually true. The colour of the scapolite varies mostly from white to grey or greenish-grey, but sometimes there is a pinkish tinge. A massive variety from further down the Ottawa, in the augmentation of Grenville, is of a pale lemon-yellow colour, and holds imbedded crystals of lilac pyroxene. The surfaces of the scapolite crystals are often dull, owing, no doubt, to partial decomposition, and sometimes much stained with oxide of iron. The decomposed portion, however, usually forms only a thin crust, beneath which the mineral appears white and exhibits its characteristic fibrous texture and cleavage. Not infrequently the crystals look as if they had been submitted to pressure while in a soft or plastic state, and have had their faces curved, or have been bulged out at the base where attached to the rock. In other cases they have been too hard to yield readily to the pressure, and have been cracked or broken, the spaces being sometimes filled with other minerals.

Many of the best scapolite crystals are imbedded in calcite, and they are very often accompanied by pyroxene. Apatite, titanite, tourmaline and other minerals are frequently imbedded in the scapolite.

Analysis by Mr. Frank Adams.

During the past summer Mr. Frank D. Adams, while engaged on one of the survey parties in tracing out some of the trap dykes north of the Ottawa, found specimens of scapolite on lot thirteen of the eighth range of Ripon, one of which he subsequently analysed at the Sheffield Scientific School, New Haven, with the following results :*

Silica	54·859
Alumina	22·448
Ferric oxide	0·486
Lime	9·092
Magnesia	trace
Potash	1·127
Soda	8·365
Chlorine	2·411
Sulphuric acid ($S O_3$)	0·796
Water (combined)	0·722
Water (hygroscopic)	0·141
	100·447
Deduction for O replaced by chlorine	.59
	99·857

Chlorine in scapolites.

The presence of chlorine in scapolites seems to have been previously almost entirely overlooked, and its detection, as well as that of sul-

* On the Presence of Chlorine in Scapolites ; by Frank D. Adams. Contributions from the Laboratory of the Sheffield Scientific School.—*American Journal of Science*, April, 1879, p. 315.

phuric acid, in the present instance, is a fact of much interest. In order to ascertain whether this was an exceptional case, fourteen other specimens of scapolite were examined by Mr. Adams, and chlorine found in them all, although in some cases the amount was small. The above analysis shows the scapolite from Ripon to be more highly acidic than most of the members of the scapolite family.

Wilsonite.

This name was many years ago given by Dr. Hunt to a mineral occurring in the township of Bathurst, where it was first observed by Dr. Wilson, formerly of Perth. By some mineralogists it is regarded as an altered scapolite, with which mineral Chapman has shown it to agree in cleavage. Hunt, on the other hand, regards it as a variety of gieseckite, and discards the idea of its being an alteration product of scapolite. (Geology of Canada, 1863, p. 483.) Wilsonite an altered scapolite.

In the townships of Templeton and Hull, a mineral with the rose-red colour and other characters of wilsonite occurs at many of the apatite mines, and certainly appears to be an alteration product of scapolite. In all the specimens seen the two minerals occurred together, and appeared to merge one into the other, the cleavage of the two minerals being continuous. Among the localities in which the wilsonite has been found are Templeton, lots twelve and twenty-three in the thirteenth, and twenty-one in the twelfth range, and Hull, lot four, range ten.

Steatite.

A soft ($H = 2 - 2\frac{1}{2}$) steatitic mineral of grey or greenish-grey colour occurs in some of the apatite veins, and is, perhaps, in some cases of the nature of pyrallolite. Specimens from Mr. Miller's "Old Red Pit," at the Fidelity Mines in Templeton, are subtranslucent, very compact, soapy in feel, and have a distinct conchoidal fracture. The mass is here and there penetrated by a prismatic mineral, which looks as if it had originally been hornblende, but which is now quite as soft as the material in which it is imbedded. In some cases bright green prisms of apatite are imbedded in a grey steatitic mineral, which in one instance looks as if it were pseudomorphous after mica. Pyrallolite.

Chlorite.

Under this general name mineralogists include a number of foliated minerals, which, though differing considerably in the relative proportions of their constituents, are, for the most part, hydrous silicates of magnesia, ferrous oxide, and alumina. At several of the apatite mines of Templeton a green chlorite-like mineral has been observed, and a specimen from the north-west half of lot eighteen in the ninth range of that township has been examined. The chloritic mineral in this case was associated with apatite, quartz, iron pyrites and calcite, and occurred in uneven folia, mostly of an olive-green colour, and with a pearly lustre. The hardness was $2\frac{1}{2}$, and specific gravity 2·61. Folia flexible, but scarcely elastic. An analysis gave the following results:

Analysis of chlorite.

Silica	35·80
Alumina	13·18
Ferric oxide	4·28
Ferrous oxide	10·18
Magnesia	22·80
Water	12·64
	98·88

This, it will be seen, is approximately the composition of ripidolite, with part of the alumina replaced by ferric oxide and part of the magnesia by ferrous oxide. The silica is higher than in ripidolite, but this is probably due to the presence of a little quartz, which was difficult to separate perfectly. The quantivalent ratio for $R : R_2 : Si : H$, deduced from the above figures, is $5 : 3 : 8 : 4\frac{1}{2}$, while for ripidolite it is $5 : 3 : 6 : 4$.

Prehnite.

This mineral, which is of frequent occurrence in connection with the copper-bearing rocks of Lake Superior, has not heretofore been found in the Laurentian of Canada. I am indebted to Mr. J. G. Miller for a specimen from lot sixteen in the twelfth range of Templeton.

The mineral is translucent and of a yellowish-white colour, with a greenish tinge in places. It seems to have occurred in a cavity, and shows rounded surfaces made up of an aggregation of crystals. The hardness is a little above 6, and specific gravity 2·891. Analysis gave the following results:

Analysis of prehnite.

Silica	42·82
Alumina	23·86
Ferric oxide	1·42
Manganous oxide	0·10
Lime	27·64
Magnesia	0·09
Water	4·82
	100·75

Before the blow-pipe the mineral fuses easily and with much intumescence.

The hardness of prehnite serves to distinguish it readily from members of the zeolite family, with some of which it might be confounded.

CHABAZITE.

"Zeolitic" minerals are said to have been observed in some of the apatite-bearing veins of North Burgess, but no particular species seems to have been identified. Among minerals collected last summer at the "Bishop Pit," on the twenty-first lot of the twelfth range of Templeton, chabazite has been detected. It occurs in small colourless or white, glassy crystals, in irregular cavities in scapolite and pyroxene. The crystals, which are mostly under an eighth of an inch in diameter, are obtuse rhombohedrons, and many of them penetration twins. Chabazite identified.

The chabazite, like the last mineral described, is evidently of secondary origin, and possibly derived from the scapolite.*

HEMATITE.

Peroxide of iron occasionally occurs enclosed in quartz in some of the apatite veins, and is also the colouring matter of the ordinary red apatite. In a crystalline condition it has not been met with in the Ottawa phosphate region, though sometimes associated with apatite in Ontario. Hematite.

RUTILE.

This mineral is reported to occur in some of the apatite-bearing veins, but I was not successful in finding any. Specimens of supposed rutile from Templeton prove to be only peroxide of iron enclosed in glassy quartz. In Norway rutile is said to be one of the most characteristic minerals of the apatite veins, and Brögger and Reusch state that if it were of any economic value it could be obtained in large quantity. One crystal found by them weighed no less than 1140 grammes.† Rutile in Norway.

PYRITE.

Though not usually a very abundant constituent of the apatite veins, pyrite is nevertheless of frequent occurrence. It is commonly massive,

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* Since the above notes were in type, Mr. Miller has kindly forwarded me a number of interesting specimens. Among them is one of prehnite from lot twenty-three in the thirteenth range of Templeton, occurring in a cavity in apatite, a crystal of the latter mineral being imbedded in the prehnite. Also a specimen of chabazite from a new locality (Portland West, lot twenty-one, range twelve), and other zeolitic minerals, one of which is evidently natrolite.

† Small crystals of rutile have been found, since the above was written, in an apatite vein on the tenth lot of the tenth range of Templeton.

Crystals of pyrite.

but sometimes occurs in well-defined crystals (cubes, octahedrons, or combinations of these forms). In some cases pyrite is imbedded in apatite, but, on the other hand, rounded crystals of green apatite occur imbedded in pyrite. At the Grant Mine, in Buckingham, very brilliant iron pyrites was observed, imbedded in fine granular calcite, both the pyrites and calcite being penetrated by small rounded prisms of pale yellowish-green apatite.

Pyrrhotite.

In some of the apatite-bearing veins of Norway pyrrhotite or magnetic pyrites is a very abundant mineral, and is sometimes accompanied by ordinary pyrites. Examples are given by Brögger and Reusch of veins in which pyrrhotite is the predominant mineral. The apatite is imbedded in the pyrrhotite, and usually in the form of much rounded crystals.

In the Ottawa district pyrrhotite is sometimes met with in the apatite veins, but, so far as yet observed, never forms such an abundant constituent as in Norway. It is also found associated with apatite in Ontario.

Chalcopyrite.

Occurrence of chalcopyrite.

This mineral was met with at several of the apatite mines in Templeton, last summer. It commonly occurs in the form of little irregular grains, or imperfect crystals, in white subtransparent calcite, the grains often being arranged more or less parallel to one of the directions of cleavage of the calcite. In one instance it was observed in similar grains imbedded in chalcedonic quartz.

Sphalerite or Zinc Blende.

Blende.

This appears to be a rare mineral in the apatite-bearing veins. A small specimen was found last summer on the seventeenth lot of the ninth range of Templeton. It was yellowish-brown in colour and associated with quartz and green apatite.

Galena.

Galena.

Minute quantities of galena have been found by Mr. Miller at his "Trusty Pit," on the twelfth lot of the twelfth range of Templeton. It occurs with smoky quartz in cavities in pink calcite.

Molybdenite.

Molybdenite.

Molybdenite has been found at the same locality as the last. In the only specimen which I have seen it was imbedded in iron pyrites, but it is stated to have been found also in apatite and pyroxene.

