SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY DEPARTMENT

OF

CANADA

FOR THE CALENDAR YEAR

1903

PRINTED BY ORDER OF PARLIAMENT

OTTAWA
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1904

To His Excellency the Right Honourable Sir Gilbert John Elliot, Earl of Minto, G.C.M.G., &c., &c., Governor General of Canada.

May it Please Your Excellency,—

The undersigned has the honour to lay before Your Excellency, in compliance with 3 Vic., Chap. 2, Section 6, the Summary Report of the Operations of the Geological Survey Department for the calendar year ending December 31, 1903.

Respectfully submitted.

CLIFFORD SIFTON,
Minister of the Interior.

January, 1904.

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SUMMARY REPORT

ON THE OPERATIONS OF

THE GEOLOGICAL SURVEY OF CANADA

FOR THE CALENDAR YEAR 1903.

The Honourable Clifford Sifton, M.P.,
Minister of the Interior,
Ottawa.

Sir,—I have the honour to submit the following Summary Report on the affairs of the Geological Survey Department for the calendar year 1903. It will be found to contain an account of all the operations carried on by the Department, both at head-quarters in Ottawa and in the field. As in previous years, it has been the constant aim of the Survey to meet the expectations and requirements of the public in conformity with the provisions of the Act governing the Department, and to give an economic and practical character to all its labours.

Principal work of the Survey.

The Survey carried on, as usual, a certain amount of palæontological, zoological, botanical, ethnological and archæological investigations, for all of which it enjoys, incidentally, considerable advantages which it is desirable to utilize in the interest of science; but by far the largest proportion of our work is directed to investigating and aiding the development of the mineral resources of the country. With this end in view, the field operations each year are spread over all the provinces and most of the territories of the Dominion, while the indoor work consists of chemical, mineralogical and lithological researches, drafting and mapmaking in all branches, preparing reports, bulletins on economic materials and other special publications, the keeping of accounts, collecting and tabulating statistics of mines and works in connection with mineral products of all kinds, the care of the library and the different branches of the museum and of our large stock of maps and field instruments, photography in connection with mapmaking, the artistic drawing of fossils, supplying collections of named minerals to educational institutions, the preparation and installing of collections of samples of the economic minerals and rocks of Canada

at exhibitions, sending out the reports, maps and other publications of the Survey, an extensive correspondence, attention to visitors on departmental business, etc. The editing and proof-reading of our publications occupies much of my time and that of the secretary, Mr. Percy Selwyn, who is very proficient in this work. Mr. Selwyn has also done good service in attending to the correspondence and other office duties during my absence in Europe and in the field.

Indispensable topographical work.

In the vast unsurveyed regions of Canada, which may be rich in economic minerals and therefore require investigation by the Survey, a certain amount of topographical work is indispensable in connection with the geological researches. The field-work of the Surveyor General of the Dominion and of the Commissioners of Crown Lands of the several provinces is mainly devoted to dividing up, by straight lines, the unoccupied lands best fitted for agriculture, and consequently, the least likely to be of value for economic minerals, and these officers have no object in causing surveys to be made of the more rocky and distant sections of the country. As it is in such regions that the work of the Geological Survey requires to be carried on, we are obliged to do the topographical work *pari passu* with the geological, in order to construct proper maps for the purposes of the Department. Therefore, the officers in charge of our field parties should be proficient surveyors as well as geologists.

The geological maps resulting from the combined topographical and geological field-work of the various members of the staff are plotted and compiled during the winter in the offices at Ottawa, by the same men who make the surveys, aided by the chief draftsman and several assistants.

Extraneous assistance.

During the season just closed, less help has been obtained from geologists outside of the Department than in the two previous years. Professor Ernest Haycock of Acadia College aided Dr. Ells in working out the geology of Charlotte county in New Brunswick. Mr. J. A. Dresser investigated the relations of copper ores to their enclosing rocks in the Eastern Townships of Quebec; Mr. G. A. Young has given us a report on the petrology of Yamaska mountain and Mr. Charles Camsell has contributed gratuitously some valuable information in regard to certain rocks and minerals in Manitoba. The fine geological map of the Pictou coal-field prepared in this office and which is nearly ready for publication by the Survey, is largely due to the labours of Mr. Henry S. Poole, extending through many years of practice as a mining engineer within the area represented. Mr. Poole has, with great liberality, given me, free of charge, except for some incidental

expenses, an able practical report on this coal-field to accompany the map. We are greatly indebted to Dr. F. D. Adams, Professor of Geology at McGill University, for a very valuable report on the artesian wells and underground waters of the Island of Montreal, which also contains additions to our previous knowledge of the geology of that island. This report is the result of a number of years' observation and collecting of information on the subject, and Dr. Adams has generously presented it for the use of the public, entirely free of charge. It is accompanied by carefully prepared tables of the 'logs' or records of borings and a geological map of the island and surrounding district. Dr. Adams was assisted in the field-work and in preparing the report by Mr. O. E. LeRoy, who was afterwards, for a time, connected with the Geological Survey.

FIELD WORK.

Field-work.

The field-work is, of course, the primary and most important of the duties assigned to the Geological Survey and all our other labours are consequent upon it. The various regions for the field operations of the season 1903 had been judiciously chosen as the results have shown. The several portions of work done have proved to be those most needed to meet present requirements. All the men sent to the field were competent to carry out their instructions and the aggregate of new information on geography, geology and a variety of other useful subjects has added greatly to our knowledge of Canada. Everyone employed was advised to exercise great care and as a consequence no misfortunes or 'accidents' of any kind occurred.

In the following brief review of the work accomplished the various regions exploited are arranged, as before, in order from northwest to southeast across the continent.

Yukon district.

In the Yukon district, Mr. R. G. McConnell, without a professional assistant, completed the work which was intended to be done for the present in the Klondike gold mining area. This consisted in tracing out the boundaries of the different rock-formations on the ground and laying them down upon a contoured topographical map which he had prepared in previous years, by the aid of Mr. Frank Johnson and Mr. Joseph Keele. Mr. McConnell, while performing his geological work in this district, also kept in view the desirability of establishing a water-supply for common use in placer mining in the future, and he has prepared an elaborate statement on the subject for the information of the commissioners who were appointed by the government last summer to investigate this matter. The maintenance of a large pro-

duction of gold in this district in years to come depends principally on obtaining a better supply of water than is procurable at present. Mr. McConnell's investigations afford further evidence of the local origin of the gold of the Klondike area.

Lardeau district, B.C.

Work was begun in the Lardeau district in southern British Columbia by Professor R. W. Brock as geologist, and Mr. W. H. Boyd as topographer. The latter is engaged in constructing a map of this region. Very little had heretofore been known of the geology which appears to be of considerable interest. Promising discoveries of gold in veins have been made in the district

Peace river country.

The demand for reliable information as to the Peace river country increased considerably last year. With a view of ascertaining the true character of the land and the climate of the upper or western portion of this region, I requested Mr. James Macoun to undertake an investigation of as much as possible of the Peace river country in general, and the upper portion in particular. He was also to verify, or otherwise, the reports and opinions of others who had preceded him. Accordingly, he started as early as the season would permit, and since his return, has written a report which will be issued as soon as possible, as a special publication of the Survey, and may not appear in the Annual Report for the year, nor in the present Summary Report. Mr. Macoun was assisted by Mr. William Spreadborough.

Coal-field in Rocky Mts., near C.P.Ry.

The growing demand for a supply of coal near the line of the Canadian Pacific railway in the Rocky mountains required this Department to make a geological survey of the region around this section of the line and for a considerable distance to the southward, for the purpose of ascertaining the nature, geological relations and extent of such coal seams as were already known and of discovering others. Mr. D. B. Dowling, who was instructed to undertake this work, examined into the geology of the mountains on either side of the railway from Banff Hot Springs to The Gap or on both sides of the Cascade and Bow rivers, and since his return he has commenced carving to scale a model of this section, which will show artistically in colours the geological structure and the relations of the various strata which include the coal

Sheep creek

seams. Mr. Dowling, according to instructions, also explored for coal about the head-waters of Sheep creek and this duty was carried out successfully. He was assisted throughout the season by Mr. Fred Bell of Winnipeg.

International boundary of B.C.

On the International boundary, which is being located along the 49th parallel in the western mountain region between British Columbia

and the State of Washington, Dr. R. A. Daly continued a geological examination on behalf of Canada. This work extended from the boundary, as a base, to an average distance of ten miles from it. His report will be found in the present volume.

Southern Keewatin.

To the southwest of Hudson bay, in the Severn district of the Hudson's Bay Company, which forms part of the vast tract now called Keewatin, there was, up to last year, a great unsurveyed area, through which the Wenisk river flows. I requested Mr. William McInnes to undertake a combined topographical and geological survey of this large stream. This he accomplished very successfully with the aid of four Indians, but without any white assistance, and returned to Ottawa early in the autumn. The accompanying complete and concise report, in which he gives very interesting information on all subjects relating to the country traversed, demonstrates what may be accomplished in a short season by a single competent officer with a small party of aborigines.

Nagagami river.

One of the canoe-routes from Lake Superior to the Albany river crosses the height-of-land a short distance northward of Montizambert on the Canadian Pacific railway and follows the Nagagami river to its junction with the Kenogami at Mamma-wé-mattawa (The meeting of many waters). Mr. W. J. Wilson of this Department was instructed to make an instrumental survey of this route; also of the lower portion of the Kaibinakagami river as far up as the point to which I had surveyed it downward in 1889, and of the Oo-sha-a-poo-ka-tick or Ridge river as far as it could be navigated by canoes. These two streams and also the Pagwitchewan fall into the Kenogami at the same place as the Nagagami. Mr. Wilson's party was also to survey the Drowning and Little Current rivers, which flow from the west and join the Kenogami between Mamma-wé-mattawa and The Forks of the Albany. Mr. Owen O'Sullivan acted as Mr. Wilson's assistant and these two gentlemen fully carried out my instructions, accomplishing all the work described. They have plotted their surveys and are compiling a map on which they will be shown, together with parts of my own surveys of 1870, '77, '86 and '87.

Other branches of Kenogami river.

Tract behind Bruce mines.

In the country behind the Bruce mines, Mr. Theo. Denis, who had assisted Mr. Ingall there in 1902, continued the work for part of the season, assisted by Mr. Uglow. On leaving this field Mr. Denis visited the salt wells and works near Windsor, Ontario, in order to obtain some necessary information and Mr. Uglow was sent to assist Dr. Hugh Ells in finishing the Prince Edward county map-sheet.

Temagami region.

For the purpose of continuing the geological mapping of the Temagami lake region, I instructed Dr. Barlow to proceed with the survey

of the map-sheet adjoining the Temiskaming sheet, (No. 599) on the west, in which the geology would no doubt prove of much interest and where deposits of valuable minerals might reasonably be expected to exist.

Prince Edward county.

The Prince Edward county map-sheet (No. 110), most of which had been worked out by Dr. R. W. Ells, still required certain areas to be completed in Prince Edward and Hastings counties and Dr. Hugh Ells, who had previously assisted in the surveys for this sheet, was requested to do the necessary work for this purpose.

Surface geology in Quebec.

The Surface geology of the province of Quebec on both sides of the St. Lawrence between Quebec city and Montreal was not sufficiently well known and Dr. Chalmers was instructed to examine this region and collect all the information possible on this branch of its geology and also in regard to artesian borings within the same limits. He performed this duty without any assistant and his report shows that a large amount of work was accomplished.

Yamaska mountain.

The investigation of the geology and petrology of the various isolated hills of volcanic origin which stand out prominently on the level plains of the southern part of Quebec has been making progress for a number of years through the labours of several geologists. A description by Dr. J. A. Dresser of Shefford and Brome mountains was published in the Summary Report for 1901. During the past season Mr. G. A. Young was carrying on an examination of Yamaska mountain and in exchange for some aid extended to him, he has given us the short report on this mountain which is published herewith.

Copper in the Eastern Townships.

The exact mode of occurrence of the copper ores of the Eastern Townships in relation to the containing rocks, being a question of considerable economic importance in the practical geology of that region, Dr. J. A, Dresser has been engaged during the last two seasons in investigating this subject. His report, illustrated by a map, shows that the copper is confined to certain ancient volcanics to which prospecting should be confined.

New Brunswick.

Our knowledge of the geology of Charlotte county, New Brunswick, left much to be desired. Accordingly, I requested Dr. Ells to supplement it by further examination, in order to determine more certainly the boundaries of the formations and the geological ages of some of the rocks. He was assisted by Mr. R. A. A. Johnston, of this department, and Professor Ernest Haycock, of Acadia College. Dr. Ells returned before the end of the season in order to re-examine some parts of the mica, graphite and phosphate regions, before preparing bulletins for publication on these economic minerals. Messrs. Johnston

and Haycock continued the work in New Brunswick till the close of the season.

Northern Nova Scotia.

The systematic detailed geological survey was continued in the northern part of the mainland of Nova Scotia by Mr. Hugh Fletcher and two assistants. The work of the season was confined principally to Annapolis, Kings and Cumberland counties. Mr. Fletcher also aided in the completion of Mr. H. S. Poole's report and map of the Pictou coal-field which are now ready for publication. Mr. Fletcher's geological researches connected with mapping and describing the geology of Nova Scotia have now extended over twenty-eight years, most of this time having been devoted to working out the structure of the various coal-fields. His work is highly appreciated by the coal-mining community and by every miner and practical geologist in the province, all of whom have the utmost confidence in the results he has arrived at, as set forth in his reports and the numerous maps which have been constructed by him from his own surveys.

Gold in Nova Scotia.

In connection with the large output of coal which is now going on in both Nova Scotia and Vancouver island, an interesting fact is worth mentioning, namely, that the only coal which is known to occur in North America on the immediate seaboard of either the Atlantic or Pacific, belongs to Canada.

The nature and arrangement of the gold-bearing veins of Nova Scotia have been further investigated by Mr. E. R. Faribault and two assistants. During the twenty years Mr. Faribault has been engaged in this work, he has produced twenty-four plans of the gold districts of the province, of which eighteen have been already published, three are ready for publication and the remaining three are in the engraver's hands. Mr. Faribault has also published numerous reports and papers on gold veins and gold mining and milling in Nova Scotia. He appears to have arrived at correct general conclusions as to the gold veins of the province and is now preparing a concise bulletin on the subject. He has just been invited by the government of the province to go to Halifax and advise it in regard to the pending legislation for the encouragement of deep mining for gold. His work has already been of great value in developing the gold resources of Nova Scotia by giving the mining of this metal a permanent character, due to a knowledge of the true nature of the veins and the assurance of a continued supply of ore.

Hudson Bay expedition.

Mr. A. P. Low of this Department was placed in command of the Hudson Bay Expedition in the SS. *Neptune*, which was commissioned to visit the shores of Hudson bay and strait and our islands lying to

the northward of the mainland of Canada on behalf of the Departments of the Geological Survey, Marine and Fisheries and Customs. Commander Low sailed from Halifax on the 22nd of August, with a total ship's company of 43. Besides having general charge of the expedition, he was instructed to make geological notes, especially with regard to any occurrences of economic minerals at all places which had not previously been visited by a geologist and more particularly at localities which could only be reached by a sea-going vessel. He was also to make surveys, if possible, during the winter, using the ship as a base of operations, and in summer in addition to other duties he was to investigate the fisheries and do whatever work he could in natural history and botany. Mr. C. F. King, of the Geological Survey, was sent as Commander Low's assistant for geology and biology. It was expected that the expedition would spend the winter in the northwestern part of Hudson bay. Interesting and important geological information will no doubt result from this expedition.

ROCK-SLIDE AT FRANK.

Rock-slide at Frank.

On the 29th of April a rock-slide of considerable magnitude took place from the face of the mountain overlooking the town of Frank, where the southern line of the Canadian Pacific railway enters the Crows Nest Pass through the Rocky mountains. The first telegraphic news of the disaster which reached Ottawa described it as a "volcanic eruption," but those who inquired as to its nature at the office of the Survey were immediately informed that this was exceedingly unlikely and indeed almost impossible. I telegraphed to Mr. W. W. Leach, who had worked in this locality for the Survey the previous season and who was then in the vicinity, asking him to telegraph me a sufficiently full description of the phenomenon. He complied with my request, and his description was immediately placed at the disposal of the press and printed in the leading newspapers.

CLAY-SLIDE ON LIÈVRE RIVER.

Clay-slide on Lièvre river.

A land-slide in the clay of the valley of the Lièvre river having taken place at Little Rapids on the morning of Sunday, 11th October, Drs. Ells and Barlow were requested to examine it as soon as possible after its occurrence, as phenomena of this kind are of some scientific and practical importance. Dr. Ells' report on what they saw is illustrated by a sketch-map and a photographic view of the ground that was affected.

AMYGDALOID IN MANITOBA.

Amygdaloid in Manitoba.