Graphite.

This mineral is said to occur in many of the apatite veins, although seen in but few of those examined last summer. In one instance it was observed in broad folia wrapping round crystals of black pyroxene, which themselves contained scales of graphite. In another case it occurred in the form of highly lustrous plates penetrating coarse crystalline calcite in various directions. In the graphite veins of Buckingham, crystals of apatite are often found imbedded in the graphite, Graphite.

Many other minerals, no doubt, occur in the apatite-bearing veins of the region in question; but, excepting a few doubtful species, the foregoing are all that have as yet come under my notice. One would naturally expect that loganite, which is so frequently mentioned by Hunt as occurring in North Burgess, would also be found here. According to Hunt also, wollastonite is sometimes a constituent of the apatite veins of Burgess, and, associated with quartz, forms interrupted beds interstratified with pyroxenite. Somewhat similar beds, in which the wollastonite is accompanied by both quartz and calcite, occur in Templeton, but as yet the wollastonite has not been observed in any of the veins of the region. Loganite and wollastonite.

Barite, again, though not anywhere found associated with apatite, occasionally forms veins near to those of apatite. Barite.

MISCELLANEOUS ROCKS AND MINERALS.

—

Manganiferous Calcite.

Isomorphous minerals.

The members of the calcite group of minerals afford us some of the best known examples of what is called *isomorphous replacement*, or the replacement of an element by one or more other chemically equivalent elements without a marked change of crystalline form. As a result of this isomorphous replacement, not only do we obtain a number of minerals which are regarded as specifically distinct (dolomite, ankerite, mesitite, &c.), but also many varieties of the species themselves. The so-called ferro-calcite, for example, is a variety of calcite with part of the calcium replaced by iron, plumbo-calcite another variety with lead, replacing calcium. Spartaite, again, is a manganiferous calcite; neotype a variety containing barium, and strontiano-calcite a variety containing strontium. In the case of dolomite also, other metals besides the calcium and magnesium are often present. As an example of this, may be mentioned the dolomite from Sutton, in the Eastern Townships, which afforded Dr. Hunt carbonate of lime 40·10, carbonate of magnesia 20·20, carbonate of iron 10·65, carbonate of manganese 7·65, insoluble 21·40=100·00.*

Analysis by Dr. Hunt.

Manganiferous calcite.

I am indebted to Mr. A. J. Hill, C.E., of Amherst, N.S., for a specimen of calcite which proves, on analysis, to be a manganiferous variety. It was found in fissures near a "trouble" in the bituminous coal of the Cumberland seam at the Joggins. The calcite had been deposited on both walls, either entirely filling the fissure or leaving cavities in the centre, and fragments of the coal were enclosed in the vein. The calcite is white and translucent, and apparently made up of an aggregation of imperfectly formed nail-head crystals. An analysis gave the following results:—

Analysis of calcite.

Calcium carbonate	96·639
Magnesium carbonate	traces.
Ferrous carbonate	1·095
Manganese carbonate	1·949
	99·683

Heated before the blow-pipe, the mineral turns black owing to the oxidation of the manganese. A very little iron pyrites is associated with the calcite.

* *Geology of Canada*, 1863, p. 613.

On the Occurrence of Olivine in Canada.

The occurrence of olivine in the eruptive rocks of Rougemont, Montarville and Mount Royal, as well as in a doleritic dyke cutting the Hudson River formation at St. Hyacinth, and in the dolomitic conglomerate or breccia of St. Helen's Island, near Montreal, was described by Dr. Hunt many years ago, and an analysis of that from Montarville given. Recently it has been found in a number of other localities, and a few facts concerning its occurrence at some of these are of sufficient interest to be given here. Occurrence of olivine.

Owing to the difficulty of navigating the Ottawa River below the railway bridge at Ste. Anne's during the time of low water, communication with a deeper channel than the one ordinarily followed was deemed necessary, and was finally effected by cutting across a ridge of rock in the bed of the river. Coffer-dams were built enclosing the required area, and when the water was pumped out an excellent opportunity was afforded of seeing the bottom of the river. The rocks exposed were sandstones and conglomerates of the Potsdam formation, striking nearly east and west and dipping to the south $\angle$ $3\frac{1}{2}°$–$4°$. Traversing these beds with a course of N. 20° W., a vertical dyke about three feet thick was found. It consisted of a rather fine-grained ground-mass holding large plates of mica sometimes an inch or more across, irregular masses and occasionally large crystals of black augite, and angular masses of olivine occasionally more than an inch in diameter. The last-named mineral gives the rock a very striking appearance, as much of it is of a bright red colour. An analysis of this red olivine gives the following results:— Olivine from Ste. Anne's.

Silica	38·560
Magnesia	44·369
Ferric oxide	1·361
Ferrous oxide	12·649
Manganous oxide*	0·112
Water (ign.)	2·914
	99·965

It is, therefore, a variety with much less iron than that from Montarville, which, according to Dr. Hunt's analysis, contains—Silica 37·17, ferrous oxide 22·54, magnesia 39·68 = 99·39.

When thin sections of the olivine from Ste. Anne's are examined with the microscope, the usual fissured or cracked appearance is seen. Along some of the cracks an alteration to serpentine has taken place, while along others a little red oxide of iron is visible. Although the

* With a little oxide of cobalt.

amount of this peroxide is small as shown both by the microscope and by analysis, it is, nevertheless, evidently the cause of the general red colour which the mineral has assumed.

Olivine from near Mount Albert.

Another locality in which olivine has recently been found is a short distance to the south-east of Mount Albert, just south of the south second fork of the Ste. Anne River, Quebec. The explorations of Mr. Richardson during the past season have shown that it there forms important rock-masses close to the serpentines of Mount Albert, which have evidently been produced by the alteration of the olivine. A specimen of the rock collected by Mr. Richardson is fine-granular, slightly friable, and pale yellowish to greyish-green in colour. It shows a few minute black grains, probably of chromite, and rarely a little of a fibrous mineral which resembles enstatite. Altogether, the rock looks remarkably like one variety of that from North Carolina, which was many years ago described by Genth, and regarded by him as the source of the serpentine and talc of the same region.* An aggregate of olivine and chromite occurs at Dun Mountain in New Zealand, and hence the name *dunite*, by which the rock is now commonly known. There, also, it is accompanied by serpentine. Rocks of somewhat similar character also occur at a number of localities in Europe. The dunite of New Zealand is stated to be an eruptive rock, while the olivine rock of North Carolina, according to Dana, is "metamorphic." Concerning the relations of the olivine rock from near Mount Albert little is known, but it is probably not eruptive.

Dunite.

Origin of olivine rocks.

The origin of such olivine rocks as those of Carolina and Mount Albert is a difficult and disputed question, but one which still remains, whether we believe that the serpentines which accompany them were derived from them or not. In opposition to the view that they owe their origin to chemical precipitation, Clarence King suggests that they may represent accumulations of olivine sands like those now occurring on the shores of the Hawaiian Islands.† Whether such accumulations did take place in the earlier geological formations we do not know, but there is certainly nothing unreasonable or unlikely in the view that magnesian precipitates may then, as in later times, have been formed and subsequently altered to olivine.

Microscopic characters of dunite.

A thin section of the olivine rock or dunite from near Mount Albert, when examined with the microscope, presents the appearance shown in Fig. 9 *a*. It is seen to consist almost entirely of granular olivine, with occasional black grains of chromic iron. Owing to an alternation of layers with finer and coarser texture, it shows a more

* *American Journal of Science*, Vol. XXXIII.; 1862, p. 199.

† *United States Geological Exploration of the Fortieth Parallel.* Vol. I., p. 117.

or less banded structure. As observed above, an enstatite-like mineral may occasionally be seen in the hand specimen, but none of it happened to occur in the portion sliced.

FIG. 9.

a *b*

Serpentine derived from dunite.

Fig. 9 *b* is drawn from a section of one of the so-called serpentines occurring near the dunite. Its relation to the latter is evident, for it still contains numerous grains of unaltered olivine. In some specimens the change has not advanced so far as here, but in other cases the olivine has almost, if not entirely, disappeared. The chromite, however, always remains.

Olivine in Nova Scotia.

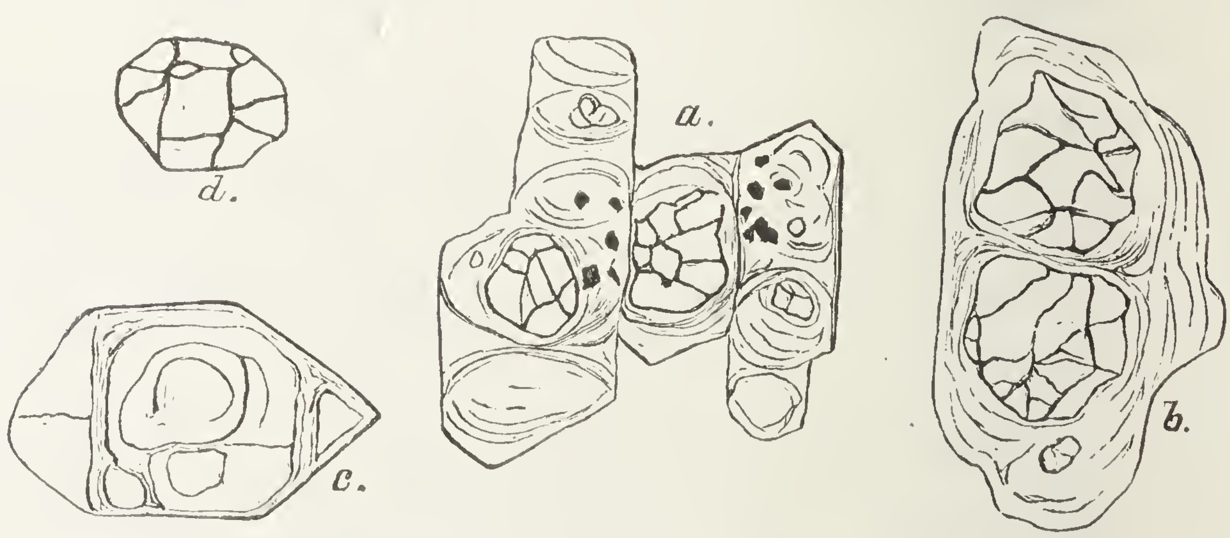
Another example of the occurrence of olivine is to be found in the case of a dark-grey dolerite occurring near South Lake, in Antigonish County, Nova Scotia. When a section of the rock is examined with the microscope, it is seen to consist of a beautifully banded triclinic feldspar, brownish augite, magnetite, and very numerous irregular grains, or occasionally rude crystals, of olivine. The olivine resembles that sometimes seen in gabbro. It is traversed by the usual cracks or rifts, which in this case appear very broad and black, and also contains great quantities of black and opaque microlites, which are probably magnetite, and which are sometimes so abundant as to render the mineral almost opaque. Some of them are arranged in parallel rod-like forms, while others are occasionally grouped in star-like or other more or less symmetrical shapes.

Olivine in British Columbia.

Olivine has also been detected in several of the eruptive rocks of British Columbia. One of these, of Tertiary age, from Kamloops, affords most beautiful examples of the alteration of olivine to serpentine. It is massive, rather fine-grained, and of a very dark olive-green colour. The examination of a slide with the microscope shows that originally the rock must have consisted of crystals and grains of olivine, augite (mostly in crystals) and a small proportion of plagioclase feldspar and magnetite. But while the augite mostly remains fresh, a large part of the olivine, which appears to be the most abundant constituent of the rock, has been altered to serpentine. Most of the olivine crystals and grains retain a nucleus of the unaltered mineral, showing the characteristic rifts, and the outlines of many crystals which are partly or entirely converted into serpentine are still perfectly sharp. In the accompanying figure (Fig. 10) *a* represents a group of crystals which are mainly composed of serpentine, but show nuclei of olivine and a few opaque grains probably of magnetite; *b* is an irregular mass also partly changed to serpentine; *c* represents a crystal which has been entirely converted into serpentine; while *d* is an almost perfectly fresh crystal of olivine.

Alteration of olivine to serpentine.

FIG. 10.



On further alteration such a rock might be almost entirely converted into serpentine. Such a change has been observed elsewhere, as, for example, in the case of many of the Würtemberg basalts, which are said to be "little more than serpentine rocks containing some magnetite, since the olivine and augite which composed the basalt are changed into serpentine." *

Serpentines of the Eastern Townships.

In this country we have other examples than those already given of the production of serpentines by the alteration of other rocks. That such is the origin of many of the serpentines of the Eastern Townships there can be little doubt. The fact of their being commonly chromiferous suggests that they may have been derived from such peridotic rocks as lherzolite, dunite, olivine-gabbro, &c. †

ON SOME OF THE DIORITES OF MONTREAL.

There are probably few regions of such limited extent that furnish

* Rutley, on authority of Dr. M. G. R. Fritzgärtner. *The Study of Rocks*, 1879, p. 117.

† Concerning these rocks and the changes which they have undergone, see Rosenbusch, *Massige Gesteine*, pp. 525-538.
Also, Bonney, On the Serpentine and Associated Rocks of the Lizard District.—*Quarterly Journal of the Geological Society*, Vol. XXXIII., p. 884.

a greater variety of interesting eruptive rocks than Montreal and its vicinity. This fact, long ago, attracted the attention of Dr. Hunt, and though many of the rocks were ably described by him, there still remains a wide field for investigation, both as regards the character of the rocks and their relative ages. Numerous facts bearing upon these points have recently been accumulated, but many additional details are required before the subject can be fully discussed.

In the *Geology of Canada* the intrusive rocks of Montreal are described as dolerites, trachytes and phonolites, the first of these constituting the main mass of Mount Royal as well as numerous dykes, while the others occur only in dykes, which are stated in some instances to cut the dolerites. No mention is, however, made of the numerous dykes of diorite which occur, and which, in some cases, have also been observed to cut the dolerite of the mountain. These diorites vary considerably in their characters, ranging in colour from light to dark grey, and in specific gravity from 2·75 to over 3.* They are usually medium to fine-grained in texture, and often porphyritic with crystals of hornblende. Sometimes, too, they are amygdaloidal, the cavities containing calcite, zeolitic minerals, and rarely epidote. They all appear to contain carbonates, the quantity of which, however, varies in different cases. Their principal constituents are hornblende, a triclinic feldspar, and titanic iron; but they commonly contain other minerals, the most important of which is, perhaps, mica. Augite is also sometimes present. The mica is occasionally so abundant that the rock becomes the mica-diorite of some lithologists. Diorite dykes.

A dyke occurring in the reservoir extension consists of what may probably be regarded as a typical variety of the diorites referred to above. It is dark grey in colour, rather fine-grained, but still showing, without the lens, quantities of acicular prisms of a black mineral which proves to be hornblende. The dyke was about two feet thick and very homogeneous, showing neither porphyritic nor amygdaloidal texture. Specimens sliced and examined with the microscope are seen to consist essentially of hornblende, a triclinic feldspar, and numerous opaque grains of titanic iron. Mica, apatite, calcite, and a little of a green chloritic mineral, are also commonly present. The hornblende appears mostly fresh, though in places slightly altered to the chloritic mineral just mentioned. It is of a rich brown colour and strongly dichroic. In cross sections the cleavage of the prisms is often beautifully displayed. The feldspar is in part

* The following are the specific gravities of a number of specimens:—

2·749	2·94	2·923	3·005
2·889	2·97	4·947	....
2·805	3·07	2·927	....

altered, but in places fresh. It is triclinic, and, judging from the unusually basic character of the diorite, must be a feldspar low in silica. The black mineral occurs mostly in irregular grains, but here and there in curious fantastic forms after the manner of titanic iron ore. That it consists mainly of this mineral, and not of magnetite, is evident from the considerable proportion of titanium dioxide shown by the analysis, and also from the fact that when the rock is pulverised the magnet removes almost nothing. The specific gravity of different fragments of the rock varied from 2·927 to 3·005. An analysis was made some time ago, and, as the composition appeared unusual, search was made for descriptions of similar rocks from other localities, but none could be found. Since then, however, Mr. G. W. Hawes has described rocks of wonderful similarity from Campton, in the State of New Hampshire.* An analysis, by Mr. Hawes, of one of these diorites is given under II. for comparison with I., which is an analysis of the diorite from Montreal just described:—

Analyses of diorite.

	I.	II.
Silica	40·95	41·94
Alumina	16·45	15·36
Ferric oxide†	13·47	3·27
Ferrous oxide	...	9·89
Manganous oxide	0·33‡	0·25
Titanium dioxide	3·39	4·15
Lime	10·53	9·47
Magnesia	6·10	5·01
Potash	1·28	0·19
Soda	4·00	5·15
Phosphoric acid	0·29	..
Carbon dioxide	..	2.47
Loss on ignition	3·84	3·29§
	100·63	100·44

On boiling I. with hydrochloric acid for several hours, and filtering, the insoluble residue after ignition amounted to only 51·80 per cent. Although the amount of carbon dioxide was not determined, it must constitute a large proportion of the loss which the rock sustains on ignition; for acetic acid dissolves 4·02 per cent. of lime and 0·67 of ferrous oxide, and these bases, if calculated as carbonates, would require 3·57 per cent. of carbon dioxide. The basic character of the rock, and the extent to which it is dissolved by hydrochloric acid,

* *Geology of New Hampshire*, Part IV., p. 160.
American Journal of Science, 1879, p. 148.

† All the iron is calculated as ferric oxide, the ferrous oxide not having been determined.

‡ With a little cobalt. § Water.

seem to indicate a feldspar of the nature of anorthite. In that case a considerable proportion of the alkalies must belong to the hornblende; but this is not improbable, as some varieties of hornblende are known to contain several per cent. of alkalies.

Another dyke, occurring within a few yards of that just described, is also of much interest. It is dark grey in colour, and, like the last, shows numerous acicular prisms of hornblende penetrating the mass in all directions. Here and there macroscopic scales of dark brown mica are seen, and the rock is dotted with numerous spots—occasionally as much as a quarter of an inch across—of a glassy, colourless to white mineral, which, on analysis, proves to be analcite. The specific gravity of the analcite is 2·255, and its composition as follows:— Interesting dyke. Analysis of analcite.

Silica	53·29
Alumina	23·33
Ferric oxide	trace.
Lime	0·64
Magnesia	trace.
Soda	14·54
Water	8·47
	100·27

The mineral was examined for potash, but none found. Before the blow-pipe it fuses easily to a colourless glass. When thin sections of the rock are examined with the microscope the analcite appears very transparent and shows but few inclusions. It is traversed by numerous reticulating cracks, but displays no characteristic cleavage. The feldspar is mostly dull, but here and there is sufficiently transparent to show its triclinic character with polarized light. The hornblende and titanic iron appear exactly similar to what occurs in the ordinary diorites of the locality. No augite has been observed, but one slide shows numerous green crystals, which are evidently pseudomorphs of serpentine after olivine.

In so far as its constituents are concerned, this rock appears to be somewhat similar to that which Tschermak, many years ago, called *teschenite*, after Teschen in Austria. Tschermak regarded the analcite as one of the normal constituents of the rock, and this it may possibly be in the present instance. On the other hand, the general similarity of the other constituents of the rock to those of the ordinary diorites of the vicinity would lead one to infer that the analcite is a secondary mineral, and that the rock is simply an altered diorite. Teschenite.

The diorites described above traverse not only the Lower Silurian limestones, but also the dolerite of Mount Royal. Rounded masses of the diorite of precisely similar character occur in the Lower Helderberg conglomerate or breccia of St. Helen's Island. Those, therefore, Age of eruptive rocks.

who would classify eruptive rocks according to age, would say that Mount Royal is a diabase and not a dolerite. Admitting such to be the case, how is it, the question may be asked, that dykes of *phonolite* are abruptly cut off by the diabase, when phonolite, according to the chronological theory, ought to be of Tertiary or more recent age? It may be that future investigations will solve the difficulty, but, in the meantime, the eruptive rocks of Montreal do not seem to fall into their proper place in a classification based upon age.