Reference has been made to the discovery of amygdaloid rock in Manitoba by Mr. Charles Camsell. As to this subject, Mr. Camsell wrote me on the 28th of November as follows :—

'With regard to the occurrence of amygdaloid at the north end of Lake Manitoba, the beds are not very extensive and are easily covered by a claim of 1,500 feet square. Smaller areas occur to the south-east and north-west. They rise about ten feet above the general level of the plain to the east, which is low and swampy ; while on the west they seem to dip under almost horizontal beds of gypsum. The amygdaloid also seems to be nearly horizontal. The dip, if any, is towards the west. The colour is usually reddish, but sometimes it is a dark purple. The cavities near the surface are nearly always empty and lined with a coating of a white substance. Occasionally they are filled with a greenish earth or with crystals of zeolites. Small particles of copper can be seen with the microscope and some copper carbonate.

'Small areas of a jasper conglomerate are associated with the amygdaloid but their relative position is uncertain.

'About seven miles to the south-east, on Sugar island in Lake St. Martin is an outcrop of crystalline trap rock, which Mr. J. B. Tyrrell describes, and which, from his assay, contains some copper, and this rock probably has some connection with the amygdaloid. East of this are small areas of coarse-grained granite surrounded by limestone.

DISCOVERY OF SILVER AND COBALT.

Discovery of silver and cobalt.

Late in the autumn, a discovery of silver and cobalt, which appears to be important, was made by men working on the line of the Temiscaming railway at Long lake, about five miles southward of Haileybury on the west shore of Temiscaming lake. The metals occur in veins, the silver, both native and as sulphide. The locality was visited by Professor W. G. Miller, Provincial Geologist of Ontario, just before it became covered by snow, and he considers the discovery to be one of much promise. The veins cut slatey rocks, apparenty belonging to the Animikie or lower Cambrian series which carries the silver ores of the Thunder Bay region. These rocks are reported to have been found also further north, around the base of the outlier of the Niagara formation which extends north-westerly from the head of the lake. If this should prove correct, there would be a prospect of finding other silver-bearing veins in this region, wherever these rocks occur.

WORK AT HEADQUARTERS.

Work at headquarters.

In the present summary of the work done by the various officers of the Department will also be found reports on that performed by the different indoor or home members of the staff, namely, as to Chemistry and Mineralogy by Dr. G. C. Hoffmann, the Mines Section by Mr. E. D. Ingall, Mapping and Engraving by Mr. C. O. Senecal, Palæontology and Zoology by Dr. J. F. Whiteaves, Vertebrate Palæontology by Mr. Lawrence M. Lambe, Botany and Ornithology by Professor John Macoun and the Library by Dr. John Thorburn.

The reports, as to both the field and home work are printed as they were written by the various officers themselves, in order that they may thus obtain full credit for their labours.

In the chemical laboratory.

The usual amount of work has been done in the chemical laboratory in connection with the examination of economic minerals collected by the officers of the staff or brought or sent in by others, but owing to the establishment of good laboratories in connection with the mining bureaus of the different provinces, the amount of assaying which we are requested to do for prospectors is limited. Mr. Donald Locke, who had been appointed to do work of this kind, resigned on the 14th of September and Mr. M. F. Connor was appointed to succeed him.

Mining statistics.

As in former years the mining section of the Department is preparing a preliminary statistical statement of the mineral production and the condition of the different branches of mining in Canada for 1903. The final details are only received from our correspondents after the close of the year and it is generally about the middle of February before the statement can be issued. This section has prepared its full report for 1902, which will be published in the course of a month or two. Besides a large amount of statistical tabulation, it contains chapters giving general information as to different economic minerals in relation to the Dominion. From this report it will be seen that Canada now produces a considerable variety of both metallic and non-metallic minerals, although it is within the recollection of many, that in the territory which now constitutes the Dominion, coal, building materials and a little iron ore were the only mineral products. At the time when the Geological Survey commenced active operations in 1843, a number of other economic minerals were known to exist, but only in small quantities. Since that time, and largely owing to the operations of the Survey and the information afforded by its reports, its museum and its showing of fine specimens of minerals at exhibitions at home and abroad, other economic minerals have been discovered in commercial quantities and more or less developed in about the follow-

Principal economic minerals of Canada.

ing order, historically : copper, coal and iron in larger quantities, lead, petroleum and natural gas, gold, iron-pyrites, gypsum, slate, cement stones, salt, mica, graphite, apatite, silver, asbestus, feldspar, nickel, zinc, corundum, chromic iron and cobalt. In addition to these, a considerable variety of marbles, granites and other ornamental rocks, gems and semi-precious stones, peat, shell-marl, ochres and other materials used as paints have been discovered in many places.

The following minerals, mentioned in alphabetical order, are those which were most frequently inquired for during the year :

Minerals enquired for during the year.

Asbestus, borax, baryte, celestite, corundum, copper ores, chromic iron, feldspar, fire-clay, fluorspar, graphite, gypsum, iron-pyrites, iron sand, kaolin, monazite, magnesite, molybdenite, natural gas, peat, pottery clay, phosphate, soapstone, silica sand, talc, vanadium, wolfram, zinc ores.

Palæontology.

In the Department of Palæontology, the reports of Dr. Whiteaves and Mr. Lawrence M. Lambe show gratifying progress. The latter has completed for publication a work on *vertebrate* fossils from the Northwest Territories, entitled 'Contributions to Canadian Palæontology,' Vol. III., (Quarto) Part II., illustrated by eight fine plates prepared by himself, which it is intended to reproduce by the Heliotype process in the same manner as the plates in his last volume on a similar subject. Professor Penhallow's paper on *Osmundites*, which was contributed to by this Department, was published during the year in Vol. XXI of the Transactions of the Royal Society of Canada.

Zoology.

The zoological work of the year has related principally to Ornithology. Dr. Whiteaves has added a number of sets of rare eggs to the collection of the eggs of Canadian birds already in the museum. Our large collection of bird-skins has been enriched by numerous additions. Professor Macoun has nearly completed his third and last volume on Canadian Birds and this important book is eagerly awaited by ornithologists all over the continent.

Botany.

In the Botanical Division, Professor Macoun's work was confined to the lower Ottawa valley and was devoted largely to the Fungi, of which he has now found no fewer than 1,100 species in this part of Canada. The 10 new species of violets of Prince Edward Island, discovered mostly by Mr. Lawrence W. Watson when employed by the Survey, have been described by Professor Green of Washington and figured by Dr. Theo. Holm of the same city. It is proposed to publish these descriptions and figures within a short time. The descriptions and figures of the ten new species of plants from Hudson bay are also ready for publication.

REPORTS, BULLETINS, SPECIAL PUBLICATIONS, ETC., WHICH HAVE BEEN ISSUED BY THE SURVEY DURING 1903.

Publications of the department in 1903.

Summary Report of the Geological Survey for the calendar year 1902, pp. 482, with 7 sections, 2 plates and 9 maps.

Part A, Vol. XV., with 9 maps, plates and sections by the geological corps.

Report on the Geology and Physical Characters of the Nastapoka Islands, Hudson Bay, Part DD, Vol. XIII., pp. 31, by A. P. Low.

Report on the Section of Chemistry and Mineralogy, Part R., Vol. XIII., pp. 67, by G. C. Hoffmann.

Section of Mines, Annual Report for 1901, Part S, Vol. XIV., pp. 160, by E. D. Ingall and J. McLeish.

Annual Report, Vol. XIII. (new series) 1900, English edition, pp. 747, with plates and maps.

Report on the Cambrian Rocks of Cape Breton, pp. 246 and 18 plates, by G. F. Matthew.

Catalogue of Canadian Birds, Part II, pp. 413, by John Macoun.

Mesozoic Fossils, Vol. I, Part V.. (and last). On some additional fossils from the Vancouver Cretaceous, with a revised list of the species therefrom. Illustrated by 12 plates, by J. F. Whiteaves.

Publications in two years.

Since January 1st, 1902, the Geological Survey Department has published 26 reports, which embrace the following subjects, viz. :— Geology and Geological Surveys, Palæontology, Botany, Zoology, Chemistry and Mineralogy, Mining and Metallurgy, &c. Within the same period the Department has also published 38 maps, both geological and topographical, besides 15 diagrams.

Maps.

The number of geological maps published within the calendar year 1903 was 27 and of diagrams, 15.

The 38 maps, above mentioned, are all of a superior character, both as to accuracy in what they represent and as to drawing and engraving. As mentioned in the report of the Geographer of the Department, in addition to the above, a considerable number of maps, some of them quite elaborate, are in various stages of preparation, and four of them are nearly complete. No map is engraved for the Department until sufficient field-work has been done to secure accuracy, and each new map must give enough fresh information to justify the expense of publication. In the colour-printing of geological maps, we have

Colour-printing.

greatly facilitated and cheapened the process for the production of any desired number of tints with a minimum of printings, by adopting a variety of patterns of parallel ruling in four directions and by over-printing these with different colours in various ways, after the manner of the 'three-colour system.'

PUBLICATIONS BY THE GEOLOGICAL SURVEY ON ECONOMIC MINERALS.

Publications on ecomic minerals.

The leading feature in the work of the Geological Survey throughout its whole history has been the attention paid to mining and economic minerals. The publications of the Department devoted to this subject aggregate more than 600, besides about 400 maps. These are in the form of Reports of Progress, Annual Reports, Summary Reports, Special Reports on individual minerals, on coal-fields and other mining districts, on the Mineral Wealth of British Columbia and the Mineral Resources of the province of Quebec, Bulletins on Economic Minerals, Handbooks on the same subject for use at exhibitions, full Descriptive Catalogues for the same purpose, etc., published throughout the whole existence of the Survey. A brief enumeration of these publications is given further on in the present report. In addition to issuing the various reports, etc., mentioned in this list, the principal officers of the Department have always endeavoured to keep the mineral wealth of Canada before the world by means of articles read before societies, institutes, associations, etc., or published in the scientific and technical journals, magazines and papers or in the Transactions or Proceedings of these bodies. The number of such articles has now reached more than 100, while the total number of the official publications of the Survey on economic geology, classified as above is over 600, as just stated.

Value of exhibitions.

Another chief means adopted by the Survey for bringing the mineral resources of Canada before the people of all nations, was by making fine displays of our mineral products at the numerous International Exhibitions which have been held, beginning with that of 1851, in England, Scotland, Ireland, on the continent of Europe and in different cities in the United States of America, at the Indian and Colonial Exhibition and at exhibitions held in Canada itself. At every one of these exhibitions, which were more or less competitive, it may be truly said that the Canadian exhibit was in every way the best. Our collections were always accompanied by Descriptive Catalogues for free distribution which were themselves precise and excellent reports on the minerals of Canada. These valuable collections were on several occasions left for permanent exhibition in the cities to which they had been sent. Although special grants may have been made to

help to defray the cost of collecting, transporting, installing and exhibiting these collections, still they were always a considerable cost to the Survey, both in money and the time of its officers. It is, therefore, marvellous that such great services could have been rendered the country at such a small cost, by the above-mentioned liberal publication, by striking displays of our economic minerals at so many International Exhibitions and in the Museum at headquarters, all simultaneously with the vigorous prosecution of the examinations of mining districts and of general geological and topographical surveying over half a continent, for the most part lying in a state of nature. The comparatively rapid progress which has been made, in spite of artificial hindrances, in the development of our mineral resources, now yielding upwards of $60,000,000 a year, is due to the above efforts more than to any other cause.

Promotion of development of mineral resources.

The reports of the Survey, having always been devoted mainly to economic geology, it was not considered necessary in the past to publish many separate reports on economic minerals, but as unavoidable delays are apt to occur in the issuing of our Annual Reports, which have now become large volumes requiring maps and other illustrations, it was decided to issue, at more frequent intervals, a part of the information formerly given in these or in other reports, in the form of separate publications, under the name of Bulletins on individual minerals, mining districts, &c., as they might be required from time to time, in order to keep the information thereon as to the whole Dominion constantly up to date.

Publications on economics.

Bulletins.

During the past year, bulletins of this kinds have been completed or are being prepared on the following subjects :—

Platinum ; printed.
Zinc ; printed.
Manganese ; in press.
Molybdenum and Tungsten ; ready for press.
Nickel ; in preparation.
Asbestus ; printed.
Coal ; in press.
Common Salt ; in press.
Infusorial Earth ; in press.
Corundum ; in preparation.
Pigments ; in preparation.
Shell Marl ; printed.
Mica ; ready for press.
Graphite " "
Apatite " "
Peat " "
Geology of the Klondike Gold District ; in preparation.
Roofing slates ; "
Gold in Nova Scotia. "

Besides the above nineteen bulletins, the data are being assembled for others on the following subjects, also in reference to the whole Dominion : copper, iron, building stones, marbles, gypsum, iron-pyrites, stones suitable for making hydraulic cement, clays, bricks, tiles

and pottery, abrasives (other than corundum), petroleum and natural gas, gems, ornamental and semi-precious stones.

DOMINION OF CANADA INDUSTRIAL EXHIBITION.

Dominion exhibition, Toronto.

The manager and secretary of the Dominion of Canada Exhibition, Dr. J. O. Orr, having consulted me in regard to the possibility of having the economic minerals of the country properly represented at that exhibition, which was to be held in Toronto from the 27th of August to the 12th of September, I referred the matter to yourself and the Hon. Mr. Fisher, as everything pertaining to exhibitions had been transferred to the Department of Agriculture at the close of the Paris International Exposition of 1900. In this case, however, it was decided that the Geological Survey should make a suitable display at Toronto. This conclusion was reached barely four weeks before the collection required to be installed in the exhibition building. Mr. C. W. Willimott was asked to superintend the work, and the whole matter was very successfully carried out.

Character of mineral exhibit.

Our large and representative collection proved to be one of the most interesting features of the Exhibition and attracted great attention, not only from the Canadian visitors, but it was also very favourably commented upon by distinguished strangers from Europe and the United States. There is no doubt it did much good in calling attention to the great mineral wealth of Canada. It was awarded a diploma and gold medal. After the close of the Exhibition, the manager and secretary sent me the following letter :—

Letter from the manager.

'DOMINION OF CANADA INDUSTRIAL EXHIBITION,
TORONTO, Oct. 22, 1903

'DR. ROBERT BELL,
Geo. Survey Department,
Ottawa, Ont.

'MY DEAR DR.,—I have to thank you on behalf of the Board of Directors of the Association for the magnificent exhibit which you sent to our Exhibition. We located it adjoining the display of the Jubilee Presents. Every one was loud in their praises, and expressed their astonishment that we possessed such rich and valuable minerals.

'We cannot express too highly our appreciation to Mr. Willimott, for his devoted attention to the exhibit at our Exhibition. His arrangement of the exhibit was all that could be desired, and the information given by him to the inquiring public was greatly appreciated. Without a doubt the exhibit was a feature of the Exhibition, and the Jury on awards have awarded the Exhibit a Gold Medal and Diploma.

'I am writing the Hon. Mr. Fisher informing him of the award, as well as expressing to him our appreciation of the Exhibit.'

'Yours very truly,

'(Sgd.) J. O. ORR,
'*Manager and Secretary.*'

OTHER MATTERS.

St. Louis Exhibition.

The display of the economic minerals of the Dominion at the International Exhibition to be held at St. Louis, U.S., in 1904, in commemoration of the purchase of Louisiana by the United States, is being attended to by the Department of Agriculture. Mr. R. L. Broadbent of the Geological Survey has been attached to that department in order to collect, install and look after this part of the Canadian exhibit.

Educational collections.

The distribution of minerals and rocks to educational institutions in all parts of the Dominion has been continued this year, and the collections enumerated in Dr. Hoffmann's report, herewith have been placed where they will be of great service to students. A considerable stock of material for these collections was obtained from the best localities known by Mr. C. W. Willimott during the summer. The details of this work are given in Dr. Hoffmann's report in the present volume.

Committee on geological nomenclature.

The International Committee on geological nomenclature, composed of two members of this Survey and two from the Geological Survey of the United States, and which was referred to in the last Summary Report, held a meeting in St. Louis, Mo., in December, at which all the members, namely, Professor Van Hise and Dr. Hayes for the United States and Dr. Robert Bell and Dr. F. D. Adams for Canada, attended, and it was arranged to do some joint field-work the coming summer, in order, if possible, to agree upon certain facts as preliminary to other work.

Proposed permanent exhibit in New York.

As much of the capital for the development of the mineral wealth of Canada has heretofore come from the city of New York, and as it would be very desirable to encourage further interest in our mines from this quarter, it may be advisable, considering the small cost that would be incurred, to place a collection of our economic minerals on permanent exhibition in that city. Looking forward to the possibility of this, I conferred with Professor Bickmore of the American Museum of Natural History on the subject, and found that he was very favourably disposed to assist in this proposal. If the matter be followed up, it may result in the establishment of a valuable agency there at a very

trifling cost. A similar collection is already installed at the Imperial Institute in London under the care of Professor Dunstan, Director, and Mr. Harrison Watson, Canadian Agent.

UTILIZATION OF LOW-GRADE PHOSPHATE ROCK.

Low-grade phosphate rock.

Dr. Wilhelm Palmer of Stockholm, Sweden, has just patented in Canada a process for the extraction of a soluble phosphate of lime from apatite-bearing rocks of low grade, which, at ordinary prices, it would not pay to dress mechanically to such a percentage as would render them profitable to export for the manufacture of fertilizers. According to the description of this process, by means of the electrolysis of chlorate of sodium, a fresh solution of chloric or perchloric acid is obtained at the anode and of hydrate of sodium at the cathode. In a separate vessel, the apatite of the low-grade phosphatic rock, in a state of powder, is dissolved out by the chloric acid thus obtained and then precipitated by the sodium hydrate. It is claimed that the chloric acid can be recovered and used in subsequent treatments of the powdered rock. If this process can be carried on at a sufficiently low cost, it may possess promising possibilites, especially when the price of phosphatic fertilizers is higher than at present.

THE INTERNATIONAL GEOLOGICAL CONGRESS.

International Geological Congress.

Early in March, 1903, a request was received from the secretary of the organization committee of the International Geological Congress, requesting an invitation from Canada to hold the tenth triennial Congress in 1906 in this country. After due consideration, the Hon. the Minister of the Interior obtained the consent of parliament for a grant of $25,000 towards meeting the expenses of holding the congress in Ottawa, and I was deputed by him, on behalf of the government and also as the representative of the Royal Society of Canada, to proceed to Vienna, where the ninth Congress was to be held, in order to personally extend to it Canada's invitation. This decision had been reached only in time to allow me to arrive in Vienna at the opening of the session on the 20th of August. About the same time that the above request had been forwarded to Canada, the secretary had sent to Mexico a similar request for an invitation from that country. It was not before my arrival at Vienna that I ascertained that the government of Mexico had immediately on receipt of the secretary's letter telegraphed the desired invitation and had at once sent an agent to Europe to canvas for its acceptance by the congress during the five months preceding the meeting. On the question of a choice being put to the congress, it

was found that there was a large majority in favour of going to Mexico for the meeting of 1906.

LIST OF PUBLICATIONS ON ECONOMIC MINERALS BY THE GEOLOGICAL SURVEY OF CANADA.

Publications on economics.

The following is a list of the principal publications bearing on Economic Minerals and Mining Districts in Canada, issued by the Geological Survey. The list comprises the subjects which have been rather fully written up or which have been the object of special investigation by the various officers of the Department. This does not by any means represent the total amount of information of a direct commercial character contained in the Reports of the Survey. Scattered through the various reports are numerous references, often important, to mineral occurrences, ores, mines, &c. Such references of this kind as appeared in the reports published previous to 1885 are entered in the "Index to Reports, 1863-1884," while each of the volumes of the New Series of Reports since 1885 contains its own index.

Reports of chemical section.

Besides these the regular annual reports of the Chemical Section are in their nature most largely economic, and of these 12 have been published since the "Geology of Canada, 1863," was issued and some 8 reports previous to that volume. The annual reports of the Mines Section of the Survey, give not only a statistical presentment of the mineral industries of Canada, but special articles are also embodied each year, giving in condensed form descriptions of Canada's economic mineral districts and resources. Of these, 16 have been issued since 1887, when this branch was inaugurated.

In addition to the above publications, there are perhaps an equal number of the Geological reports of districts mapped in the usual course of the Survey work which include information about important groups of economic mineral deposits and mining districts.

Of the maps issued, at least 100 cover specific mining districts.

Enumeration.

To sum up—the publications of the Survey on economic subjects are as follow :—

Special economic publications	75
Chemical Section Reports	20
Mines Section Reports	16
General Geological Reports, which include descriptions of mining districts, occurrences of economic minerals, &c., about	126

Bulletins prepared, in course of preparation and published to January, 1904.	18
Maps covering mining districts, about	100
Maps, geological, but of economic interest, about	250
	605

In all about 605 publications of direct economic interest may therefore be obtained from the Geological Survey.

CANADA. (GENERAL.)

No. in the List of Publications. — Canada in general.

Apatite.

126 On Canadian Apatite.—Hoffmann. Rep. of Prog., 1877–8. (14 pp.)

Reprint. Report on the Canadian phosphates considered with reference to their application to agriculture.—Brome, G., 1870. (23 pp.)

Iron ores.

96 Notes on the iron ores of Canada and their development.—Harrington. Report of Prog., 1873–4. (70 pp.)

Marl.

Reprint. Marl deposits in Ontario, Quebec, New Brunswick and Nova Scotia.—Ells, 1902. (10 pp.)

Petroleum.

63 On the Geology of Petroleum.—Hunt. Rep. of Prog., 1863–6. (30 pp.)

Salt.

63 Geology of salt deposits.—Hunt. Rep. of Prog., 1863–6. (18 pp.)

General Reports.

50 Geology of Canada.—Economic Geology and Mining prior to 1863.

167 Report of observations on some mines and minerals in Ontario, Quebec and Nova Scotia.—Willimott, Rep. of Prog., 1882–4. (28 pp.)

221 Observations on Mining Laws and Mining in Canada with suggestions for the better development of the mineral resources of the Dominion.—Coste. Vol. 1. (N.S.) Part K. (15 pp.)

Mineral statistics and mines.

* Mineral Statistics and Mines.—Annual Report of the Section of Mines of the Geological Survey of Canada, 1886 to 1902.

List of Publications Number.			List of Publications Number.		
245	Report for	1886	602	Report for	1895
272	"	1887	625	"	1896
300	"	1888	662	"	1897
301	"	1889	698	"	1898
334	"	1890	718	"	1899
335	"	1891	744	"	1900
360	"	1892	800	"	1901
572	"	1893–4	836	"	1902

Descriptive catalogue.

Descriptive catalogues of economic minerals displayed at International exhibitions. These contain descriptions of economic minerals, deposits, quantities, utilization, values, &c.

394 Paris Exhibition, 1855.

398 London International Exhibition, 1862.

402 Paris Mineral Exhibition, 1867.

405 Philadelphia International Exhibition, 1876.

406 Paris International Exhibition, 1878.

409 Colonial and Indian Exhibition, London, 1886.

413 Chicago World's Columbian Exhibition, 1893.

693 Paris Exhibition, 1900.

Handbooks, descriptive of Canada's Mineral resources; prepared for the following exhibitions, Paris, 1900; Glasgow, 1901; Cork, 1902; Wolverhampton, 1902.

Records of mines.

86 Records of Mines and Mineral Statistics. Compilation by Charles Robb, of results of statistics, &c., collected by R. Bell and E. Hartley, 1873.

* The Annual Reports of the Section of Mines present yearly statistics (figures of production, imports and exports) and the state of the Canadian Mining Industry, as well as a large amount of technological matter relating to mining, descriptions of mines, development of mineral deposits, &c. From time to time, special articles on various mineral subjects of economic interest have been written by the officers of the Section and other members of the Geological Survey staff, as the result of personal investigation and of compilation of data from reliable sources. A list of the subjects thus written up more or less fully in the Reports of the Mines Section will be found on page 14.

Trans. Roy. Soc. Canada.—The Huronian System of Canada. Vol. V., Sect. 4, 1888.—R. Bell.

Canadian Naturalist and Geologist.—Roofing slate as a source of wealth in Canada. Vol. III, 1863.—R. Bell.

Proceedings Canadian Inst.—The Mode of Occurrence of Apatite in Canada, Ser. III, Vol. III, 1884–5.—R. Bell.

Fourteen annual reviews of the progress of mining in Canada, from 1863 to 1877, published in Monetary Times, Montreal; Engineering and Mining Journal, New York; Mining Journal, London; reports of Trade and Commerce of Montreal.—R. Bell. Mining reviews.

Sketch of the Geology of the Provinces of Ontario and Quebec. Walling's Atlas and Gazetteer of Canada, 1875.—R. Bell.

Nova Scotia. Nova Scotia.

Coal.

69 Reports on parts of Pictou coal-field, with appendix on coals and iron ores.—Hartley and Logan, 1870. (186 pp.)

89 On the coal mines of Eastern or Sidney coal-field.—Robb, C. Rep. of Prog., 1872–3. (52 pp.)

101 Report of explorations and surveys in Cape Breton, with especial reference to coal areas.—Robb, C. Rep. of Prog., 1874–5. (100 pp.)

685 Descriptive note of the Sidney coal-field.—Fletcher, 1900. (16 pp.)

94 On the exploration and survey of the Springhill coal-field. Cumberland County.—Barlow, S. Rep. of Prog., 1873–4. (13 pp.)

94 On a portion of the coal-field of Cumberland County.—McOuat. Rep. of Prog., 1873–4. (6 pp.)

817 Coal of Cumberland County, with map of Springhill colliery.—H. Fletcher. Summary Rep., Geol. Survey, 1902.

Gold.

407 Report on the gold region of Nova Scotia.—Sterry Hunt. 1868. (48 pp.)

7 Reports on the Nova Scotia gold fields. Summary Reports 1888–1903. Numbers on list of publications: 259, 293 320, 323, 353, 355, 553, 583, 614, 644, 674, 691, 717, 762, 807.

Iron Ores.

89 On the Acadia iron ore deposits of Londonderry, Colchester County.—Selwyn. Rep. of Prog., 1872–3. (12 pp.)

Reports on economics.

69 Iron ores and coals of Pictou coal field. Appendix to the the report on part of Pictou coal field.—Hartley and Logan, 1870.

General.

243 Economic minerals of the counties of Guysboro', Antigonish, Pictou, Colchester and Halifax.—Fletcher and Faribault. Vol. II. (N.S.) Part P. (16 pp.)

331 Economic minerals in counties of Pictou and Colchester.—Fletcher. Vol. V. (N.S.) Part P. (23 pp.)

628 Economic minerals in south-west Nova Scotia.—Bailey. Vol. IX., Part M. (20 pp.)

816 Geology of Prince Edward Island, with reference to proposed boring for coal.—Ells. Summary Geol. Survey, 1902.

New Brunswick.

New Brunswick.

Albertite.

114 Composition of albertite as compared with coal and asphalt, and report on Albert and Westmoreland Counties.—Bailey and Ells. Rep. of Prog., 1876–7. (14 pp.)

816 The Albert shales deposits.—Ells. Summary Report, 1902. (7 pp.)

Coal.

803 The coal prospects of New Brunswick.—Poole, H. S. Vo XIII., Part MM.

Iron Ores.

101 On the iron ore deposits of Carleton County.—Ells. Rep. of Prog., 1874–5. (7 pp.)

General.

661 The mineral resources of New Brunswick.—Bailey. Vol. X, Part M. (128 pp.)

QUEBEC AND LABRADOR. Quebec and Labrador.

Apatite.

167 Report on the Apatite deposits of Ottawa County.—Torrance, J. F.—Rep. of Prog., 1882–4. (32 pp.)

126 On Canadian Apatite.—Hoffmann. Rep. of Prog., 1877–8. (14 pp.)

94 Notes on Apatite in Templeton and Portland Tps. and on Graphite in Buckinghan Tp.—Vennor. Rep. of Prog., 1873–4. (36 pp.)

114 Notes on Apatite, iron ore and plumbago deposits of Ottawa County.—Vennor. Rep. of Prog., 1876–7. (31 pp.)

763 On occurrences of apatite, mica and graphite north of Ottawa.—Osann. Vol. XII. Part O. (84 pp.)

Copper.

50 Copper-bearing rocks of the Eastern Townships.—Geol. of Can., 1863. W. E. Logan.

63 List of copper localities in Eastern Canada. Rep. of Prog., 1863–6. (26 pp.)

816 Investigations on the copper-bearing rocks of the Eastern Townships.—Dresser. Summary, 1902. (14 pp.)

Graphite. Graphite.

119 On Canadian graphite.—Hoffmann. Rep. of Prog., 1876–7. (24 pp.)

110 Examination of graphite from Buckingham Tp.—Hoffmann. Rep. of Prog., 1875–6. (14 pp.)

94 Notes on graphite of Buckingham Tp. and apatite of Templeton and Portland Tps.—Vennor. Rep. of Prog., 1873–4. (6 pp.)

114 Notes on plumbago, iron ores and apatite deposits of Ottawa County.—Vennor. Rep. of Prog., 1876–7. (31 pp.)

763 On occurrence of graphite, mica and apatite north of Ottawa. —Osann. Vol. XII. Part O. (84 pp.)

On the mode of occurrence of plumbago in Grenville.—Published in New York, 1866. R. Bell.

Gold.

Gold.

64 On the gold regions of Lower Canada.—Logan, Michel and Hunt. Rep. of Prog., 1863–6. (38 pp.)

8 On the gold of the Chaudière River and vicinity.—Logan. Rep. of Prog., 1850–1. (6 pp.)

399 Notes on the gold of Eastern Canada.—Reprints of various portions of reports of the Geological Survey of Canada, from 1848 to 1863. (40 pp.)

460 Reports of the gold regions of Canada.—Michel and Hunt, 1866. (72 pp.)

583 Notes on alluvial gold mining in the Chaudière district.—Chalmers. Summary, 1895. (12 pp.)

670 History and development of gold mining industry in the Chaudière District.—Chalmers, Vol. X, Part J. (90 pp.)

Iron Ores.

591 Iron ores of the district north of Montreal, with appendix on the smelting of titaniferous iron ores.—Adams, Vol. VIII, Part J. (44 pp.)

114 Notes on iron ores, apatite and plumbago deposits of Ottawa County.—Vennor. Rep. of Prog., 1876–7. (31 pp.)

Petroleum.

Petroleum.

400 Petroleum.—Its geological relations considered with special reference to its occurrence in Gaspé.—Hunt, T. S., 1865. (19 pp.)

816 Report of operations and description of Gaspé oil field.—Ells. Summary, 1902. (23 pp.)

400 Geological and topographical map of a portion of Gaspé Peninsula, from surveys by Dr. Bell, accompanying report on occurrence of petroleum in that region. Pamphlet published by the Geological Survey.

General. General.

Report on alleged discovery of coal at Baie St. Paul. Rep. of Prog., 1849.—Logan. (8 pp.)

297 Report on the mineral resources of the Province of Quebec. —Ells. Vol. IV., Part K. (159 pp.)

739 Economic minerals of the Ottawa River map sheet.—Ells. Vol. XII, Part J. (44 pp.)

154 Notes on some of the mines in the Province of Quebec. In the Eastern Townships and in Ottawa County.—Willimott. Rep. of Prog., 1880–2–4. (25 pp.)

268 Economic minerals in the counties of Megantic, Beance, Dorchester, Lévis, Bellechasse and Montmagny.—Ells. Vol. III. Part K. (13 pp.)

591 Economic minerals of a portion of the Laurentian area north of Montreal.—Adams. Vol. VIII, Part J. (44 pp.)

584 Economic minerals of Labrador Peninsula along the East Main, Koksoak, Hamilton and other rivers.—Low. Vol. VIII, Part L. (7 pp.)

819 Geology of the Nastapoka islands, Hudson Bay.—A. P. Low. Vol. XIII. Part DD.

125 Exploration of the east coast of Hudson Bay, with map of the East-main coast. Rep. of Prog., 1877–8.—R. Bell.

Trans. Royal Soc. Canada.—The geology and economic minerals of Hudson Bay and northern Canada. Vol. II, 1884. R. Bell.

Trans. American Institute of Mining Engs.—The Mineral Resources of the Hudson Bay Territories.—Feb. 1886. R. Bell.

Report Dept. Marine and Fisheries.—Report on Labrador Coast and Hudson Strait. 'Neptune' Expedition, 1884. R. Bell.

Report Dept. Marine and Fisheries.—Report on Geology of Hudson Bay and Strait. 'Alert' Expedition, 1885.—R. Bell.

Report Dept. Marine and Fisheries.—Report on the third Hudson Bay expedition, 1886. R. Bell.

ONTARIO. Ontario.

Apatite.

83 On phosphate of lime and mica in Eastern Ontario.—Broome, G. Rep. of Prog., 1870–71. (5 pp.)

Copper.

See also under *Nickel.*

63 On the copper-bearing rocks of Lake Superior.—Macfarlane, T. Rep. of Prog., 1863–66. (45 pp.)

4 On the geology and economic minerals of Lake Superior.—Logan. Rep. of Prog., 1846–47. (46 pp.)

391 Remarks on the mining region of Lake Superior and report on mining locations on Canadian shore of the lake.—Logan, 1847. (31 pp.)

392 Report on the north shore of Lake Huron, with appendix on the contents of lodes.—Logan, 1849. (51 pp.)

816 Note on geology and mineral deposits of Bruce Mines district.—Ingall. Summary, 1902. (10 pp.)

Nickel.

Nickel.

Bulletin Geol. Soc. America.—The Nickel and Copper deposits of the Sudbury district, Vol. II. Feb., 1891. R. Bell.

326 Report on the Sudbury Mining district.—R. Bell. Vol. IV., Part F. (95 pp.)

Reprint On the Nickel and Copper deposits of the Sudbury district. —Barlow, 1891. (18 pp.)

816 The Sudbury Mining district.—A. E. Barlow. Summary, 1902. (15 pp.)

761 Sudbury Mining district.—A. E. Barlow. Summary Rep. Geol. Surv., 1901.

816 Sudbury Mining district.—A. E. Barlow. Summary Rep. 1902. (15 pp.)

Corundum.