Magnetic Iron Ore.

According to Dr. G. M. Dawson, deposits of magnetic iron ore occur near the west end of Cherry Bluff, on Kamloops Lake, British Columbia. The ore forms irregular veins varying from the thickness of a sheet of paper up to three feet or more in a sort of diorite, and is often associated with epidote. A specimen which has been analysed was bluish-black in colour, and showed in places a curious sub-columnar structure. The only gangue visible was a little quartz and calcite. The results of the analysis are as follows:

Analysis of magnetite.

Ferric oxide	64·85
Ferrous oxide	27·57
Manganous oxide	0·09
Lime	1·26
Magnesia	0·78
Phosphoric acid	0·23
Sulphuric acid	0.07
Carbonic acid	0·33
Water	0·37
Insoluble matter	4·07
	99·62
Metallic iron	66·84
Phosphorus	0·100
Sulphur	0·028

The proportions of ferric and ferrous oxide are nearly those required by theory for magnetite, the ratio of ferrous to ferric oxide being 1: 2·35 instead of 1: 2·22. Calculation would give 28·64 and 63·65 per cent., respectively, of ferrous and ferric oxide, instead of the proportions given in the analysis. The insoluble residue consisted chiefly of silica, but also contained a little alumina, iron, lime and magnesia.

Spathic Iron Ore.

In the summer of 1877, beds of spathic iron ore were discovered by Dr. Robert Bell at Flint Island and elsewhere near Hudson Bay, in rocks supposed to belong to the Nipigon group. Some of the specimens show a distinctly crystalline texture, while others are very compact. Owing to their containing manganese they were dark brown to black.

A specimen of the compact variety from Flint Island gave on analysis: Analysis of spathic iron ore.

Ferrous carbonate	52·70
Manganous carbonate	24·64
Calcium carbonate	traces.
Magnesium carbonate	11·81
Insoluble residue	10·94
	100·09
Metallic iron	25·44

It was brownish-grey in colour, and had a specific gravity of 3·49. The insoluble matter was white and mainly silica. The ore is interesting on account of the rather unusually large proportion of manganese which it contains, and which would make it valuable for the manufacture of spiegeleisen. Ores of the kind have long been mined at a number of localities in Europe, but there the most important deposits are of Devonian and Permian age.

Another specimen from Flint Island was little more than a fine-grained quartzite charged with carbonates of iron and manganese. It contained 13·62 per cent. of iron. On the same island coarsely crystalline siderite occurs in veins, associated with quartz, though not in sufficient quantity to be considered economically important.

Davieau's Island, on the east coast of Hudson Bay, is another locality in which Dr. Bell has found spathic iron ore. A specimen collected by him is distinctly crystalline in texture, and contains 27·83 per cent. of iron. The proportion of manganese has not been determined, but is probably high. Fuller details concerning the localities of these spathic ores are given by Dr. Bell in his report.

Lignite, or Brown Coal.

Hat Creek, British Columbia.—In his report on the southern part of the interior of British Columbia (page 121), Dr. G. M. Dawson has described the occurrence of an enormous bed of lignite in rocks of Tertiary age. The bottom of the seam could not be seen, as it was concealed beneath the waters of the stream, but the thickness of lignite above the water-line was found to be forty-two feet.

A specimen received for examination was a dull brown to black lignite, cracking on drying, and then presenting black conchoidal

Analyses of lignites.

surfaces, with more or less pitchy lustre. Analyses by slow and fast coking gave the following results :

	Slow coking.	Fast coking.
Water (at 100°–115°C.)	8·60	8·60
Volatile combustible matter......	35·51	41·42
Fixed carbon....................	46·84	40·93
Ash (white)	9·05	9·05
	100·00	100·00

The powder showed no disposition to coke. When heated with a solution of caustic potash, it coloured the solution intensely brown.

Junction of Nicola and Coldwater Rivers, British Columbia.—Proximate analyses of coals from this region were given in last year's report, but since then another specimen has been examined which came from the uppermost seam (fifteen feet four inches) of the section given in Dr. Dawson's report (p. 125). It was black, somewhat pitchy in lustre, and showed distinct planes of bedding. The powder was brownish-black, and coloured a solution of caustic potash brown, though not very intensely. Slow and fast coking gave the following results:

	Slow coking.	Fast coking.
Water (at 100°–115°C.)..........	5·78	5·78
Volatile combustible matter......	27·65	33·72
Fixed carbon....................	52·69	46·62
Ash (reddish-white).............	13·88	13·88
	100·00	100·00

The powder was not fritted even by rapid heating.

Kohasganko Stream, British Columbia.—This specimen was brought by Dr. G. M. Dawson from a seam of lignite occurring on the above named stream.* It was dull brown to black, and on drying fell into small fragments, often with highly lustrous surfaces. It showed distinct lamination and a good deal of mineral charcoal between the layers. The powder was blackish-brown and coloured the potash solution very strongly. By slow and rapid heating the following results were obtained:

	Slow coking.	Rapid coking.
Water (at 100°–115° C)..........	9·90	9·90
Volatile combustible matter......	37.71	42·61
Fixed carbon....................	38·85	33·95
Ash (pale grey).................	13·54	13·54
	100·00	100·00

Good coal from Belly River.

Belly River, North-West Territory.—A specimen of coal from near Belly River, recently received for examination from the Surveyor-

* See Report of Progress, 1876-77, p. 76.

General, Mr. L. A. Russell, proved to be of excellent quality. In appearance it resembled a true bituminous coal from the Carboniferous, though really of Cretaceous or possibly Tertiary age. It contained a little mineral charcoal and occasional thin films of calcite in joints. Colour black and fracture uneven to sub-conchoidal. Analyses by slow and fast coking gave the following:

	Slow coking.	Fast coking.
Hygroscopic water	5·79	5·79
Volatile combustible matter	41·25	35·20
Fixed carbon	47·91	53·96
Ash (reddish-grey)	5·05	5·05
	100·00	100·00
Ratio of volatile combustible matter to fixed carbon	1 : 1.16	1 : 1.53

The powder was slightly sintered by rapid heating. It also coloured a potash solution brown, but not so deeply as the lignites just described.

GOLD AND SILVER ASSAYS.

Cariboo District, British Columbia.

In the Report of Progress for 1876-77 a series of assays was published of samples taken from a number of quartz veins in the Cariboo district, British Columbia; but in almost every instance the proportions of gold and silver found were very trifling. Subsequently, other samples were sent for examination by the Deputy Minister of Mines. They were assayed, and the results, which were forwarded to Victoria in June last, showed a much larger quantity of gold than in the specimens previously examined. The results may be given in tabular form, as follows:

Assays of quartz from Cariboo.

	Gold. Oz. to ton of 2,000 lbs.	Silver. Oz. to ton of 2,000 lbs.
No. 1	1·243	0·134
" 2	0·802	0·249
" 3	0·116	0·233
" 4	3·245	0·213
" 5	2·450	0.359
" 6	1·568	0·374
" 7	0·972	0.263
" 8	2·296	0.396
" 9	0·124	0·176

The first six samples were in fragments and consisted mainly of quartz and iron pyrites—the latter mineral in larger proportion than in most of the specimens previously assayed. The remaining samples were in powder, and it is probable that Nos. 7, 8, 9 were simply 2, Average amount of gold.

5 and 3, respectively, but pulverised. The average amount of gold in the first six is 1·571 ounces to the ton of 2,000 lbs., and of silver only 0·26 ounces.

MISCELLANEOUS LOCALITIES.

Miscellaneous gold and silver assays.

1.—*Cinnemousun Narrows, British Columbia.*

Rusty quartz with iron pyrites, the latter constituting about one-third the bulk of the specimens.

Gold	Distinct traces.
Silver	0·087 ounces to the ton.

2.—*From a Large Vein south-east of Cinnemousun Narrows, B.C.*

Quartz, much stained with oxide of iron. The specimen was found to contain,

Gold	Distinct traces.
Silver	1·02 ounces to the ton.

3.—*North Fork of Cherry Creek, B.C. From "Vernon's Silver Lead."*

Quartz, a good deal stained with oxide of iron, and carrying a little galena and iron pyrites. The specimens also showed an occasional green stain, possibly indicating the presence of tetrahedrite, a mineral known to occur on Cherry Creek.

Gold	0·058 ounces to the ton.
Silver	8·254 " " " "

4.—*Cherry Creek, B.C.*

Pellets of galena from Cherry Creek, above the Cañon. They were found in the sluice-boxes higher up the stream than the known silver-bearing lodes. Assay by scorification gave—

Silver	220·937 ounces to the ton.

5—*Cherry Creek, B.C.*

Argentiferous tetrahedrite.

The occurrence of rich silver ore on Cherry Creek has been described by Dr. G. M. Dawson in his report (p. 160), and several samples from the locality have been assayed. The first of these was a mass of about twenty pounds weight, which was sent to the Paris Exhibition of 1789. It consisted of an argentiferous tetrahedrite or freibergite, with some galena and zinc blende in a gangue of white quartz. Fragments were broken off so as to represent the whole as far as possible without destroying the specimen, and assays of these by scorification gave,

Silver	658 437 ounces to the ton.

Another specimen, collected by Mr. J. Fraser Torrance as being a fairly rich sample of the ore, and also consisting of quartz, tetrahedrite, galena and blende, gave,

Silver...................... 255,937 ounces to the ton.

A second sample received from Mr. Torrance, and stated to represent a vein eighteen inches thick, gave,

Silver...................... 53·958 ounces to the ton

It consisted of the same minerals as the other specimens, the proportion of gangue, of course, being very much larger. In all three cases the buttons contained a little gold.

6.—*Locality?*

A specimen from British Columbia, received from Mr. Camby, of the Canada Pacific Railway Survey. It consisted of milky-white quartz, holding a considerable quantity of galena, iron pyrites, and copper pyrites.