Corundum.

644 Note on the Corundum belt of Hastings district.—A. E. Barlow. Summary, 1897. (18 pp.)

Gold.

403 Report on the Gold region of the county of Hastings.—Hunt and Michel, 1867. (11 pp.)

167 Report on the Gold region of the Lake of the Woods.—Coste. Rep. of Prog., 1882–84, Part K. (21 pp.)

Iron Ores.

723 Report on the iron ores of the Kingston and Pembrooke Ry. district.—Ingall. Vol. XII., Part I. (91 pp.)

Natural Gas.

332 Report on Natural Gas and Petroleum in the province of Ontario prior to 1891.—Brumell. Vol. V., Part Q. (94 pp.)

Petroleum. Petroleum.

332 Report on natural gas and petroleum in Ontario prior to 1891.—Brumell. Vol. V. Part Q. (94 pp.)

Trans. Roy. Soc., Canada.—The petroleum field of Ontario.—Vol. V., Sect. 4, 1887. R. Bell.

63 Geology of Grand Manitoulin island, as to anticlinals and petroleum.—Report Geol. Survey, 1863–6. R. Bell.

Salt.

71 On the Goderich salt region.—Hunt, T. S. Rep. of Prog., 1866–9. (36 pp.)

117 The Goderich salt region and Attrill's exploration with the diamond drill.—Hunt, T. S. Rep. of Prog., 1876–7. (23 pp.)

101 Observations on the history and statistics of the trade and manufacture of Canadian salt.—Smith, J. L. Rep. of Prog., 1874–5. (33 pp.)

63 On the geology of salt.—Hunt, T. S. Rep. of Prog., 1863–6. (15 pp.)

Silver.

266 Report on mines and mining on Lake Superior.—Ingall. Vol. III, Part H. (131 pp.)

General. General.

101 Notes on some of the economic minerals of eastern Ontario.—Vennor. Rep. of Prog., 1874–5. (50 pp.)

215 Economic minerals of the lake of the Woods region.—Lawson. Vol. I., Part CC. (11 pp.)

672 Economic minerals of the Temiscaming district.—A. E. Barlow. Vol. X, Part I. (21 pp.)

678 Economic minerals of area of Seine river and Lake Shebandowan sheet.—McInnes. Vol. X, Part. H. (4 pp.)

155 Report of the geology of the Lake of the Woods and adjacent country.—Rep. of Prog., 1880-1-2. R. Bell.

Canadian Naturalist and Geologist.—The mineral region of Lake Superior. Ser. II, Vol. 7, 1875. R. Bell.

Geology of Ontario with special reference to economic minerals. (52 pp.) R. Bell. Report of Royal Commission on mineral resources of Ontario.—1890.

Glossary of Terms used in Mining. R. Bell. (18 pp.)

The Laurentian and Huronian systems of north of Lake Huron. (36 pp.) Report Bureau of Mines, 1891. R. Bell.

Manitoba and Northwest Territories.

Manitoba and Northwest Territories.

Coal.

*408 Note on the geology of the Bow and Belly rivers with especial reference to the coal deposits.—Dawson, G. M., 1882. (24 pp.)

168 Analyses of coals and lignites of the Northwest Territories.—Hoffmann. Rep. of Prog., 1882-4, Part M. (44 pp.)

Reprint. Report on the Tertiary lignite formation in the vicinity of the 49th parallel. Dawson, 1874. (31 pp.)

816 Note on the Blairmore—Frank coal-field.—Leach. Summary, 1902. (11 pp.)

717 Note on the lignite areas and copper deposits of Yukon Territory.—McConnell. Summary, 1900. (7 pp.)

147 On the lignite tertiary formation from the Souris river to the 108th Meridian.—Dawson, G. M. Rep. of Prog., 1879-80, Part A. Appendix I.

Copper.

Copper.

717 Note on copper deposits and lignite areas of Yukon Territory.—McConnell. Summary Rep. Geol. Survey, 1900. (7 pp.)

* Also Rep. of Prog., 1880-1-2, Part B.

Gold.

687 Preliminary report on the Klondike gold field.—McConnell. 1900. (44 pp.)

761 The Yukon district—McConnell. Summary Report for 1901.

The geology of the Klondike Gold district.—McConnell—(in preparation.)

General. General.

325 Economic minerals of Northwestern Manitoba and adjacent parts of Assiniboia and Saskatchewan.—Tyrrell. Vol. V, Part E. (12 pp.)

237 Economic minerals of Northern Alberta and adjacent parts of Assiniboia and Saskatchewan.—Tyrrell. Vol. II, Part E. (7 pp.)

167 On part of the basin of Athabaska river. R. Bell—Rep. of Prog., 1882–3–4. Part CC.

324 Economic minerals of portions of district of Athabaska between Peace river and Athabaska river.—McConnell. Vol. V, Part D. (5 pp.)

629 Report on an exploration in the Yukon district, N. W. T., and adjacent northern portions of British Columbia, 1887.--G. M. Dawson.

816 Economic minerals of region south of Fort Smith, Slave river.—Camsell. Summary Rep., Geol. Survey, 1902.

816 Economic minerals of Eastern Assiniboia and Southern Manitoba.—Dowling. Summary, 1902. (21 pp.)

Proceedings Canadian Inst. On the occurrence of petroleum in the Northwest Territories.—Ser. III, Vol I, 1879–83. R. Bell.

British Columbia. British Columbia.

Coal.

84 On the coal-fields of the east coast of Vancouver island.—Richardson. Rep. of Prog., 1871–2. (18 pp.)

89 On the coal-fields of Vancouver and Queen Charlotte islands.—Richardson. Rep. of Prog., 1872–3. (32 pp.)

114 Report on the coal-fields of Nanaimo, Comox, Cowitchin, Burrard Inlet, and Sooke, B.C. Richardson. Rep. of Prog., 1876–7. (32 pp.)

717 Preliminary Note on Crows Nest Pass coal-field.—McEvoy. Summary 1900. (10 pp.)

Copper.

816 Preliminary report on the Boundary Mining district.—Brock. Summary Rep. Geol. Survey, 1902. (45 pp.)

Gold.

Gold.

816 Preliminary report on the Boundary Mining district.—Brock. Summary Rep. Geol. Survey, 1902. (45 pp.)

263 Report on the Geology of the Mining district of Cariboo.—Bowman. Vol. III. Part C. (49 pp.)

743 Report on Atlin Mining district.—Gwillim. Vol. XII. Part B. (48 pp.)

General.

General.

271 The Mineral Wealth of British Columbia, with a list of localities of minerals of economic value.—Dawson, G. M. Vol. III. Part R. (163 pp.)

115 General note on the mines and minerals of economic value of British Columbia, with a list of localities.—Rep. of Prog., 1876–7. (47 pp.)

294 Economic minerals of a portion of the West Kootenay district.—Dawson. Vol. IV. Part B. (23 pp.)

573 Economic minerals in area covered by Kamloops map-sheet.—Dawson. Vol. VII. Part E. (38 pp.)

Reprint. Report on climate, agricultural value, general geological features and minerals of economic nature of part of northern portion of British Columbia, and the Peace River country.—Dawson, 1880. (25 pp.)

BAFFINLAND.

Baffinland. Report on the south coast of Baffinland containing notes on mica, graphite, apatite and limestones. Annual Report for 1897, with a map.—Dr. R. Bell.

ANNUAL REPORTS OF THE MINES SECTION.

Analysis of Contents (other than the Statistics).

Feldspar—

List and description of deposits 1897
Enquiries for uses and tests of Canadian feldspars 1898

Graphite. *Graphite*—

Mode of occurrence, with map 1897
Deposits and industry 1890
List of producers and properties 1896
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Gypsum—

List of occurrences, analyses, &c 1897
Description of works and industry 1890
Industry in Manitoba 1900

Iron. *Iron*—

Theory of formation of some iron deposits 1887
Iron ores of Canada 1891
Annotated list of analyses of Nova Scotia ores 1897
Progress of iron and steel industry, production, &c 1899
Particulars of bounties, &c 1901
" " 1902

Lead. *Lead*—

Description of occurrences 1890
Lead deposits in Canada 1897
Particulars of bounties on lead 1900
" " " 1902

Manganese—

Manganese in Nova Scotia and New Brunswick 1890
Deposits of manganese ore at Hillsborough, N.B 1897
Article on deposits of manganese in Canada and table of analyses 1902

Magnesite. *Magnesite*—

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Mercury—

Ores of mercury in Canada 1896
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Occurrences of mica in Quebec, Ontario and British Columbia 1897
Description of deposit at Téte Jaune Cache..... 1898
Tests of Canadian mica at Imperial Institute, London, Eng. 1900

Mineral Pigments— Pigments.

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OFFICERS' REPORTS.

Klondike District, Yukon Territory.

Mr. R. G. McConnell.

Klondike district. The principal work of the season consisted of a somewhat detailed examination of the geology and mining resources of the Klondike region; but before proceeding there, a short trip was made to Frank, Alberta, with Mr. Brock, for the purpose of examining into the causes of the disastrous land-slide which occurred at that place in April. A short report on the slide, with maps and illustrations, was prepared before leaving for the field.

Field work. I left Ottawa for Dawson on June 12, and arrived there on June the 24th. The three months open season remaining was spent altogether in the Klondike gold fields, with the exception of a few days occupied in a trip to the coal-field recently opened up on Coal creek, and in a hurried examination of the Ogilvie range, at the head of Rock creek.

A preliminary examination of the Klondike gold fields was made by the writer in 1899, and a report of it published the following winter. It is intended to re-write this report during the coming winter and to add to it the additional information acquired since. It is unnecessary

therefore in this summary to give any detailed description of the district or do more than refer to some of the changed conditions.

Production of Klondike gold field.

The gold production of the Yukon Territory since the discovery of the Klondike gold fields in 1896, is valued by the Mines Section of the Department, at nearly $96,000,000. The production by years is as follows :—

1896	$ 300,000
1897	2,500,000
1898	10,000,000
1899	16,000,000
1900	22,275,000
1901	18,000,000
1902	14,500,000
1903	12,250,000
	$ 95,825,000

Condition of camp.

The whole of this great amount, with the exception of about $1,000,000, credited to the smaller camps, was obtained from the various Klondike creeks and benches, and principally from Bonanza, Eldorado, Hunker and Dominion creeks, and the Bonanza benches. The dwindling production since 1900, in spite of the increasing use of machinery, is largely due to the gradual exhaustion of the phenomenally rich spots on Eldorado and Bonanza creeks, and on some of the Bonanza benches, and does not mark a corresponding decline in the mining industry of the region. The number of creek claims worked, and the amount of gravel handled, have increased rather than diminished in recent years, but the average grade of the gravel mined is much lower. Very few claims, if any, on the more important creeks are being abandoned even when completely worked over, as there is a general expectation that most of them will pay to be re-worked, especially if a water-supply system is established, and some of them are being re-worked under present conditions. Worked-out claims on the richer portions of Eldorado creek are worth from $10,000 to $15,000 apiece.

High level gravels.

The high level gravels, so far as placer mining is concerned, show greater signs of exhaustion than the creek gravels. Work has almost stopped on some of the principal Bonanza hills and the number of men employed is steadily decreasing. These gravels are much deeper than the creek gravels, usually ranging in this respect from 50 feet to 150 feet, and only the lower three to five feet over part of the area covered, is rich enough to work by the ordinary methods. They are

well situated for hydraulicking, but the scarcity of local water prevents the general adoption of this method.

Old creeks restaked.

No new creeks of importance have been discovered since 1899, although in some cases creeks and portions of creeks, which had been staked and partially or wholly abandoned, on account of the low grade of the gravels, are now being worked. This has occurred in the case of All Gold creek, a tributary of Flat creek. The valley of this creek was staked in the early days of the camp from head to mouth; a few holes were sunk to bed rock, but as no particularly rich spots were discovered, the claims were all, or nearly all, abandoned. They have been re-staked during the last two seasons and pay gravel has been found at a number of points. The longest pay-stretch, so far discovered, occurs near the mouth of the creek, where several adjoining claims are being worked. The pay is light, none of the claims yielding much more than good wages and some scarcely that. All Gold creek heads with Dominion and Hunker creeks, but flows in the opposite direction towards the Flat creek depression, and it is the only creek draining the eastern and northeastern slopes of the Klondike hills on which gold in paying quantities has so far been discovered. The general character of the valley and of the gravels conform to the general type. The White channel gravels occur in considerable volume on the left limit, along the lower portion of the valley, and are overlaid near the mouth of the creek, as is the case on Bonanza and Hunker creeks, by rounded river gravels. They rest on a bench of varying width, cut into the side of the valley at an elevation of from 150 to 250 feet above the present creek-bottom, the elevation increasing, as usual, towards the mouth of the valley. The White channel gravels of All Gold creek have not, so far, yielded gold in paying quantities. Fair prospects are reported from a couple of places, but on account of the scarcity of water for sluicing purposes, practically no work has been done.

All Gold creek.

Lower Dominion.

The lower part of Dominion creek, like All Gold creek, was largely abandoned after the first rush, but is now, particularly between the mouths of Gold Run and Sulphur creeks, one of the busiest localities in the Klondike. The valley of Dominion creek from Jansen creek down to the mouth, is very wide, the flats along this portion averaging from a third to half a mile in width. The pay streak in these wide flats was difficult to find, and it required the patient and systematic prospecting of several seasons to define it along the valley. The gravels are not high grade in the Eldorado meaning of the word, but most of the claims yield fair returns when carefully worked. The depth to bed-rock averages about 35 feet.

The gravels on the lower part of Dominion, Sulphur and Gold Run creeks differ from the ordinary creek gravels of the district. They consist of a deposit of white silicious gravels in the lower part and flat yellow gravels above. The latter represents the wash of the stream at present, but the former probably belongs to the period of the high-level White channel gravels. At first sight it appears peculiar to find these gravels on Bonanza, Hunker and other creeks, occupying high benches, while on Dominion and Sulphur creeks they underlie the present valley flats, but the apparent anomaly admits of an easy explanation. Their elevated position on Bonanza and Hunker creeks has been explained in former reports as being due to an elevation of the country, which gave the streams increased grades and enabled them to cut deep, steep-sided secondary valleys in the floors of their old channels. Both Bonanza and Hunker creeks discharge almost directly into the Yukon, the master stream of the district, and they were affected immediately by the deepening of the Yukon valley. Dominion creek, on the other hand, empties into Indian river, many miles above the junction of the latter with the Yukon. Indian river is itself a comparatively small stream, and the increased cutting power which it acquired in common with the other streams after the elevation of the country, has been expended in the lower portion of the valley and has not, so far, materially affected the upper portion. A secondary valley, in places narrowed to a canyon, is traceable from the mouth of the Indian river upstream to a point above Quartz creek, where it merges with the older valley. The wide flats which form the bottom of the valley of the main stream, and of the large tributaries like Dominion creek, above this point, correspond therefore, in a general way, to the old valleys of Bonanza and Hunker creeks, now represented by high benches, and not to the present valley bottoms. The white gravels on Dominion creek are comparatively thin, seldom exceeding 15 feet in thickness and at places are absent altogether.

Lower Dominion gravels.

Other creeks.

The pay-streak on Lower Dominion commences at Gold Run creek and is apparently a continuation of the pay-streak of that creek, as no paying claims have so far been discovered above the mouth of Gold Run for several miles. The pay-streak has been traced down the valley almost to the mouth of Australia creek.

The great reduction in the cost of mining, which has given value to these comparatively low grade gravels, is due not to any radical change in the methods of mining, so far as the laying out of the work is concerned, but to the great cheapening of freight rates up the creeks since the construction of the government roads and to the general introduction of machinery. The ordinary equipment of a mine on Dominion

Cost of mining.

creek costs from $5,000 to $8,000 on the ground, and consists of a 35 to 50 H.P. boiler for furnishing power, a hoist and self-dumping bucket, worked by an 8 to 10 H.P. engine, a centrifugal pump, with a six-inch discharge for elevating water for sluicing, driven by an engine usually of about 15 H.P. and a small Worthington pump with a three-inch discharge and a one-inch nozzle for thawing, or a set of points when the thawing is done by steam. The operating expenses of an ordinary plant, with one shift and night thawing, amounts to about $100 per day, and from 50 to 60 cubic yards of material are mined and sluiced daily. The cost of handling a cubic yard of gravel has been reduced nearly one-half since 1899.

Two methods.

The two methods of mining commonly employed in the Klondike, viz., by open cut, or by hoisting and drifting, are described in the Summary Report for 1899. These methods are still generally employed, the principal change being in the substitution of machinery for hand labour. In a few cases, however, attempts have been made,

Dredging.

more or less successfully, to introduce cheaper methods. A dredge, originally intended for work on the Lewis river, has been operating on Bonanza creek for the last three seasons. The work done has shown that when the gravels are completely thawed out, they can be mined very cheaply by dredging, but when frost is encountered, thawing, as in the other methods must be resorted to. In dredging also the bed-rock is not seen, and there is always some uncertainty in regard to the completeness of the recovery of the gold. Where the bed-rock is hard and blocky, the gold often sinks down along the jointage and bedding planes to a depth of 4 or 5 feet, and some of it must almost necessarily be left behind. In soft bed-rock, on the other hand, the recovery of the gold is probably nearly complete.

Steam shovels.

Steam shovels are employed on several claims in the district, and where the conditions are suitable, they handle the gravels and certain kinds of bed-rock cheaply and effectively. The overlying muck requires to be sluiced off in the ordinary way, and the gravels must be thawed out before good work can be done.

Cheap mining.

Another attempt at cheap mining in the creeks introduces the hydraulicking principle, but it is still only in the experimental stage. On Gold Run creek two claims have been equipped with long China pumps and bucket elevators. The pumps and elevators, each about 70 feet in height, rest in a sump, excavated 12 to 14 feet in bed-rock. The gravels are washed into the sump by a stream of water under small pressure, and are carried up by the bucket elevator and dumped into the sluice boxes. The China pump elevates the water used in hydraulicking and it serves again to wash the gravels. It is proposed

to mine a number of the claims on Gold Run creek by this method if the two experimental plants prove successful.

Hydraulicking. The high level, White channel gravels along Bonanza and Hunker creeks, are still largely worked by the expensive sinking and drifting method, and until an adequate water-supply system is established, this is the only possible method on the majority of the hills. A number of attemps to hydraulic these gravels have been made, both with gravity water and water pumped up from the creeks. The pumping method has been generally unsuccessful, and can only pay when the gravels are extremely rich, owing to the high price of fuel. Where cheap gravity water is obtainable, however, the results have been very good. The Anglo-Klondike Company, under the management of Mr. Coffee, has been operating successfully for the past two seasons two small hydraulic plants, one on Fox gulch and the other above Boulder creek. The water is flumed and siphoned from a point on Boulder creek about three miles above its mouth. A supply of about 200 inches is available for a few weeks in spring and autumn, and is delivered under a head of nearly 200 feet. In Mr. Coffee's report to his company for 1902, it is stated that in a run of 22 days, 29,000 cubic yards were sluiced and that the actual hydraulicking cost was under 15 cents per cubic yard. The total operating expenses, including cost of plant and cleaning bed-rock, amounted to 35 cents per cubic yard, or $1.96 per square yard of bed-rock. In the same report it is stated that the average cost of mining and sluicing by the ordinary drifting method amounted to $5.85 per square yard of bed-rock, or nearly three times as much.

The demonstration of the feasibility of hydraulicking successfully the frozen hill gravel is important, but under present circumstances can only be taken advantage of to a very limited extent, as the available local supply of gravity water is small and intermittent and is only obtainable at a few points.

Volume of White channel gravels. The White channel gravels have a total volume on Bonanza creek and its tributaries of approximately 250,000,000 cubic yards, and on Hunker creek and its tributaries of 200,000,000 cubic yards. They are everywhere more or less auriferous, and sufficient work has already been done to prove that a large proportion, at least, of the whole deposit would pay to hydraulic if water could be obtained at reasonable rates. The present price of water delivered on the hills is $7 per sluice-head per hour on Lovett gulch, and $8 to $9 further up the valley, and even at these rates some work is possible. These gravels are very favourably situated for hydraulicking, as they rest on comparatively narrow benches, cut into the sides of the valley, at elevations of from 150 to 300 feet above the present valley bottom.

Quartz mining.

Quartz mining in the district has so far made little progress, although a great many claims have been staked and some development work has been done. Quartz veins occur everywhere but are usually small and non-persistent, and the values are very irregular. The large veins from 6 to 10 feet in width which are occasionally found are usually lenticular in shape and soon narrow in, along the strike. The veins often carry more or less feldspar, and in some respects resemble the pegmatites.

Violet group.

Some work was done during the past season on a claim in the Violet group, situated on the summit of the ridge separating Eldorado creek from Ophir creek, a tributary of Indian river. The workings consist of a short open cut and a couple of shafts. The open cut follows a quartz vein 5 to 6 feet in width, broken by a number of small faults. The vein strikes with the enclosing schists in a south-easterly direction, but dips across them. A shaft has been sunk a short distance north of the vein to intercept it in depth, and it is intended to continue it down to a depth of 150 feet. The quartz contains considerable iron pyrites and near the surface weathers to a rusty colour. Some gelena is also present. The gold values are variable, but are stated to average from $10 to $11 per ton.

Lepine creek.

A visit was made during the season to Lepine creek, north of the Klondike, where a large number of claims have been staked on a band of sericite schist, the ordinary country rock of the district. Only one claim was worked during the past season. This claim is situated south of the deep valley of Ruiter creek, a tributary of Lepine creek. The schists here are traversed by a wide dyke, probably an acid andesite and both schists and dyke-rock are completely decomposed to a depth of at least 15 feet. This decomposed material constitutes the ore. A tramway, half a mile in length, has been built, and the ore is trammed down to Ruiter creek and treated in a small cyanide plant. The result of the season's operations is not known. A number of specimens were collected, which are being assayed.*

Ore in Ogilvie range.

Considerable prospecting was done during the season in the Ogilvie range, north-east of Dawson, and a number of claims were located on Rock creek, a tributary of the Klondike, and on Spotted Fawn creek, a tributary of Twelve-mile river, but only a few of these were examined. The rocks on the south-westerly slope of this range consist of cherts, dark slates, shales and quartzites, with occasional bands of tuffs and green schists, a succession very similar to that on the Upper MacMillan river. Areas of igneous rocks also occur, principally syenites and diorites, and on the North Fork of Spotted Fawn creek exposures of an interesting leucite rock were found.

* The results will appear as an appendix to this volume.

A marked feature of the range is the peculiar forms of the mountains in an area of syenite porphyry, which extends from Spotted Fawn creek northward across Twelve-mile river. This rock is strongly jointed vertically, and weathers into ruinous, wedge-shaped ridges, surmounted by lines of sharp pinnacles and lofty tower-shaped peaks. The pillared character of the region is so remarkable that the prospectors have given it the name of the tombstone country. Sculpture of mountains.

A number of claims have been staked in this syenite area, principally in small, irregularly shaped inclusions of altered slate. No veins were seen. The inclusions contain varying quantities of pyrite and weather to a rusty colour on the surface. They are reported to carry gold. A small vein, a few inches in width, carrying galena and pyrite, occurs on the North Fork of Spotted Fawn creek, in a porphyry dyke cutting slates and quartzites. The vein is too small to be of value. None of the prospects examined appeared promising, but they show that the region is metalliferous to some extent and may therefore contain deposits of value.

Various efforts have been made since the Klondike gold fields were discovered to utilize the lignite seams in the vicinity. A long, narrow area of lignite-bearing rocks, probably of Tertiary age, occurs along the base of the Ogilvie range, and has been traced from the Klondike river, in a north-westerly direction, to a point beyond Cliff creek, a distance of over 60 miles. The streams draining this portion of the Ogilvie range cross the lignite area on their way to the Yukon, and on most of them outcrops of lignite coal are found. Some mining has been done on Rock creek and on Cliff creek, a small stream entering the Yukon from the east a few miles below Forty-mile river, but work is now stopped at both places. Lignite.

During the past season considerable work has been done at Coal creek by the Coal Creek Coal Mining Company. The seam worked occurs on the South Fork of Coal creek at an elevation of 960 feet above the Yukon, and the workings are connected with the Yukon by a narrow-gauge railway, eleven miles and three-quarters in length. Lignite mining on Coal creek.

The seam worked, varies in thickness from 4 to 11 feet, and is overlaid by 3 inches of clay, followed by 12 feet of moderately hard sandstone. The floor consists of 6 feet of clay, resting on 16 feet of sandstone, below which is a band of black shale. The seam dips to the south-east at an angle of 45 degrees for a distance of 210 feet from the surface, and then bends round and dips to the south-west. The principal working consists of an incline 490 feet in length. The lignite is hauled to the Yukon over a narrow-gauge railway just completed,

and taken up the river to Dawson, a distance of about 50 miles on barges. Bunkers of 500 tons capacity are in course of construction at the mine and at the river.

The coal from this seam is of good quality, and is very similar to the Cliff creek coal, an analysis of which is published in the 1901 Summary Report. It is pure for a lignite, and has been used with satisfactory results, both for steam and heating purposes. It is sold at Dawson at $16 per ton. The price of spruce wood—the usual fuel—is generally $7 to $8 per cord at Dawson, and $8 to $15 on the creeks.

Lignite on Ruby creek.

A second lignite area occurs south of the Klondike on Indian river. A small seam outcropping on Ruby creek, a tributary of Indian river, was worked to some extent during the winter of 1902, but has since been abandoned. At the time of my visit the tunnel had fallen in, and nothing could be learned in regard to either the character or size of the seam.

The Lardeau District, B.C.

Mr. R. W. Brock.

INTRODUCTION.

Lardeau district, B.C.

The month of May and the first half of June were occupied in examining the Frank landslide, writing a report thereon, and laying down the geological lines on the Boundary creek topographical sheet, which had just been completed, so that it was not until June 18 that I set out for the ordinary field-work. I was accompanied by Mr. W. H. Boyd, of this office, who again took charge of the topographical branch of the work. Our instructions were to commence the explorations of the district lying north of that embraced in the West Kootenay map-sheet, recently issued by this survey. The area covered by this new map-sheet, which may be referred to as the Lardeau sheet, is that lying between Schroeder creek, the head of Slocan lake, and the mouth of Mosquito creek, on the south; Albert canyon on the north; the divide between Kootenay lake and Duncan river and the Upper Columbia waters on the east, and the divide between Columbia and Okanogan waters on the west. Our instructions were to confine the work as far as practicable to the southern half of the sheet. Since the triangulation of the West Kootenay sheet was carried north from a short base near the southern portion of that district, it would not bear further extension northwards, so it was deemed advisable to commence the survey of the new sheet at Revelstoke on the main line

of the C.P.R., thus tying on with surveys of the railway belt made by the Dominion Lands Branch.

Revelstoke. Base line used.

Revelstoke was accordingly selected as the basis of operations for the season. A tangent of five miles on the Arrowhead branch of the C.P.R. near Revelstoke which had been measured by the Dominion Lands Branch, was used as a base, and from this the triangulation of the mountains was commenced. The triangulation was carried on to Arrowhead on Upper Arrow lake, and across to Fish river. A micrometer survey was made of the east shore of Upper Arrow lake to St. Leon Springs, there tying on to the survey of the Columbia from the International boundary line, which had been made during the exploration of the west Kootenay sheet. Returning, a log-survey was made of the west shore from St. Leon to Arrowhead. From the Revelstoke Arrowhead triangulation a strip of country about 20 miles wide was surveyed south-eastward to the end of Trout lake. The boundaries of this area are Boyd creek on Fish river and the Lardeau Duncan Divide, on the north-east, and the Trout and Arrow Lake Divide on the south-west. Included in this area are the North-east Arm of Upper Arrow lake, the district about Camborne, the district about Ferguson and Ten-mile, and the Trout Lake district. The new district of Poplar creek on Lardeau river, which sprang into importance on account of the gold discoveries made there this summer, was also examined.

The season was exceptionally unfavourable for field-work. The winter snow did not melt on the higher ground until late in July. This, with the broken weather, made it impossible to carry out the work on the peaks till the end of July, August was also a wet month and on the 4th of September work on the loftier ranges was stopped by fresh snow-falls which continued during the month. On Sept. 19, on account of the unfavourable weather, field-work was abandoned, and preparations were made for returning to Ottawa. During almost half of this short season the weather made effective field-work impossible.

Physiography.

Physiography.

The district lies in one of the most rugged and picturesque portions of the Selkirk mountains. Huge, massive mountains, culminating in lofty craggy peaks, supporting numerous glaciers and perpetual snow-fields, are seperated by steep-walled, narrow valleys. The mountains

Note.—The bearings in this report, unless otherwise stated, are magnetic. The local variation of the compass may be taken as about 25 degrees east.

Altitudes.

are in an early stage of their life history, and are therefore thoroughly Alpine in character. The altitude of the mountains gradually increases going northward and eastward from the head of Upper Arrow lake, from rather more than 8,000 feet to perhaps 11,000, north and east of the Duncan river. West of the Columbia river the country is also rugged, individual peaks reaching 9,000 feet. Though the Columbia valley is usually taken as the dividing line between the Selkirks and Gold Ranges, it is probable that in structure and time of formation, the range just west of the upper part of Upper Arrow lake will be found to correspond to the Selkirks, its position being explained by an arrangement of the ranges *en echelon*, like those of the Rockies.

Two main valleys.

There are two main longitudinal valleys in this part of the country, which have in general a north and south trend. These are the Columbia and Arrow Lake valley in the west, and the Duncan-Kootenay valley in the east. The valleys tributary to these, in the district examined, depend for their direction largely upon the local structural features of the rocks. The rocks are mostly stratified or schistose, folded in general along north-west and south-east axes, with a vertical system of master-joints at right angles to the direction of folding. Conforming to this structure, the valleys are north-west and south-east, or at right angles to this, except where influenced by local peculiarities. One of the most important of these valleys is that of Fish river and its continuation—the North-east Arm of Upper Arrow lake, which comes in from the north, cutting across the strike of the rocks. The chief valley of the district is that of Trout lake and Lardeau river, which following with considerable exactness the strike of the rock, forms a natural highway between the North-east Arm and the Duncan-Kootenay valley. A similar north-west and south-east valley, farther south, forms a pass between Nakusp on the Upper Arrow lake and the head of Slocan lake.

Character of valleys.

The smaller valleys are deep, narrow and V-shaped; the larger steep-walled and U-shaped. The gradient of the lower part of the valley is usually steep for a few miles, trenched into a canyon near its mouth by the occupying stream. The middle portion has a moderate slope, while at the extreme head it rises steeply to a funnel-shaped basin or a park-like amphitheatre. These valleys dissect the district into a number of mountain ridges, having in general a north-west-south-east trend, with

Montains.

offsetting ridges at right angles. These mountains are big, blocky masses terminating in rugged, narrow, serrated ridges whose even sky-line is relieved in detail by numerous pinnacles and spires. This even sky-line suggestive of a dissected peneplain, which is a striking feature

in a panoramic view from almost any peak, is remarkable in so mountainous a district. It seems to be due to sameness in physical and structural conditions of the rocks over a wide area, with perhaps planation by the Cordillerian ice-sheet. Where the country rock is granite or limestone, the mountains are loftier and the sky-line becomes uneven. A thin band of limestone (known locally as the "limedike") is a conspicuous feature in the topography. It forms wedge-shaped ridges which rise precipitously above the surrounding country, and weather into castellated and fantastic forms resembling the famous Dolomites of the Alps. It formerly was the divide between streams draining into the Duncan and Lardeau rivers, but many of these have now sawn through it by a headward growth. The ridges do not taper off gradually as they approach the valley, but run steeply down to the valley level. The ends of the ridges running into the larger valley have all been truncated.

The Columbia valley is a mile and a half wide from Revelstoke to the head of Arrow lake, and very flat. The river with numerous islands and sloughs winds back and forth between the basis of the mountains. When in flood, large areas of the valley are under water. The head of the lake is silted up with material brought down by the river. The shores of Arrow lake rise somewhat precipitously, especially in the east, for the first few hundred feet, where a rock-terrace of varying width occurs. Above this, the slopes are again steep. The mountain slope on the north of the North-east Arm is precipitous. The head of the Arm is silted up by Fish river; in high water its delta is flooded so that high-water and low-water maps of the head of the Arm differ very materially. The Trout lake-Lardeau valley from Beaton, rises about 1,000 feet in the first three and a half miles. From the first lake to Trout lake its slope is so gentle that the divide between Staubert creek and Trout creek can only be detected by the flow of the water. Trout lake, which occupied the central stretch of the valley is a fiord-like body of water about 18 miles long with an average width of about half a mile. The head of the lake has a straight gravelly beach. Along the west side, the beach is continuous to Five-mile creek. The shores for the rest of its length are precipitous except where tributary streams enter. There fans project out into the lake. The valley which is remarkably straight, contracts near the lower end of the lake, from which the Lardeau river issues through a rock channel. The lower part of the Lardeau valley has a low gradient. Numerous soundings were taken of Trout lake, which proved the bed to be flat transversly, and basin-shaped longitudinally. The shores run down at an angle of about 45 deg. The depth of the

Trout lake valley.

main body of the lake is about 700 feet, the deepest point, nearly opposite Eight-mile creek, being 765 feet. At the head, the bed drops rapidly, but toward the outlet it gradually rises; in the narrows it varies from 120 to 200 feet, and is 96 feet deep at the outlet. Its depth is thus greater than any found in the Arrow lakes or in Kootenay lake, though not so great as that of Slocan lake.

The deepest point ascertained in the North-west Arm of Upper Arrow lake was 550 feet—about a quarter of a mile east of Whiskey point.

Water-powers.