Gold........................ 0·029 ounces to the ton.
Silver...................... 1·079 " " " "

7.—*Gros Cap, Lake Superior (Brown's Silver Mine).*

A specimen received from Dr. R. Bell, and consisting of rather fine granular galena and zinc blende in a gangue of calcite and quartz.

Silver...................... 0·058 ounces to the ton.

The proportion of galena and blende was small; but even taking this into consideration, it is evident that neither of these minerals contains much silver.

8.—*Victoria Mine, Garden River.*

Coarse crystalline galena * with curved faces. It was carefully freed from gangue, and found to contain,

Silver......................30·623 ounces to the ton.

Another sample received at the same time, but from which the gangue was not separated, gave,

Silver........................21·146 ounces to the ton.

9.—*Lake Temiscaming, Ontario.*

Specimens of galena from a locality discovered in 1877 by Mr. Edward Wright, of Ottawa. The galena is coarse crystalline, and resembles in appearance much of that from the Victoria (Argentiferous galena from Lake Temiscaming.)

* For other assays of galena from this locality, see Report of Progress, 1876-77, p. 480.

Mine, near Garden River. Like the latter, too, it probably occurs in rocks of Huronian age, Lake Temiscaming being on the line of these rocks. A specimen of the galena, entirely freed from gangue, gave, by scorification,

Silver......................18·958 ounces to the ton.

Another specimen, received from Mr. Wright at the same time, but containing a good deal of rock matter, gave,

Silver......................11.66 ounces to the ton.

A third specimen of galena from a point about fifty feet from that at which the above was taken gave, after careful separation of the gangue,

Silver......................18·229 ounces to the ton.

10.—*Richmond Gulf, Hudson Bay.*

Coarse crystalline galena from the south side of the entrance of the gulf. Collected by Professor Bell in 1877. It was found to contain,

Silver......................12·03 ounces to the ton.

11.—*Hartford Mine, Capelton, P.Q.*

Tetrahedrite from Capelton, Quebec.

At this mine a steel-grey tetrahedrite occurs, associated with copper pyrites. A specimen containing only a very little of the latter mineral was assayed in order to ascertain whether it was argentiferous, and yielded,

Silver......................75.03 ounces to the ton.

12.—*Near Sherbrooke, P.Q.*

Copper pyrites.

Specimens of copper ore examined for silver, at the request of Mr. A. Holland, of Ottawa. The specimens consisted of copper pyrites, a little iron pyrites, and glassy quartz. They yielded,

Silver......................19.687 ounces to the ton.

It is well known that the copper ores of the Eastern Townships, as a rule, contain silver; but the proportion is usually less than that found in Mr. Holland's specimens.

13.—*Musquash Harbour, New Brunswick.*

Galena from New Brunswick.

Specimens of galena received through Mr. Ells from the *Lancaster Silver Mining Company* of St. John, N.B. The galena was separated as far as possible from the gangue of quartz in which it occurred, and gave,

Silver......................14·219 ounces to the ton.

The veins are stated to occur in rocks of Laurentian age, but the galena contains more silver than any other from the Laurentian which I have hitherto examined.

GEOLOGICAL SURVEY OF CANADA.

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

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA.

CANADIAN APATITE,

BY

CHRISTIAN HOFFMANN, F. Inst. Chem.

PUBLISHED BY AUTHORITY OF PARLIAMENT

Montreal:
DAWSON BROTHERS.
1879

GEOLOGICAL SURVEY OF CANADA,

MONTREAL, May 31, 1879.

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

Director of the Geological Survey of Canada.

SIR,—Acting in accordance with your suggestion I have carried out a series of analyses of Canadian apatite, the results of which I have now the pleasure of submitting to you.

I have the honor to be,

Sir,

Your obedient servant,

CHRISTIAN HOFFMANN.

CHEMICAL CONTRIBUTIONS

TO THE

GEOLOGY OF CANADA,

BY

CHRISTIAN HOFFMANN, F. Inst. Chem.

ON CANADIAN APATITE.

Manner in which the Samples analyzed were selected.

The samples were in all cases good-sized hand specimens; in selecting the same such pieces were taken as were most free from foreign mineral admixture, or, in other words, apparently the purest of that particular variety in the heap (usually a very large one) from which it was taken. As a rule, therefore, the various analyses may be said to represent, in a measure, the composition of these particular varieties in their greatest practically attainable state of purity; such, indeed, as might be secured by careful cobbing,—and not the composition of an average sample of any particular output, and the reader is cautioned against accepting the results in any other light. In some instances the material upon which the analysis was conducted, was said to represent a fair average of the vein; in other cases, by the exercise of a little care it would be quite possible to procure large quantities of the variety almost, if not equally, as pure as the sample examined. The instances in which these remarks hold good will be found specified, together with others of a similar tenor, under the various analyses.

Manner of selecting the samples.

Brief allusion to some of the Methods employed in the analysis.

Brief allusion to methods employed in the analysis.

The fluorine was determined in accordance with Wöhler's method, as modified by Fresenius. (Fresenius' Quantitative Chemical Analysis, sixth German edition, Vol. I., p. 431.) The apatite, reduced to an impalpable powder and intimately mixed with finely pulverized quartz, is decomposed in a flask with concentrated sulphuric acid. The fluorine being estimated by collecting and weighing the fluoride of silicon evolved.

The phosphoric acid was estimated by Sonnenschein's process of precipitation with molybdic acid—subsequently precipitating as phosphate of magnesia and ammonia, and weighing as pyrophosphate of magnesia.

Explanatory Remarks.

Explanatory remarks.

By the term "insoluble residue" is implied that portion of the apatite left undissolved by the action of hydrochloric acid; the mineral having been previously treated with hydrochloric acid, and evaporated to complete dryness.

The term "variety" has not been employed in its strictest sense, inasmuch as all the specimens here examined would, properly speaking, come under the one variety, fluor-apatite; I have, however, permitted myself its use in a wider sense, referring more particularly to texture.

It has been assumed, as is indeed most probable, that the whole of the phosphoric acid is present in combination with lime, and that any excess of this latter beyond that required for the phosphoric and carbonic acids, may possibly—conjointly with the magnesia, alumina, and in some instances a portion of the iron,—pertain to associated foreign mineral matter.

Apatite, *var.* 1.

Analysis of apatite from Storrington.

From the fourteenth lot of the sixth range of the township of Storrington.

The sample was received from W. J. Morris, Esq., who informed me that he was disposed to regard it as representing a fair average of a quantity of some three hundred tons extracted; that about twenty tons of the first two hundred taken out contained some mica derived from the foot-wall, but that this appeared to have since run out. The vein ranged from seven to fourteen inches in width.

Massive, compact. Lustre dull. Colour greyish to reddish-white, with reddish-brown coloured stripes or bands, which impart to the rock a stratified appearance (in some specimens these markings are less distinct). This variety of apatite may not inappropriately be said to resemble, at a first glance, a fine-grained "variegated sandstone." Tough. Fracture uneven. Colour of powder white with a faint reddish tinge. Specific gravity 3·1393.

After drying at 100° C., its composition was found to be as follows:

Phosphoric acid [1]	40·373
Fluorine [2]	3·311
Chlorine [3]	0·438
Carbonic acid [4]	0·026
Lime	47·828
Calcium	3·732
Magnesia	0·151
Alumina	0·609
Sesquioxide of iron	0·151
Alkalies	?
Insoluble residue	3·890
	100·509

1 Equal to 88·138 tribasic phosphate of lime.
2 Equal to 6·796 fluoride of calcium.
3 Equal to 0·685 chloride of calcium.
4 Equal to 0·059 carbonate of lime.

APATITE, *var.* 2.

From the "Grant Mine," situate on the south-half of the eighteenth lot of the twelfth range of the township of Buckingham. The property of the Buckingham Mining Company. Analysis of apatite from Buckingham.

In the earlier stages of the working about two hundred and fifty tons of this variety were taken out; as the shaft increased in depth, this particular kind was not, nor has it so far, since been met with; it is however inferred, that it will be found again with the other phosphate which lies near the surface, and has yet to be removed.

Massive, vitreous. Brittle. Fracture uneven, angular; in some specimens sub-conchoidal. Lustre sub-vitreous. In thin splinters translucent. Colour pale greenish-grey. Colour of powder pale greenish-white. This variety of apatite closely resembles in its aspect "porcelain jasper." It is not unfrequently penetrated by thin seams of calcite. Hardness 5. Specific gravity 3·1493.

After drying at 100° C., its composition was found to be as follows:

Phosphoric acid[1]	41·080
Fluorine[2]	3·474
Chlorine[3]	0·260
Carbonic acid[4]	0·370
Lime	49·161
Calcium	3·803
Magnesia	0·158
Alumina	0·705
Sesquioxide of iron	0·125
Alkalies	?
Insoluble residue	0·370
	99·506

1 Equal to 89·682 tribasic phosphate of lime.
2 Equal to 7·131 fluoride of calcium.
3 Equal to 0·406 chloride of calcium.
4 Equal to 0.840 carbonate of lime.

Apatite, *var.* 3.

Analysis of apatite from North Burgess.

From the sixteenth lot of the third range of the township of North Burgess.

Massive, confusedly crystalline, weak-defined schistose texture. Fracture uneven. Lustre sub-vitreous, in parts dull. Colour dull red. Colour of powder pale red. Specific gravity 3·1603.

After drying at 100° C., the composition was found to be as follows:

Phosphoric acid[1]	39·046
Fluorine	3·791
Chlorine[3]	0·476
Carbonic acid[4]	0·096
Lime	46·327
Calcium	4·258
Magnesia	0·548
Alumina	1·190
Sesquioxide of iron	1·290
Alkalies	?
Insoluble residue	3·490
	100·512

1 Equal to 85·241 tribasic phosphate of lime.
2 Equal to 7·781 fluoride of calcium.
3 Equal to 0·744 chloride of calcium.
4 Equal to 0·218 carbonate of lime.

APATITE, *var.* 4.

From the "Ritchie Mine," situate on the seventh lot of the seventh range of the township of Portland. Analysis of apatite from Portland.