Since most of the valleys are hanging, with respect to the valleys they are tributary to, the streams occupying them usually debouch through canyons, at the heads of which are waterfalls. Thus the district is plentifully supplied with water powers for local purposes. On Fish river and Lardeau creek this feature is accentuated by bands of hard rock near the mouths. Thus, while the valley of Fish river is wide and flat above Camborne, between this town and its mouth it is constricted to a narrow gorge with steep gradient. A band of siliceous rocks through which it cuts is a contributory cause of this. The smaller valleys are occupied by mountain torrents, the large by lakes or large swift-flowing brooks or rivers. Owing to the heavy precipitation, particularly as snow during the winter months, the brooks are well supplied with water during the greater part of the year.

GLACIERS AND GLACIATION.

Glaciation.

While the topographical features of the district are manifestly due to the erosion of a region of uplift by river action, there is abundant evidence that the resulting features have been modified by the action of ice. The tops of the ridges have been beveled off, cirques and basins scooped out. The larger valleys where ice could act, have been changed from V-shaped valleys to steep-walled U-shaped ones, the ends of the ridges truncated so that they rise abruptly from the valleys like gigantic cut-banks. The beds of these valleys have been scoured and deepened, so that the tributary valleys lie above as hanging valleys. Transported boulders are scattered over the mountain sides and on the ridges; rock surfaces are scored, fluted and striated. All the higher mountains carry numerous snowfields and glaciers, on the southern exposures as well as on the more protected. Some of the glaciers and snow-fields are several miles wide. The distance to which the glaciers descend depends upon the size of the snow-field, the declivity, exposure, and like factors; but few, if any, get below 6,100 feet, and most of them terminate at about 7,000. From the small terminal moraines in some cases lying beyond the end of the ice, it is

to be inferred that the glaciers have retreated rapidly. This conclusion receives support from evidence that the lower parts of the valleys were recently occupied by ice. Thus Pool Creek valley must have been occupied by a glacier as far as Camp creek at no remote period. The valley is U-shaped with steep walls (50° and 55° respectively), and although some tributaries enter it and snow-slides are numerous, little debris has as yet accumulated in this part of the valley. One tributary stream runs across the valley to join Pool creek over a bed of boulders 10 or 12 feet above the level of the valley, but this raised bed is only a few feet wide. The glaciers have, however, retreated little during the last few years. In one case trees were found growing close to the end of the glacier. The present glaciers are therefore merely remnants of large valley glaciers. In the country to the north and east these glaciers are still of large dimensions. Though comparatively small, the glaciers of this district have considerable thickness. Some are one hundred or more feet thick, even at their lower terminals. They are traversed by numerous crevasses, which makes travel over them somewhat dangerous. In summer, at least, their movement is rapid for the streams which issue from them are charged, especially during the day, with rock-meal from abrasion, and the grinding down of their ground moraines. At the head of Bear creek, where a glacier from Pool ridge discharges over a precipice, each day while we were camped there, the thunder of ice-masses breaking away from the end of the glacier would be heard, so that the movement of this ice-mass must have been a considerable number of feet per day. At night the movement seems to be somewhat arrested. These valley glaciers have produced rock basins and cirques at the head of the streams, but in slates and schists these are usually not well preserved, unless the glacier has only recently vacated them, the stream altering their forms to funnel-shaped basins. For this reason, if for no other, well-formed cirques are less common than in granitic rocks. While some of the glacial phenomena are accounted for by the action of local glaciers, many of the observed facts can only be explained by the action of a large ice-sheet travelling southward, which covered the whole country with the possible exception of some of the higher peaks. Evidences of this ice-sheet which Dr. Dawson has called the Cordilleran glacier, are to be found all over southern British Columbia. The local glaciers may be considered as relics of this former ice-sheet. The direction of the lower part of the ice mass was controlled by that of the larger valleys which it filled. It flowed southward through them. In theses the striation is therefore parallel to the sides of the valley. The upper part of the mass, however, was only slightly effected by the topography, so that the striation produced by it on the high ridges and peaks give the general

Movement of the glaciers.

Cordilleran ice sheet.

course of its movement. On Sproat mountain, which is 8,000 feet high, and which is cut on all sides by deep valleys, the rocks are beautifully fluted and polished by ice flowing in bearing of 123° as proved by several of the criteria for recognizing the direction of ice movements. Crossing the ridge at the head of Mohawk creek, at an elevation of over 7,000 feet, the glacial striæ run 127° and 137°. These also, from the local topography, could not have been produced by local glaciers. Boulders of a porphyritic granite which occurs about 20 miles north, are found here and at about the same elevation on the Pool-Lardeau Creek divide. The direction of movement of the Cordilleran glacier in this district, therefore, corresponds closely to that observed for it in other parts of southern British Columbia, where the average direction is about S. 30° East (Astr.).

There is strong evidence of the important effects of abrasion by this ice-mass. Some of this evidence has already been referred to in describing the fiord-like character of the larger valleys, the production of high-hanging valleys etc. A characteristic result is the production of lake basins. The Trout lake Lardeau valley contains three of these, that of Trout lake being the most important. Trout lake, as we have seen, is 765 feet deep, has a rock lip, and there is a rock divide above its head. There is no evidence of important faulting here, but every indication that the valley bottom is a huge 'dug out.' The 'lime dikes' are much more precipitous on their southern faces than on their northern, that is, on their southern face the slates have been much more heavily eroded. There are no differences in the character or attitudes of the beds to explain this fact, which is most readily accounted for by the plucking action of the Cordilleran glacier. A pot-hole occurs in the rocks on the south-west shore of the lake below American creek, which has probably been produced by an englacial stream.

Terraces.

A little boulder clay occurs under the gravels at Arrowhead. Terraces of silt and gravel occur at a few protected points, particularly along the Lardeau river valley. The highest one observed was at an elevation of about 3,000 feet They are not so numerous, nor do they reach the elevation of the terraces in the more southerly and less rugged parts of British Columbia, but this is easily explained by the character of the country and the greater erosion.

VEGETATION.

Timber.

The larger valleys and mountain sides are, or have been, well forested with valuable timber. Pine, hemlock, Douglas fir and giant cedar and tamarac, are the most important trees from an economic standpoint. The boles are of large diameter and are straight and tall.

In the smaller valleys, and at points, in the larger, the numerous snow slides have cut swathes through the timber. In some places they keep the mountain sides and valley bottoms swept bare. The timber line has an altitude of about 7,500 feet in favourable locations, but usually the accumulations of snow, snow-slides, etc., prevent timber from growing in any quantity much above 6,000 feet, and in many places less than this. Except where snow-slides cut away the timber, allowing a rank growth of grass and mountain weeds there is no horse-feed at the lower levels. Higher up where timber grows in park-like clumps, and above timber-line, the feed is usually excellent. Under-growth is dense in the timber up to about 5,000 feet. Owing to the heavy precipitation, forest fires have not done as great damage to the timber here as in some other parts of British Columbia. The destruction by forest fires might in part be prevented were it not for the apathy of the people toward the loss of this valuable resource. Unfortunately, many regard this mode of deforestation with approval as aiding prospecting. Electric storms are, however, an important source of fires. While camped on Arrow lake, four separate fires were started within a radius of 8 miles in an arc of 80 degrees, by one thunder storm. Had it not been succeeded by a couple of days' rain, much valuable timber would have been destroyed. On several occasions I have seen bad fires started in this way in the mountains—sometimes by electric storms that were unaccompanied by any rain. Most of the valuable timber has been appropriated on Upper Arrow lake and its tributary valleys and on Fish river and Trout lake valleys. Saw-mills are in operation at Arrowhead, Comaplix, Trout Lake City, and a couple of large mills to saw lumber for export are in course of construction at Arrowhead. Timber for mining purposes can usually be obtained in abundance on the spot, unless, of course, the location is above timber-line. Above timber-line, heather and alpine flowers grow in great luxuriance. Some successful experiments in the cultivation of fruit and other crops have been made in the Lardeau-Trout lake and Arrow lake valleys.

Electric storm a source of forest fires.

Rocks of the district.

GENERAL GEOLOGY.

The district is largely made up of sedimentary rocks. These consist of dark slate, with some bands of dark carbonaceous limestone and marls, sandstones, conglomerates, tuffs and rocks formed by the metamorphism of these, as phyllites, micaceous, hornblendic, garnetiferous, schists; spotted, and pyritiferous phyllites, talcose schists, calc-schists and crystalline limestones. But eruptive rocks are also important. Green diorite and gabbro-porphyrite rocks occur, usually nearly or quite parallel to the bedding of the sedimentary rocks. Bands of

greenish chloritic schists which represent these rocks in a squeezed condition are abundant. Dykes of a light greenish, yellow-weathering, porphyritic rock occur through a long belt of country, and granite intrusions occur to the north and south-west of the district, while in places, aplitic and pegmatitic dykes proceeding from them are very numerous.

THE STRATIFED ROCKS.

The shales are dark, more or less carbonaceous rocks, in places somewhat calcareous and merging into carbonaceous marls. They are thinly fissile, with the cleavage parallel to the bedding. In places they are sufficiently massive and cleavable to form roofing-slates. More commonly they are found altered by dynamic, and in places by contact metamorphism to phyllites and schists. The phyllites are usually dark to lead-coloured rocks, the incipient development of mica giving them a glossy or nacreous appearance. A graphitoid phyllite is not uncommon, especially near ore-deposits. At some points, particularly approaching the belt characterized by the 'lime-dykes', cubes of pyrite are plentifully developed, giving the rock a spotted, porphyritic appearance. In places these cubes are one inch in diameter. On Trout lake road a thin coating of quartz is deposited around these cubes. Sometimes thin lamellae of quartz are intercalated through the phyllites. At some points the crystalization is more advanced, and glossy sericite schists result. Hornblendic schists with the hornblende in thin needles, and garnetiferous schists are also produced. The schists become coarsely crystalline and gneissose only near the granite contact and where the rocks are much cut up by aplite and pegmatite dikes. The marly bands when metamorphose produce graphitoid lime-schists, hornblendic schists and light-colored calc-schists. Some belts, particularly near the lime-dyke zone, are characterized by light-coloured yellowish and reddish, flecked, soft, friable schists, sometimes with an unctuous, talo-like feel. Small cubes of pyrite, often altered to brownish limonite, are frequently scattered through the rocks.

Interbanded with the slates are a number of limestone beds. When weathered, these are usually dark carbonaceous blocky rocks. On the Beaton-Trout lake wagon road, a couple of miles from Beaton, (at the north-west corner post of the Albert D. mineral claim) several dark limestone bands occur in the dark slates. These contain numerous poorly preserved fossil remains. They are sometimes represented by scattered calcite nodules. Those that have preserved some of their original forms appear to be fragments of crinoid stems. Near the head of Murray brook a limestone band contains rings with dark centres,

Fossils.

which also appear to be crinoid joints. These are the only fossil remains so far found in the district.

When metamorphosed, the limestone becomes white and crystallized. Some of these bands form pure, white, fine-grained marble, in hand specimens at least, resembling the fine qualities of marble used for artistic purposes. The limestone beds which vary in thickness from a few inches to several hundred feet, are distributed somewhat sparingly through the slates and phyllites, except in certain zones. They are more abundant along the north-eastern portion of the district examined, where the thickest bed forms the well-known lime-dykes. The limestone of the lime dykes is mostly white and crystalline, but some less altered portions are drab or dark-coloured. In some portions it is replaced partly or wholly by white silica, and quartz stringers form a network through it. These outstanding on account of weathering, make it possible to scale the precipitous peaks which would otherwise be quite inaccessible. As is common in limestone, waterways have been dissolved in it, forming caverns, natural bridges, winze and tunnel-like openings in which dog-tooth and nail-head spar, concretionary limonite and large masses of concentric, radiated arragonite are developed. The arragonite is of beautiful shades of honey-yellow, green and buish green, and can be obtained in masses as large as $1\frac{1}{2}$ x 1 foot. The slates, phyllites and schists are also silicified in places, and have quartz veins, lenses and stringers developed in them. At several points along the mineralized belts, massive quartzites occur. On the north slope of Silver Cup mountain, where several wide and continuous bands occur, the field evidence points to their being silicified slates. On the Netty L. wagon road, at the Mabee Tunnel, an ovoid mass, twenty feet or more long, of a dark siliceous rock occurs, round which the slates are wrapped. Rocks like it in appearance, but in long bands, occur on Gainer creek and other points, but these rocks appear to be indurated sandstones. The bare, dome-shaped hill, north of the head of the North-east Arm consists of a band of highly siliceous rock. A somewhat similar rock occurs on the Ferguson road above Trout Lake City. The field evidence rather points to their formation through impregnation and replacement of the country rock with silica, but the microscope indicates a clastic origin.

Marble.

Arragonite.

Quartzite.

On the north-east shore of Trout lake, near Eight-mile creek, severals beds of conglomerate occur, interbanded with the slate, one over ten feet thick. The angular to rounded pebbles, which range from $2\frac{1}{2}$ inches in size, are of white and rose quartz, and slate, in an argillaceous matrix. Some are elongated, like portions of a squeezed and broken quartz vein. A similar rock along the strike of these beds outcrops on the Trout lake—Beaton wagon road.

Conglomerate.

Chloritic schists.

Green fissile and fine-grained greyish schists are largely developed in the sedimentary rocks almost everywhere in the district. At most points their perfect foliation parallel to the dip of the sedimentary rock gives them a resemblance to stratified rocks, but they possess a much greater specific gravity than the latter. The thickness of the same bed varies when followed along the strike, and a large band is apt to divide into several smaller ones with phyllites between. At several points, as at the head of Menhinick creek and Murray creek, similar rocks are produced by the alteration of dykes of a basic eruptive, which are often intercalated in the stratified series. These schists are therefore in all probability altered eruptive rocks.

ERUPTIVE ROCKS.

Gabbro porphyrites.

At a number of points, dykes and masses of green rocks occur concerning whose eruptive origin there can be no doubt. In the present summary, they will be referred to simply as greenstones. At the head of Menhinick creek the greenstone is a heavy mottled gabbro with long green pyroxene crystals, plagioclase and a dark brown mineral with good cleavage. On the ridge between Gainer creek and Cariboo creek, dykes of a somewhat similar rock occur which fork and send tongues out into the slates, altered near the contact; although in general the dykes conform in direction to the dip and strike of the formation. The greenstone at the head of Murray brook is more dioritic in appearance, consisting of hornblende, biotite, plagioclase and some pyrite.

Diabase schist.

In almost all, if not all of the mineralized zones, a green, yellow-weathering rock occurs. Frequently it is schistose, somewhat resembling the chlorite schists, but differing in colour, in the occasional development of serpertine, and in its characteristic weather crust. Sometimes it remains more or less massive and, if large, shows a marked porphyritic texture in the centre of the band, while the borders remain fine-grained. While conforming closely to the dip and strike of the enclosing rocks, it does not always follow them. From its weathering and its high content in lime it is usually called a dolomite, but there is no question that it is an eruptive rock, occurring in the form of sheets and dykes. Its texture alone, where unaltered by mashing, would be sufficient to prove this, were no other evidence obtainable. Microscopic examination points to its having been a diabase, but it now consists of a mixture of quartz, sericite, serpentine and carbonates. It will be referred to as diabase schist.

Granite.

The granite which extends along the south-western edge of the area examined is a rather fine-grained, light-coloured, acid granite, consisting

of quartz, white to slightly reddish orthoclase, white plagioclase, sometimes altered to epidote, and a small quantity of a coloured constituent, which is sometimes biotite and sometimes hornblende. It is full of little cavities formed by contraction on cooling (miarolitic structure). Fine-grained aplite dykes and coarse quartzose pegmatites are abundant in many localities near the granite mass. Coarse-grained porphyritic granodiorite (tonalite, the Nelson granite of the West Kootenay sheet) occurs up Fish river to the north, and numerous glacial erratics of it are scattered over the Lardeau district.

AGES OF THE ROCKS.

The geological ages of the rocks which have been described, could not be definitely determined by the work done this summer. The oldest rocks are those of the sedimentary series. They contain fossiliferous bands which, however, are useless for determining the horizon of the rocks. They are almost certainly palaeozoic and probably about carboniferous. No doubt they correspond to the Slocan series of the West Kootenay district. The greenstones, and therefore, in all probability the chloritic schists, are later than these, but there is no evidence as to their exact age. The diabase schist is newer than the green schists. The granite, I think, belongs to the same intrusion as the Valhalla of the West Kootenay sheet. If so, it is a comparatively late rock, possibly Cretaceous or Tertiary. The only definite evidence regarding its age obtainable this summer, was that it is later than any other Lardeau formation, and it is a very fresh-looking rock.

DISTRIBUTION OF THE ROCKS.

Distribution of the rocks.