This specimen was collected by Dr. B. J. Harrington, who informs me that at the spot whence it was taken, the mass, *as exposed*, measured nearly twenty feet across, and in the whole of this thickness the only apparent foreign mineral admixture consisted of a few crystals of pyroxene and mica, and that, consequently, this specimen might be regarded as representing a large portion of said *exposed* mass.

Massive, lamellar; the laminæ varying in thickness from one to eight millimetres, the faces of the same are not unfrequently coated with a more or less delicate film of calcite; the coherence between the individual plates varies; when struck the rock has a tendency to split along the line of lamination rather than across. Brittle. Fracture across the laminæ uneven, angular. Lustre of this fracture vitreous, that of the clean surface of the laminæ resinous. Colour bright sea-green. Colour of powder white with a faint greenish tinge. Semi-transparent; in thin splinters, transparent. Hardness 5. Specific gravity 3·1884.

The following interesting fact in connection with this apatite is perhaps, not altogether unworthy of mention; after a short exposure to a low red-heat in a covered crucible it becomes perfectly colourless, its lustre being not at all, and its diaphaneity very slightly affected.

After drying at 100° C., its composition was found to be as follows:

Phosphoric acid[1]	41·139
Fluorine[2]	3·863
Chlorine[3]	0·229
Carbonic acid[4]	0.223
Lime	49·335
Calcium	4·195
Magnesia	0·180
Alumina	0·566
Sesquioxide of iron	0·094
Alkalies	?
Insoluble residue	0·060
	99·884

1 Equal to 89·810 tribasic phosphate of lime.
2 Equal to 7·929 fluoride of calcium.
3 Equal to 0·358 chloride of calcium.
4 Equal to 0.507 carbonate of lime.

APATITE, *var.* 5.

Analysis of apatite from Loughborough.

From the tenth lot of the tenth range of the township of Loughborough. W. J. Morris, Esq., by whom the specimen was presented, stated that the vein from which it was taken—and of which, in his opinion, it might be considered a fair sample,—had a width of about seven feet.

Massive, compact. Lustre dull, in parts sub-resinous. Brittle. Fracture uneven, angular. Colour dull-red. Colour of powder reddish-white. Interpenetrated by delicate films of specular iron. Specific gravity 3·1641.

After drying at 100° C., its composition was found to be as follows:

Phosphoric acid[1]	40·868
Fluorine[2]	3·731
Chlorine[3]	0·428
Carbonic acid[4]	0·105
Lime	48·475
Calcium	4·168
Magnesia	0·158
Alumina	0·835
Sesquioxide of iron	0·905
Alkalies	?
Insoluble residue	1·150
	100·823

1 Equal to 89·219 tribasic phosphate of lime.
2 Equal to 7·658 fluoride of calcium.
3 Equal to 0·669 chloride of calcium.
4 Equal to 0·239 carbonate of lime.

APATITE, *var.* 6.

Analysis of apatite from Portland.

From the "Watts Mine," situate on the sixth lot of the first range of the township of Portland. The property of the Buckingham Mining Company.

About seventy per cent. of the phosphate raised from this mine consists of this variety, the balance is similar to that described below, wherein the compact crystalline phosphate preponderates, sometimes to the almost total exclusion of the fine-granular.

Massive, crystalline-granular. Friable. Fracture uneven, granular. Prevailing colour greenish-white. Colour of powder white. Lustre glimmering. Specific gravity 3·1676.

The texture of this variety varies from a very fine-granular crystalline, greenish to greyish-white, homogeneous, somewhat easily friable rock, closely resembling a disintegrating sandstone,—to crystalline granular, with imbedded rounded fragments of semi-transparent sea-green apatite, constituting what, perhaps, might not inaptly be designated a conglomerate—thence passing on to a condition in which the fragments become more numerous and larger, to the almost total exclusion of the fine-granular matrix.

After drying at 100° C., its composition was found to be as follows:

Phosphoric acid[1]	40·518
Fluorine[2]	3·377
Chlorine[3]	0·086
Carbonic acid[4]	0·855
Lime	49·041
Calcium	3·603
Magnesia	0·205
Alumina	0·267
Sesquioxide of iron	0·083
Alkalies	?
Insoluble residue	1·630
	99·665

1 Equal to 88·455 tribasic phosphate of lime.
2 Equal to 6·932 fluoride of calcium
3 Equal to 0·134 chloride of calcium.
4 Equal to 1·943 carbonate of lime.

Apatite, *var.* 7.

From the "Grant Mine," situated on the south-half of the eighteenth lot of the twelfth range of the township of Buckingham. The property of the Buckingham Mining Company.

Analysis of apatite from Buckingham.

About five hundred tons of this variety have been taken out at this mine; it is still met with, but not in such large quantities.

Massive, crystalline, fine-granular, with occasional imbedded rounded fragments of semi-transparent sea-green apatite. Prevailing colour greyish-green. Lustre glistening, due to the presence of intermixed grains of pyrrhotite. Somewhat tough. Fracture uneven, granular. Colour of powder greenish-grey. Specific gravity 3·2441.

In selecting the material for analysis the aforementioned imbedded rounded fragments were excluded (as also in those specimens upon which the specific gravity was determined), the object being to ascertain the composition of the granular matrix; it need hardly be remarked that their presence would have raised the percentage of tribasic phosphate.

After drying at 100° C., its composition was found to be as follows:

Phosphoric acid[1]	34·032
Fluorine[2]	2·855
Chlorine[3]	0·101
Carbonic acid[4]	2·848
Sulphur[5]	3·507
Lime	44·198
Calcium	3·062
Magnesia	0·422
Alumina	1·979
Nickel, cobalt and copper present, but were	not det'd
Iron	5·370
Sesquioxide of iron	0·120
Alkalies	?
Insoluble residue	2·050
	100·544

1 Equal to 74·295 tribasic phosphate of lime.
2 Equal to 5·860 fluoride of calcium.
3 Equal to 0·158 chloride of calcium.
4 Equal to 6·473 carbonate of lime.
5 Equal to 8·877 pyrrhotite.

The nickel, cobalt and copper shown to be present, pertain to the associated pyrrhotite. In calculating the amount of the latter (in accordance with the formula $Fe_7 S_8$) corresponding to the sulphur found, their presence has been ignored, as a consequence, the total iron found has been somewhat too largely drawn upon, so that the balance, which was assumed and calculated to be present as peroxide, is somewhat, though possibly very slightly below the actual amount present.

APATITE, *var.* 8.

Analysis of apatite from Templeton.

From the "Doctor Pit," situate on the twelfth lot of the twelfth range of the township of Templeton. The property of the Templeton and North Ottawa Mining Company.

This specimen was collected by Dr. B. J. Harrington, who states that so far as the working had advanced, this particular kind had not been found in any great quantity, but formed a portion of a vein consisting of a crystalline-granular, somewhat friable variety, very similar to that described under Apatite, var. 6, and a compact crystalline variety.

Massive, compact. Fracture uneven. Lustre feeble, waxy. Translucent. Colour pale greenish-white Colour of powder white with a faint greenish tinge. Specific gravity 3·1750.

After drying at 100° C., the composition was found to be as follows:

Phosphoric acid[1]	40·812
Fluorine[2]	3·554
Chlorine[3]	0·040
Carbonic acid[4]	0·518
Lime	49·102
Calcium	3·763
Magnesia	0·620
Alumina	0·565
Sesquioxide of iron	0.125
Alkalies	?
Insoluble residue	0·630
	99·729

1 Equal to 89·098 tribasic phosphate of lime.
2 Equal to 7·295 fluoride of calcium.
3 Equal to 0·062 chloride of calcium.
4 Equal to 1·177 carbonate of lime.

The results of the foregoing analyses have been embodied in Table I. with the object of affording easy reference, and facilitating comparison, not only the one with the other, but alike with those contained in Table II., which embraces analyses of fluor-apatites from some of the principal European localities. In selecting these latter analyses I have only availed myself of those wherein the fluorine has been determined by direct estimation; further, in transcribing them, I have taken the liberty of presenting them in a somewhat different form to that in which they appeared,—that is to say, in analyses A. B. C. where the amount of tribasic phosphate of lime, fluoride and chloride of calcium was given, the amount of phosphoric acid, fluorine, chlorine, lime and calcium thus represented has been calculated and stated separately. In like manner in analysis E. where the amount of fluoride of calcium was given, the amount of fluorine and calcium thus represented has been calculated and stated separately. In the other analyses viz., D. F. G. and H. the total lime found was given and stated as such; in these instances the amount of lime corresponding to the calcium (now stated as such) required for the fluorine or fluorine and chlorine, as the case might be, has been deducted from the total quantity given: as a result of this altered representation, the analyses do not now foot up so high as in the originals.

Explanatory remarks on Table ii.

TABLE I.—SHOWING THE COMPOSITION OF CERTAIN CANADIAN FLUOR-APATITES.

	1.	2.	3.	4.	5	6.	7.	8.
Phosphoric acid[1]	40·373	41·080	39·046	41·139	40·868	40·518	34·032	40·812
Fluorine[2]	3·311	3·474	3·791	3·863	3·731	3·377	2·855	3·554
Chlorine[3]	0 438	0·260	0·476	0·229	0·428	0·086	0·101	0·040
Carbonic acid[4]	0·026	0·370	0.096	0·223	0·105	0·855	2·848	0·518
Sulphur[5]	......	......	......	......	......	......	3·507	......
Lime	47·828	49·161	46·327	49·335	48·475	49·041	44·198	49·102
Calcium	3·732	3·803	4·258	4·195	4·168	3·603	3·062	3·763
Magnesia	0·151	0·158	0·548	0·180	0·158	0·205	0·422	0·620
Alumina	0·609	0·705	1·190	0·566	0·835	0·267	1·979	0·565
Nickel, cobalt and copper	......	......	......	......	......	......	not det'd.	......
Iron	......	......	......	......	......	......	5·370	......
Sesquioxide of iron	0.151	0·125	1·290	0·094	0·905	0·083	0·120	0·125
Alkalies—presence not ascertained—	?	?	?	?	?	?	?	?
Insoluble residue	3·890	0·370	3·490	0·060	1·150	1·630	2·050	0·630
	100·509	99·506	100·512	99·884	100·823	99·665	100·544	99·729
Specific gravity	3·1393	3·1493	3·1603	3·1884	3·1641	3·1676	3·2441	3·1750
1 Equal to tribasic phosphate of lime	88·138	89·682	85·241	89·810	89·219	88·455	74·295	89·098
2 Equal to fluoride of calcium	6·796	7·131	7·781	7·929	7·658	6·932	5·860	7·295
3 Equal to chloride of calcium	0·685	0·406	0·744	0·358	0·669	0·134	0·158	0·062
4 Equal to carbonate of lime	0·059	0·840	0·218	0·507	0·239	1·943	6·473	1·177
5 Equal to pyrrhotite	......	......	......	......	......	......	8·877	......