The distribution of the rocks can be referred to only briefly in this preliminary report. At Revelstoke the rocks consist of schists, gneisses, impure crystalline limestones, pegmatites, granites, etc. That is, the sedimentary series is much cut up by granitic intrusive rocks and is highly metamorphosed. The same holds true on the Columbia river and upper part of Upper Arrow lake. Masses of granite and their dykes, many of them between beds of the stratified rock, are numerous. A large mass of granite occurs at Saw-mill point, extending southward to near Halcyon. The main body of granite occurs between Arrow lake and Trout lake, forming the greater part of the Lardeau-Arrow lake divide. It extends south-eastward over the Trout lake slope forming the heads of the tributary brooks, and about Rock creek comes within a mile or so of the lake. From hence its contact is more southerly, so that at Poplar creek it is found about 10 miles up the

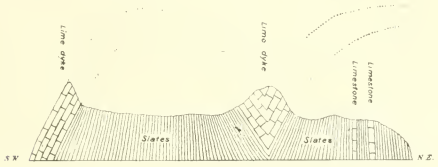
brook from the Lardeau valley. Further south it appears to attain even larger dimensions. The Trout Lake valley, the North-east Arm and the country between Fish river and the Columbia, are largely made up of the dark slates and phyllites with some limestone bands and a little of the greenstone and green schists. The strike of the beds is about 280°, so that these rocks extend as long bands about north-west and south-east across the district. Between the north-east arm and Camborne an important band of the green schists crosses the Trout lake–Ferguson wagon road and the south-west face of Silver Cup mountain. They are also important on the Lardeau river. At Camborne and for a little distance north is a band of slates and phyllites, with dykes of the diabase schist. This band extends south-easterly across the country, crossing Beatrice mountain at the head of Mohawk creek, over Nettie L. mountain, and over the north-east slope and summit of Silver Cup mountain. It crosses the Lardeau river about Tenderfoot creek, and continues through Poplar creek. Northeast of this band, the green schists are again developed, giving place a little farther north-east to the lime-dyke series which consists of a mixture of slates, phyllites, schists, and some greenstone dykes. Some dykes of diabase schist and important limestone bands also occur. This series, easily traceable on account of the way in which the heavy band of limestone withstands weathering, can easily be followed across the whole length of the district in a direction of about 285 degrees. This formation is met with a short distance up Gainer creek, at the head of the North Fork of Lardeau creek, and the heads of Pool and Lexington creeks.

ATTITUDE OF THE ROCKS AND STRUCTURE OF THE DISTRICT.

Geological structure.

Since there is a close resemblance between the stratified rocks across the district, except in the degree of metamorphism they have undergone, since the greenstone and green schist bands are not always continuous and uniformally interbanded with the stratified rocks, and since there are few well-marked horizons, it is difficult to make out the structure of the district. In the greater part of the district the rocks are tightly folded along axes running approximately 280°. The axes pitch northward in the northern part of the district. At many points they are compound folds, the main arch consisting of a number of anticline and syncline folds (anticlinorium). This structure is further complicated by the intrusion of eruptives and at a few points at least, by faulting. In the northern part of the district near the Columbia the folds are more open. Mount Cartier and the mountains along this range appear to be on the summit of an anticlinorium, the rocks

dipping north-westward on the Columbia slope, and at a comparatively low angle north-eastward on the eastern slope. Around the Northeast Arm the beds are much disturbed by granite intrusion and consequent minor faulting. Throughout the rest of the district the strike is remarkably uniform. (between 250 and 300 deg. but mostly 280, which is about the average of all readings) and the dip pretty constantly northward at a high angle, except where influenced by minor folding. Trout lake valley appears to be on the south-westerly limb of a large, slightly overturned anticline. The conglomorate seen here, which might form a key horizon for working out the structure, was not seen elsewhere. At the head of Gainer creek the structure is revealed by the lime-dykes. The first (most south-westerly) dyke is formed by the outcropping of a limestone band in the southwest limb of an appressed anticline. A subordinate anticline and syncline with the anticlinal arch eroded, the syncline still remaining, forms the second dyke as shown in the following diagram. Folding and faulting.



SECTION ON RANGE EAST OF PORCUPINE CREEK SHEWING LIME DYKES

A few miles to the south-east, on the ridge east of Cariboo creek, the the minor fold is a syncline and the major anticline is slightly overturned so that the limestone band dips a trifle northward.

The north-western limb of this great fold probably occurs away to the northwest of the West Fork of the Duncan. where a range appears to be composed of limestone. A second structural feature of great regularity and importance is the jointing at right angles to the strike, which with the bedding planes, cuts the rocks into rectangular blocks. These two structural features determine the chief topographical lines. Importance of jointing planes.

LANDSLIDES.

On the 28th of February, 1903, a mass of rock broke away from a precipitous bluff on the northwest side of the Northeast Arm, about two miles from Arrowhead. The base of the break is about 4,470 feet above sea, or 3,050 above the lake. The top of the break is about Arrowhead rockslide.

900 feet (estimated) above the base, or 3,900 above the lake. The width of the mass was estimated at about 300 feet and the average thickness perhaps 30 feet. It is probable therefore that at least 600,000 tons of rock broke away. It fell against the side of a funnel-shaped depression in the rock, out of which it ran as a narrow stream down a steep draw to the lake, which is here very deep. A small fan was formed at the base of the draw. The lake was frozen at the time, but the sliding rock of course broke the ice, and caused a wave which was estimated by the officers of the steamer *Kootenay*, to be about 6 ft. high. The tug *Revelstoke* was thrown up on shore and drawn back three times by the waves, and the hulk of the old steamer *Nakusp*, which lay sunk at Arrowhead, was tossed about for a few moments on top of the waves before sinking once more. Had it not been for the shoulder of rock which broke the fall of the slide rock, the wave would probably have been destructive in its violence. The rock composing the bluff consists of phyllite, striking approximately east and west and dipping, where the break occurred, at an angle of 50 deg. north. The rocks have a strong east and west jointing with a dip of 60 deg. south. Along the dip of the rock and the dip of the joint planes, the mass broke away in a zig-zag line, leaving an almost perpendicular face (considerably over 80 deg.). Behind this steep face are several open joints which will probably occasion further slides of small dimensions. As the rock-mass broke away largely across the beds, the Arrowhead slide would be classified as a Bergsturz like the great Frank rock-slide. Compared with the latter, the Arrowhead slide is of course diminutive. The causes of the slide were wholly natural. The rock-mass was in a state of unstable equilibrium, dissected by divisional planes, along which it was easily separated. The ties binding it to the shoulder of the mountain were gradually snapped by the action of atmospheric agencies, perhaps assisted by the earthquake tremor of 1901, until finally they were unable to bear the additional weight of the winter snow and the mass broke away along these divisional planes. Landslips have occurred in several other points in the district examined.

Attractions for tourists.

The grandeur of the scenery, the ease of access, the opportunity for mountain climbing, hunting and fishing, and of becoming acquainted with the characters of a western mining camp, should attract tourists and other visitors to the Lardeau. Fair hotels and transportation facilities already exist.

DEVELOPMENT OF THE DISTRICT.

The Lardeau country has been recognized as a mineral district for some time. Claims were located near Comaplix on the Northeast

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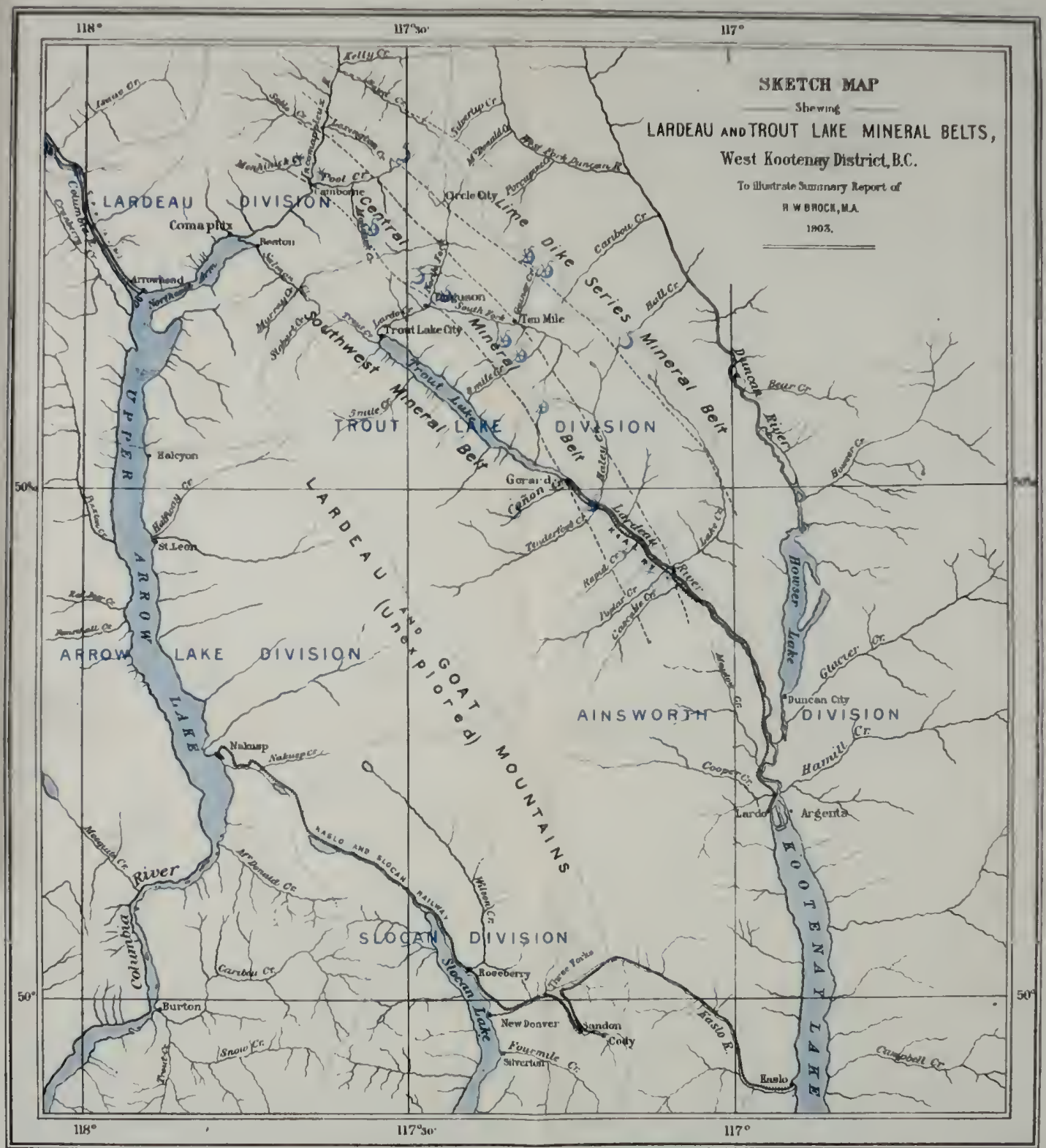
1904



Drawn for photolithography by O E Prud'homme

To accompany Part AA, Vol. XV.

Scale 8 miles to 1 inch

10 5 0 10 20 30

No. 853.

* *Gold.* *Gold-silver-lead sulphurets.* *Argentiferous galena.*

Arm as far back as 1888, and the Lardeau itself was prospected and staked ten years ago. From that time on, prospecting has continued and the development and opening up of the district have gone slowly forward. But the district has not received as careful attention from either prospectors or mining men as its mineral indications would warrant. Several causes have contributed to this. The rugged nature of the country, its isolation and consequent distance from smelters have made it impossible to handle anything but the richest ores; prospectors decided that it was a silver-lead district only, and searched for nothing else; the depression in the silver-lead markets had a strong retarding influence on the young undeveloped district; many claim owners in view of the high assays obtainable and regardless of the great cost of mining and transporting the ore, held their claims at prices that were prohibitive in an undeveloped district where so many natural difficulties had to be overcome. However, the district is now easily accessible and, in many parts, well opened up with roads and trails which greatly facilitate prospecting. A number of claims are now opened up and provided with the means for handling ore, and in some cases, treating it on the spot. With the successful operation of these and the recent discoveries of rich gold ores on Poplar creek the past summer, it is to be anticipated that the district will soon receive more careful attention from both prospectors and mining men. Developement of the district.

TRANSPORTATION FACILITIES.

The Lardeau district can be entered from the Upper Arrow lake or from Kootenay lake, the steamer connecting with the Arrowhead branch of the C.P.R. and the Arrow lake steamers run to Comaplix and Beaton at the head of Northeast Arm. From these points wagon roads, with stage lines, run to Camborne, the centre of the Fish river camp. From Beaton, a wagon road also extends to Trout Lake city at the head of Trout lake, and from thence a wagon road runs up Lardeau creek to Ferguson and Ten Mile. Stage lines operate between Beaton, Trout lake and Ferguson. A steamer connects Trout Lake city with Gerrard at the foot of the lake. From the latter, a branch line of the C.P.R. connects Lasdo, at the head of Kootenay lake, whence steamers run daily to Kaslo and Nelson. From these main lines of travel trails, run up the principle creeks. Routes of travel.

Mining Geology.

Fish River Camp.

This camp, situated on the lower part of Fish river, was located as a silver-lead camp, but at present the principle development is confined to gold leads. The ores occur in two zones. Camborne is situated on the south-western edge of one of these which extends north-westward up Menhinick creek and south-eastward across Pool and Mohawk creeks, over Great Northern mountain to Ferguson camp. Its extension south-eastward from the latter camp will be referred to later.

Mineral belts. This zone consists of a somewhat narrow belt of slate and phyllites cut by the greyish-green, yellow-weathering diabase-schist lying between somewhat broad bands of the green schist. In width and continuance this zone is somewhat irregular, owing to the nature of the green schist already alluded to, which may divide it into a number of subordinate bands, but in general it is easily traceable across the country. Farther to the north, at the head of Pool and Lexington creeks, and on Boyd, Kellie, McRae, Bullard and McDougal creeks is the lime-dyke series—the second mineralized zone. This runs with considerable regularity south-eastward. The green schists, so far observed, contain no ore bodies. A long line of claims has been staked all along the lime dyke series. The ores so far found are mostly galena with some blende, tetrahedrite, a little copper and iron pyrites, with quartz, calcite, siderite, and some sericite as gangue. Some of the ores carry high silver values, but some, as the Alma, on Pool creek, are large, low-grade ore bodies. Many of these claims have been crown-granted and are now lying idle. Little work of any kind was being done on this belt during the past season, attention being largely confined to the more southerly zone.

Eva gold lead. Claims were located some time ago on this belt for silver-lead. In 1900 an in experienced prospector discovered a quartz vein with some specks of galena on the lower slope of Lexington mountain, between Pool creek and Fish river, which he staked as a silver-lead claim. Assays revealed a high gold content, and a number of gold claims were staked on this lead. The Imperial Development Syndicate, Limited, of Nelson, was formed to take over and work some of these claims, under the management of Mr. A. H. Gracie. After some development, the Eva group was sold to the Calumet and B.C. Gold Mines, Limited. The Imperial Syndicate is now exploiting the Cholla group.

The main lead has been followed from Fish river south-eastward over the shoulder of Lexington mountain for about a mile, and it probably extends to Pool creek.

Eva Group.

On this group, now being operated by the Calumet and B.C. Gold Mines, Limited, the greatest amount of work on the lead has been done. The lead here consists of two veins, lying in and along two fault planes, connected by numerous cross-veins and stringers. The direction of the lead is about 120°, cutting the formation at a low angle. At the camp level the confining faults are 175 feet apart, and dip 80° away from one another. Since they are converging upwards, at No. 6 tunnel, 500 feet above, they are closer together, being 90 feet apart. Below, at No. 3 tunnel, the west fault changes its dip eastward. The country rocks are spotted phyllites, cut by the yellow weathering diabase schist. The veins are of quartz, carrying siderite and sulphides, the latter usually in small quantities only, together with free gold. The sulphides consist of pyrite, sometimes crystallized in the form of cubes, and pyritohedra, a little galena and zinc blende. In the Eva shaft the sulphides, especially pyrite, are present in quantity. The veins vary in width from a few inches to many feet. Gouge along the faults has usually confined the ore-bearing solutions within these planes and the crushed country rock between them, so that the veins occur along these lines and in the country rock between them. The southerly vein is called No. 1, the northerly No. 2. Large masses of quartz may be developed, especially where cross-veins join No. 1 and No. 2 veins. The cross-veins have not been observed to extend through No. 1 and No. 2 out into the country rock. In places the lead is of solid vein matter, sometimes banded, and with divisional planes parallel to the walls or to the stratification of the country rock. Sometimes the veins hold inclusions of the country rock, more or less replaced or mineralized by vein matter; in other places the quartz is deposited in bands between the lines of stratification. The rock between No. 1 and No. 2 veins and the cross veins, is itself often somewhat mineralized with quartz and pyrite, assaying perhaps $2.50 per ton. Slight faults subsequent to the vein formation, sometimes interrupt the continuity of the vein. Gold may be panned from the quartz almost everywhere, but the values are not evenly distributed. At No. 5 tunnel the vein and the cross vein, which form a small cliff with 50 feet exposed, are said to run $90 per ton. The quartz in the winze between No. 5 and No. 3 tunnels is said to sample $73 and the dump $50. Gold occurs, visible to the naked eye, in solid

Eva mine.