NOTE.—The numbers heading the columns correspond with those particularizing the variety, and which appear over the respective analyses in the preceding pages.

TABLE II.—SHOWING THE COMPOSITION OF CERTAIN EUROPEAN FLUOR-APATITES.

	A.	B.	C.	D.	E.	F.	G.	H.
Phosphoric acid[1]	42·229	42·172	42·215	40·120	34·630	34·480	41 990	41·980
Fluorine[2]	3·415	3·434	3·746	2·160	3·313	3·450	4·200	4·020
Chlorine[3]	0·512	0·566	0·096	0·060	......	......	0·010	0·110
Carbonic acid[4]	......	......	......	......	......	1·510	......	......
Lime	49·960	49·894	49·945	50·269	41·150	40·705	49·752	49.898
Calcium	3·884	3·934	3·998	2·308	3·487	3·632	4·427	4·294
Magnesia	......	......	......	......	......	0·160	......	......
Alumina	......	......	......	......	......	1·080	......	......
Sesquioxide of iron	......	......	......	0·610	3·800*b*	6·420	......	......
Alkalies	......	......	......	......	......	1·000*c*	......	......
Silica	......	......	......	3·100*a*	12·370	4·830	......	......
Water	......	......	......	......	1·250	2·450	......	......
	100·000	100·000	100·000	98·627	100·000	99·717	100·379	100·302
1 Equal to tribasic phosphate of lime	92·189	92·066	92·160	87·586	75·601	75·273	91·668	91·646
2 Equal to fluoride of calcium	7·010	7·049	7·690	4·434	6·800	7·082	8·621	8·252
3 Equal to chloride of calcium	0·801	0·885	0·150	0·094	......	......	0·016	0·172
4 Equal to carbonate of lime	......	......	......	......	......	3·432	......	......

A. From Arendal, Norway, by G. Rose.
B. From Murcia, Spain, by G. Rose.
C. From Greiner, Tyrol, by G. Rose.
D. From Estramadura, Spain, by Garzo and Penuelas.
E. From Estramadura, Spain, by P. Thibault.
F. From Staffel, Nassau, Germany, by Foster.
G. From Tokovaia, Ural, Russia, by Pusirevski.
H. From Slüdianka, Russia, by Pusirevski.

a. With alumina.——*b.* With some alumina, magnesia, iodine (traces) and carbonic acid (by difference).——*c.* Consisting of potash 0·58 and soda 0·42.

Iodine and Bromine in Apatite.

Iodine and bromine in apatite.

Iodine has been shown to be present in certain varieties of apatite from the departments of Lot and Tarn-et-Garonne: P. Thibault has found it in Nassau phosphate, in Spanish phosphorite from the vicinity of Coçues (Estramadura) and has also established its presence in coprolites found in the Valley of the Rhone, near Bellegarde (Ain) close to the Swiss frontier: Petersen also found it in apatite from Diez, Nassau, and that from Amberg, Bavaria, afforded H. Reinsch in addition to iodine a trace of bromine.

Analysis of apatite from the department of Lot.

According to an analysis by P. Thibault, a sample of apatite from the department of Lot, contained:—

Phosphoric acid [1]	33.05
Lime	47.09
Silica	2.71
Alumina, oxide of iron, magnesia, chlorine, fluorine, iodine ($\frac{12}{10000}$), carbonic acid (by difference).	12·86
Water	4.29
	100.00

1 Equal to 72·151 tribasic phosphate of lime.

It has been suggested that the apatite from the departments of Lot and of Tarn-et-Garonne might possibly be utilized as a commercial source of iodine, and efforts have been made in this direction by M. P. Thibault at the Super-phosphate Works of MM. Maxime Michelet et Paul Thibault, (à la Villette-Paris). The phosphates employed at these works consist of apatite from the department of Lot, coprolites from the Ardennes and Spanish phosphorite.

The plant at this factory may be briefly described as follows:—

Brief description of the superphosphate works of MM. Michelet and Thibault.

Two endless belts, the one of leather with wooden scoops or cups for raising the powdered phosphate, the other of gutta-percha with scoops or cups of the same material for raising the acid. On motion being communicated to these belts, the powder and acid are raised simultaneously and dropped into an horizontal, cylindrical, cast-iron mixer where the powder and liquid are thoroughly intermixed by the revolving spindle of the mixer and its blades, after which the mass passes down through a shoot into brick chambers where it solidifies and whence it is afterwards withdrawn. The acid vapours generated in the mixer and chambers are withdrawn from these vessels by means of a powerful aspirator and made to traverse a sheet-iron cylinder lined with lead and filled with fragments of coke, upon which a constant stream of water is kept trickling from above, and pass finally into the factory chimney. By this arrangement the acid vapours generated on mixing the powdered phosphate with the acid and which

Removal of the noxious gases generated in the process of superphosphating.

are at all times discomforting and often (especially when fluor-apatites are being worked) positively injurious to those exposed to their influence, are carried off and completely absorbed. When phosphates containing iodine are employed, the iodine disengaged during their conversion into superphosphate and carried away in the state of vapour or as hydriodic acid, is completely absorbed and by allowing the same liquid to retraverse the coke, the solution may contain as much as eight grammes of iodine to the litre. It will be thus seen that it is quite possible to collect all the iodine which is disengaged in the gaseous condition; the amount thus disengaged however is very far from representing the total amount originally contained in the apatite, the greater part unfortunately remaining in the superphosphate; and, so far as I am aware, a method has yet to be discovered whereby that portion of the iodine may be profitably extracted.

Collection of the iodine.

If, however, the method devised by M. P. Thibault does not so far permit of the recovery of all the iodine it nevertheless possesses other important advantages, such as a continuous process of manufacture, considerable saving of manual labour, and complete absence of noxious vapours.

Advantages of P. Thibault's method.

From its usually high content of phosphate of lime Canadian apatite may be regarded as a most eligible material for the manufacture of a concentrated superphosphate. Generally speaking it contains (as will be seen on reference to Table I.) only small quantities of oxide of iron, and not unfrequently the amount is altogether quite insignificant: it is to be remembered that No. 7 is a very exceptionally occurring variety, has only been met with at this mine, and there only, as stated, in small quantity.

Canadian apatite as a material for the manufacture of superphosphate.

All the Canadian apatite hitherto met with belongs to the variety fluor-apatite, and is very similar in composition to that derived from many European localities, as will be seen on comparing Table I. with II. A great deal of the phosphatic material at present extensively employed in the manufacture of superphosphate, contains more or less fluoride of calcium, this may be said of Spanish phosphorite, German or Nassau phosphate and most coprolites: when such material are treated with sulphuric acid in the process of superphosphating, hydrofluoric acid is evolved, which not only causes discomfort, but is injurious to the workmen. For this reason, at works where no special precautions are taken to effect the removal of the noxious gases evolved in the mixing process, any phosphatic material containing much fluorine is apt to be looked upon with some disfavour: its presence, however, can be a matter of very little moment when the very simple and effective device, for drawing off and absorbing these gases, as car-

On the presence of fluoride of calcium in phosphatic material employed in the manufacture of superphosphate.

ried out at the works of MM. Michelet and Thibault (afore briefly described) is adopted.

Concluding remarks.

It was originally contemplated to make some practical and comparative experiments with European and Canadian phosphate in order to ascertain the relative facility with which they admitted of being reduced to a fine powder; sufficient time could not be found to carry out this intention. There is, however, no reason for supposing that in this respect they compare at all unfavourably with foreign apatites.

In the manufacture of superphosphate from mineral phosphates it is almost impossible in practice to render the whole of the phosphate of lime soluble, more or less (according to the skill and care bestowed in the manufacture) of the latter remaining in its original unchanged state. In order to employ the mineral phosphates to the best advantage, it is requisite that they should be reduced to an almost impalpable powder, and that the mixing of this latter with the acid should be most thorough.

NOTE ON A GEOLOGICAL MAP

OF A

PORTION OF THE SOUTHERN INTERIOR OF BRITISH COLUMBIA.

The accompanying map is that referred to in the Report on British Columbia, published in the Report of Progress of the Geological Survey of Canada for 1877-78. Various circumstances have delayed its execution to the present time, but without adding to the information at command for the district.

It is believed that the geographical outline and topography of the present map will be found, for the district it embraces, considerably in advance of any yet published, the acurate surveys of the Canadian Pacific Railway fixing certain points and lines from which running surveys have been carried by most of the travelled routes.

The geological outlines, while probably accurate enough where crossed by the lines of survey and examination, are necessarily, in extensive intervening regions, more or less conjectural, and while it is believed that the map gives a fair general representation of the distribution of such of the more important subdivisions of the rock series of the country, as it has been found possible to distinguish, it must be accepted in detail as a sketch only.

The pre-Cretaceous rocks may be regarded as a whole, as a contorted and metamorphosed series on which the Cretaceous and Tertiary rocks rest. It has been impossible with present information to satisfactorily define the Triassic areas, and while the general distribution of the highly metamorphic rocks of the Coast and Gold Ranges has been indicated by a difference of tint, this is not intended to imply of necessity a difference in age, from that of the less altered old rocks of the Interior Plateau. It is highly probable, however, that in the Gold Ranges areas of pre-Silurian crystalline rocks occur, the boundaries of which have not yet been traced.

GEORGE M. DAWSON.

Montreal, July, 1880.

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Alfred R. C. Selwyn, F.R.S., F.G.S. Director
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1877
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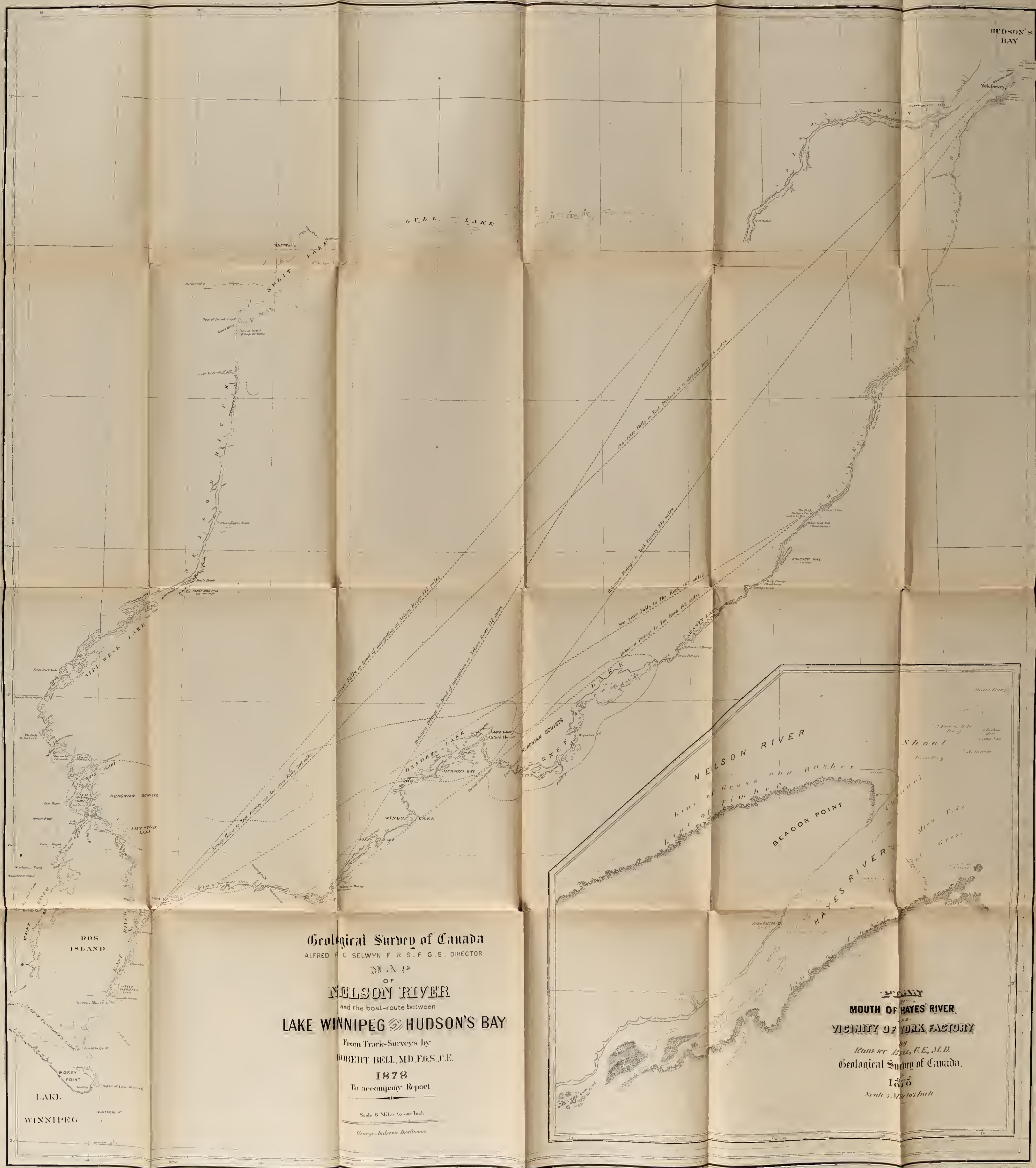
Geological Survey of Canada
ALFRED R. C. SELWYN F. R. S., F. G. S. DIRECTOR.
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and the boat-route between
LAKE WINNIPEG & HUDSON'S BAY
From Track-Surveys by
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PLAN
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KNEE LAKE
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WINDY LAKE
MOSSY POINT
LAKE WINNIPEG
ROS ISLAND
WEST RIVER
BEACON POINT
HAYES RIVER
Shoal
Sea river Falls to York Factory in a straight line
Robinson Portage to York Factory 234 miles
Sea river Falls to The Rock
Robinson Portage to The Rock 182 miles
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Geological Survey of Canada
A.R.C. SELWYN. F.R.S. DIRECTOR.
MAP
OF
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To accompany Dr. BELL'S Report for 1878.
Compiled from Surveys by
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DOMINION LANDS DEPT. From Drunken to Broken-Head River.
1878.
Scale 8 Miles to One Inch.
A. S. COCHRANE
DRAUGHTSMAN.
ROSS ISLAND
WEST RIVER
EAST RIVER
LIMESTONE BAY
LIMESTONE Pt.
GREAT PLAY GREEN LAKE
MOSSY POINT
MONTREAL Pt.
FIRST ROCKY Pt.
SECOND ROCKY Pt.
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Selkirk Island
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POPLAR Pt.
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FISHER BAY
THE DOG'S HEAD
THE BULL'S HEAD
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RED RIVER

Geological Survey of Canada
ALFRED R. C. SELWYN F.R.S. F.G.S. DIRECTOR.
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EAST COAST of HUDSON'S BAY
FROM A TRACK-SURVEY BY Dr R. BELL
To Accompany Report of Progress for
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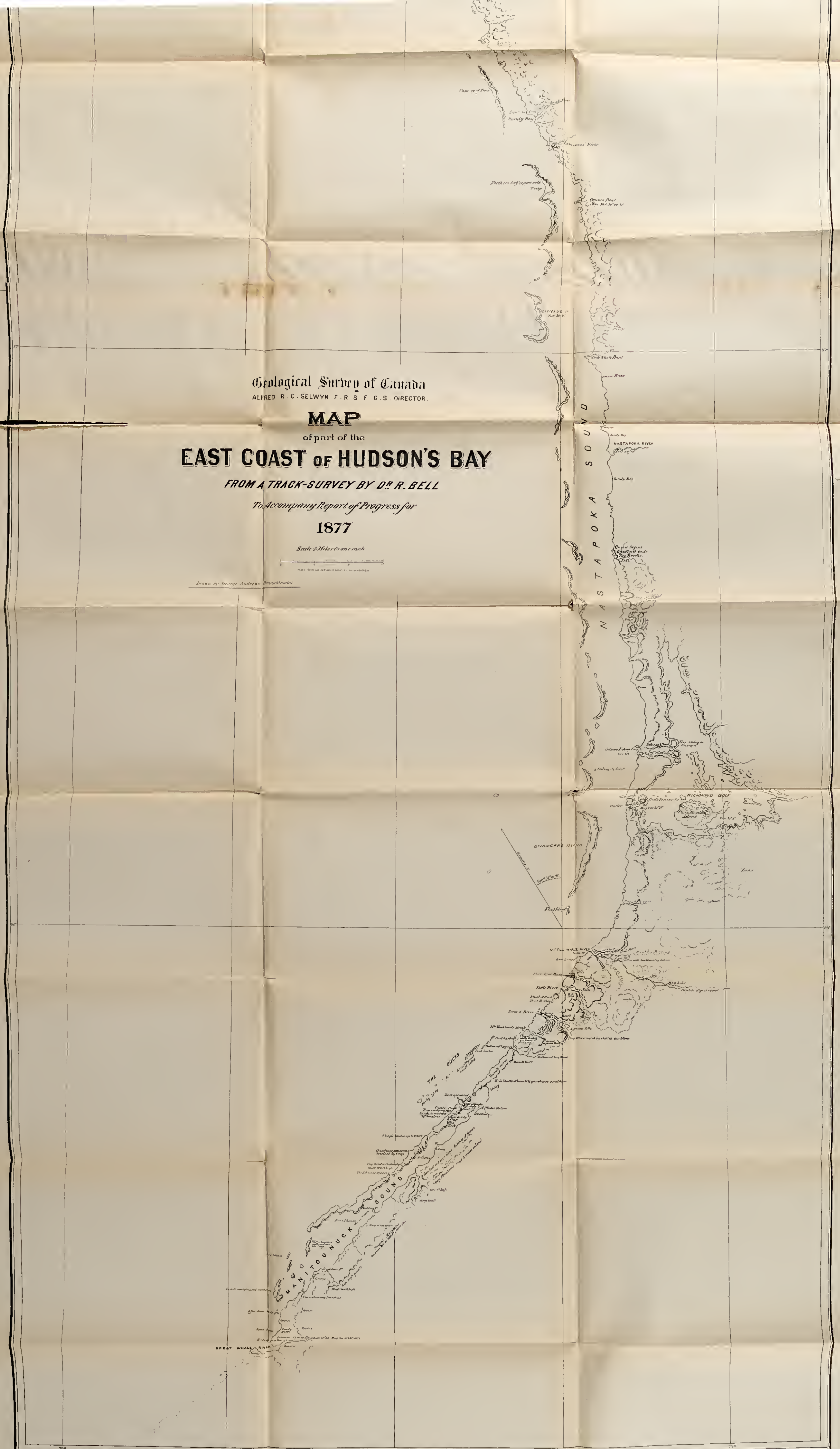
FIVE-MILE INLET
HOPEWELL SOUND
HOPEWELL POINT
LAND-LOCKED HARBOR
BELL'S HARBOR
NASTAPOKA SOUND
NASTAPOKA RIVER
Island about 30 miles off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of part of the
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1877
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NASTAPOKA RIVER
RICHMOND GULF
LITTLE WHALE RIVER
THE DUCKS
MANITOUNUCK SOUND
GREAT WHALE RIVER