Vein minerals.

Distribution of values.

quartz, in seams in the quartz and along the selvage of a vein. Generally it is in small scales and nuggets ; sometimes scattered thickly through the quartz in particles as fine as needle points. It is often concentrated along the walls of a vein, or round the inclusions. As the walls and inclusions are often highly carbonaceous, the carbon may be responsible for the enrichment. The veins are usually of higher grade where a cross vein joins. Zinc blende is said to be a good indicator of values. The pyrite in the Highland Mary shaft is said to carry as high as $2,000 per ton. Galena may or may not carry gold values.

About 2,200 feet of development work has been done on the claim. Of this 500 ft. has been done on No. 2 vein ; the rest consisting of tunnels, winzes, shafts and cross-cuts to No. 2 vein, has been done on No. 1.

The lower tunnel is about 1,000 feet below the Highland Mary shaft and 1,000 feet above the river valley, down to which the vein has been followed, proving its continuance in depth. An aerial tram was being constructed from the lower tunnel to raise the ore over a shoulder of the hill and convey it 4,200 feet to a stamp mill, which has been built on the north side of Pool creek above Camborne. The mill is well-constructed and well-equipped with ten stamps, resting on a graded rock foundation. The machinery is to be operated by three Pelton wheels run by water, drawn by a flume from Pool creek, giving a 400 feet head. The mill was almost completed when visited by me in August, and is now running, so that the values carried by the run of mine will soon be determined. The operations connected with the Eva group are being carried on under the superintendence of Mr. John Knox, jr., M.E.

Stamp mill.

The Oyster-Criterion Group.

Oyster-criterion mine.

This group of claims, operated by the Ophir-Lade Mining Syndicate, Limited, is situated southeast of the Eva group on the extension of the same lode. As on the Eva group, the lode consists of a belt of fractured country rock, containing several well-defined veins, one of which is probably the Eva No. 2. The yellow-weathering diabase schist which characterizes the Eva lead, is in evidence here also. As in the Eva, while the veins are partly fissure-fillings, replacement of the country rock by vein material has also been important. The country rock, which is mostly lead-gray carbonaceous phyllite, may be seen in all stages of alteration to solid vein-matter. Quartz is developed between laminae of the phyllites. This vein material then eats into

the rock-forming cloud-like masses and the grains of the rock gradually lose their identity. Finally they are completely changed to vein matter, though often with nuclei of the phyllite remaining. In places therefore the lead may consist of a mass of reticulating veinlets of quartz with phyllite inclusions between. The gold is often concentrated around these inclusions, which are frequently somewhat graphitoid; consequently the mottled parts of the vein are often rich. The gold may be visible to the eye, sometimes in rather coarse nuggets, and almost all, if not all, of the vein will pan gold. What has been said of the distribution of gold values in the Eva appears to hold good here. In the Criterion shaft the vein with some phyllite inclusions is 15 feet wide. The Criterion tunnel runs in a northerly direction for 135 feet, when a galena vein, five feet wide is encountered, which strikes 43 degrees. The tunnel then follows the galena vein. This vein lies between two slips, with gouge and slickensided walls. In about 65 feet along the galena lode, the Criterion quartz vein is encountered striking 261 degrees, angle 65 degrees north. The galena vein, here narrowed down to about 1 foot, cuts through the quartz vein and faults it, the eastern limb being encountered 15 ft. farther in. The gouge on the walls of the galena vein continues unbroken through the quartz. The eastern limb of the quartz vein strikes 90 degrees, and dips at an angle of about 38 deg., so that the galena vein fault was not a simple slip, but the movement was a rotary one. A cross cut on the quartz vein 4 to 5 feet wide is said to sample $80 to the ton. About 60 feet beyond the quartz vein, the faults which the galena vein has been following, diverge, the easterly one running 60 deg. while the westerly turns to 18 degrees. The galena vein and the tunnel follow the latter. Three hundred and fifty feet in from the cross-cut the galena vein encounters an east and west fault with a dip of 80 degrees south, which cuts it off completely. A little farther in a second fault is met with. At 525 feet, a quartz vein several feet wide was encountered in the tunnel, striking 295 deg., angle, 80 deg. south. This is believed to be Eva No. 2 vein.

Veins and faults.

In all about 1,600 feet of work has been done on the Oyster, Criterion Group at the time it was visited. The galena vein contains galena, blende, copper and iron pyrites, largely developed, in a quartz gangue. A thin film of a silver-bearing mineral like argentite was also noticed. This vein is said to carry about $10 in gold, beside silver values. From the way in which the two quartz veins are striking they should intersect on the Oyster claim. Near their intersection it is possible that cross veins and other veins may be encountered, and reasoning from analogy, where the veins intersect increased

Contents of vein.

values may be expected, as in the Eva where the intersection of veins favourably affects the gold content. An aerial tramway has been constructed from the mine to a stamp mill erected on the south bank of Pool creek behind the town of Camborne, 3,500 feet from the mine and 1,500 below it. The mill is a ten-stamp one, to be operated by water-power obtained from Pool creek. The mill, under construction at the time of my visit, is to be well equipped with crushers, vanners, and all the necessary machinery for a gold mill. A compressor to supply power for drills at the mine was also to be installed at the mill. The Oyster-Criterion operations were being carried on under the direction of Mr. James Lade.

Camborne Group.

Camborne group.

This group, situated on Menhinick creek on the west side of Fish river, a short distance above Camborne, has been operated by the Northwestern Development Syndicate; the chief work has been done on the Goldfinch claim, about 1,600 feet above the mouth of the creek. There are several veins of quartz in phyllites that strike 150 deg., angle 60 deg. north, or toward the Eva mine. This mine is often said to be on the western continuation of the Eva lode, since, if the latter crosses the river, this is about where it should be found, but this statement does not admit of direct proof. Be this as it may, it lies in the same mineral zone. The vein, however, so far as seen, does not possess great regularity, thereby making exploitation more difficult. The values are not evenly distributed. In some places, the ore is of exceptional richness, specimens being obtained that are full of coarse gold; at other points values are low. The ore consists of white, sometimes watery, quartz with a sprinkling of galena, blende, pyrite and chalcopyrite. The yellow, apparently very pure gold, occurs with the sulphides, particularly alongside the blende, though often with the galena, and also scattered through the quartz. Many of the richest specimens are in contact with the phyllites, and one was seen in which an inclusion of phyllite was itself impregnated with gold. The ten-stamp mill at the mouth of Menhinick creek, connected with the mine by an aerial tram, is operated by water power from Menhinick creek, and has treated some ore, but it was not in operation when visited. The vein-matter as mined was put through the mill—apparently diluting the rich ore with a large amount of lean material. Although no concentrating was done, the extraction is said to have been 90 per cent of the values, showing that these ores are amenable to stamp-mill treatment, and that most of the gold is free. The operations so far conducted on this group, however, do not afford a basis on which to estimate the values of the gold ores of Fish river camp.

Nature of ore.

Other Occurrences.

Quartz veins occur on a number of other claims. The Cholla group is being developed by the Imperial syndicate. The veins sometimes stand up like stone fences above the softer phyllites. On the Copper Dollar and the Kingston very large masses of quartz occur which, though of low grade, should be of economic importance if they contain the values they are credited with. At the Beatrice, on the divide between Mohawk creek and the North Fork of Lardeau creek, about six or seven miles from Camborne and five thousand feet above it, is a promising looking vein of quartz, one and a half to four feet wide, heavily mineralized with medium to very fine grained galena and light brown zinc blende intimately mixed, a considerable quantity of very fine grained tetrahedrite and pyrite in bands through the ore. The ore is said to carry three to eight dollars in gold, up to 280 ounces of silver, and 20 per cent lead. A shipment of 280 tons rawhided to Ferguson is said to have yielded a substantial profit, notwithstanding the long haul. A second similar vein and a quartz vein containing free gold with a little of the sulphides also occur. About 300 feet of work has been done on these veins, but the main operation has been the running of two tunnels from the north base of the hill to eventually tap the silver-lead and quartz veins at depth. Beatrice and other claims.

The country rocks are slate and phyllite so carbonaceous as to blacken everything they come in contact with, striking about 296 degrees, angle 65 degrees north, but much contorted, rolled and slickensided. In the same basin are several quartz veins which may be auriferous.

SUMMARY.

The foregoing description will illustrate the character of Fish river camp. Two classes of ores occur—silver-lead ores carrying a small gold value, and gold quartz ores carrying very small quantities of the sulphides found in the silver-lead ores. Evidence regarding the relative ages of these two classes of veins is not conclusive. The galena vein on the Criterion is evidently newer than the Criterion quartz vein. On the other hand, it is cut off by a fault parallel to that occupied by the Eva No. 2 vein. These faults are likely to have been formed at the same time. If this is so, the Eva No. 2 must be later than the galena vein; that is, some of the gold veins may be older and some newer than the silver-lead vein. In this case they may all have been formed during one long continued period of mineralization, but during different stages, the mineralizing solutions changing somewhat in composition. Further information is necessary before these points can be Two classes of ore.

settled. Little development has been done on the silver-lead veins, though some are promising-looking. The work already done on the quartz veins has shown a considerable tonnage of ore, much being of good grade. The veins have been shown to have continuity both horizontally and vertically. At the deepest point at which it has been seen in the valleys, and at the deepest point below the actual surface of the ground yet reached (100 feet on the Criterion, probably deeper on the Eva) the character of the ore remains unchanged. The two new stamp mills will soon demonstrate whether the whole or the greater part of the vein-matter can be profitably treated. If so, the future of the camp is assured. But even if only the richer portions of the veins can be treated; if they mill as high as they are said to sample, careful management, judgment, and the close study of the ore, may be expected to be attended by at least a fair measure of success. From the character of the deposits it is evident that there always exists a possibility of striking rich pockets, and that further veins may be encountered, thereby adding to the prospects of the district.

Prospective tonnage of ore.

FERGUSON CAMP.

Ferguson is the mining centre of Lardeau creek. The mineral zone from Camborne crosses to the Lardeau slope from the Beatrice, and continues over Great Northern mountain, over the spur of Ferguson mountain, between the forks of Lardeau creek and up the north slope of Silver Cup mountain to its summit. On this belt, numerous claims have been located. Three of these will be described as illustrative of this section. The most important mining operations yet carried on in the Lardeau district are those in connection with the Nettie L. and Silver Cup mines, conducted by two English companies, the Great Western Mines, Limited and the Silver Cup Mines, Limited, with Mr. George Attwood, M. E., consulting engineer, and Mr. Donald G. Forbes, general manager.

Ferguson mountain.

NETTIE L. MINE.

The Nettie L. is situated on a spur of Ferguson mountain in the neighbourhood of 5,100 feet above sea or 2,100 above the town. A wagon road about two miles long connects it with Five-mile on the south fork of Lardeau creek.

Nettie L. mine.

The country rocks are carbonaceous phyllites and slates. The silicious rocks already referred to occur in the neighborhood, also dykes of the diabase. The average strike of the rocks is about 280 deg. but it varies somewhat on account of folding. There seems to have

been developed locally a small canoe-shaped syncline, whose symmetry is disturbed by faulting. While the westerly strike and high-angle northerly dip are most commonly seen, locally any strike and dip may be found according to the position of the point in the fold.

About 6,000 feet of work has been done on this property, principally on the Nettie L. and Ajax claims. Three main ore bodies have been opened up, known as the Main lead, the Cross lead and the Big Quartz vein. The lowest level on the Nettie L. starts in as a cross-cut tunnel southward across the formation, and 300 feet below the uppermost working. It cuts across the big 40-feet quartz-lead which strikes south-east, and continues to the main lead, about 670 feet in. It then follows the main lead eastward about 800 feet. At the end of this drift the quartz lead has come in contact with the main lead. This level is connected through to the upper workings on the lead. The quartz lead cuts across the formation, and the main lead while nearly following the strike of the rocks, is independent of their bedding. The walls of the main lead are sometimes slips. Stringers run off into the country rock which is fractured and traversed by slips. There are two levels above this lower one. On the surface, near the upper tunnel, the cross vein coming in from the southeast, turns to 321 degrees and then round to 2 degrees, which course it is following when cut off by the slip, forming the south wall of the main lead. In the second level it is still cut by the main lead, but in the lower workings, it is said to angle round and become parallel to or join the main lead. Its relationship to the bedding of the rock could not be solved beyond doubt, on account of the fracturing and slipping in the rock, but it appeared to be cutting the formation. On the other hand, its course would suggest that it occurred between the beds forming the end of the canoe-shaped synclinal basin. To the east on the Ajax, at the east end of the drift, ore occurs in seams and reticulating veins following the strike of the rocks. The strike is eastward with a northerly dip, but followed eastward, the beds successively bend northward with a westerly dip; that is, we have here the eastern end of a synclinal basin. Successive portions of the ore following the beds turn northward from their original course. The occurrence of ore on the axes of folds—miniature saddle reefs or saddle reefs inverted—is not an uncommon feature in the minor folds of the Lardeau district. This folding is accompanied by a certain amount of slipping and faulting. The cross lead, as its attitude suggests, may possibly represent ore occupying a similar position at the western end of the fold, but more work will have to be done between the Ajax and Nettie L. before this can be proved. So far the evidence is rather unfavour-

Lower workings.

Upper workings.

Inverted saddle veins.

able to such a theory. The ore consists of quartz, usually heavily mineralized with tetrahedrite, galena, blende, and some copper and iron pyrites. Where weathered, wire silver is sometimes found. Occasionally the various minerals occur as separate bands in the ore. Sometimes the tetrahedrite surrounds masses of blende, and veins and veinlets of copper pyrites traverse the tetrahedrite, so that the order of development of the minerals has been—blende, tetrahedrite, copper pyrites and galena. Calcite and sericite occur in the quartz gangue. The vein material may form a wide solid mass or may occur as numerous reticulating veins and stringers in the rock. While mostly occurring in and about fissures, it may be deposited between the beds. Replacement of the country rock by vein material has taken place, so that all stages of development may be met from a few stringers of quartz to a complete network, and finally the whole rock may be replaced by ore. The rock is usually highly carbonaceous near the ores. Besides silver and lead values, the ores carry some gold. Gold is found in the tetrahedrite and, in the Ajax tunnel, quartz with blende, pyrite and a little galena is said to run $100 in gold. Some assays are said to have run as high as 20 ozs. in gold. About 2,300 tons of ore have been shipped, said to have returned over $121,000 net. The average values are said to be:—Gold, 13 oz.; silver, 149·6 oz.; lead, 26·9 per cent. The ore retains its character and values at the greatest depth yet attained, 300 feet.

Values of the ore.

Shipments were discontinued in June, pending the completion of an 8,000-feet tramway from the mines to the silver mill, under construction at Five-mile, to treat this and the Silver Cup ore. Up to the present time, on account of the long haul by wagon to Trout lake, and the cost of shipping to the smelter at Nelson or Trail, only the higher grade ore could be handled, and a dump of about 4,000 tons of second grade ore is now ready for the mill. It is expected that this and the ore from the large quartz vein can be successfully handled under the new conditions. About 50 men were being employed at the mine. The mine is equipped with an air compressor, etc.

SILVER CUP MINE.

The Silver Cup Group consists of nine claims situated on the north slope of Silver Cup mountain, south of the South Fork of Lardeau creek, about 5 or 6 miles from Ferguson, and at an elevation of rather more than 6,500 feet above sea. About 5,000 feet of work has been done, mostly on the Silver Cup and Sunshine claims. The country rock consists of carbonaceous slates with the usual strike and dip, and dykes of the yellow-weathering diabase schist, which sometimes cut the

Silver cup mine.

slates although generally about parallel to them. The ore occurs in two leads, striking nearly parallel to the formation. The northern lead is called the Silver Cup lead and the southern, the Blind lead, as it is not exposed on the surface. Between the two leads are cross fissures, one of which makes a large body of ore. The ore body usually consists of a number of veins of quartz parallel or nearly parallel to the formation, with a network of cross veins. The ore is localized in chutes, lenticular in form, both horizontally and vertically. Some of these are of large size, one continuous slope being 275 feet long. The chute on the cross vein is 7 feet wide. The chutes occur where cross fissures meet the lead, especially those from the foot wall of the Blind lead and the hanging wall of the Silver Cup. The ground is traversed by numerous slips running in all directions. Some form apparent walls to the lead, but vein matter is usually found beyond them. So far the ore is confined to the slates, though the diabase schist is mineralized with pyrite and one dyke is close to the hanging wall and another close to the foot wall. Ore chutes.

The character of the ore is similar to that of the Nettie L. Tetrahedrite has been taken out in blocks as large as 18 inches in diameter. Some of the best tetrahedrite has been found at the bottom of the winze in the lowest workings—600 ft. below the highest—showing that the values are not due to mere superficial alteration and enrichment of the vein, but are continuous to a considerable depth at least. Besides the silver and lead values (172 oz. silver and 23 per cent lead) the ore carries $12 per ton in gold. The pyrite in the vein seems to be the chief gold-carrier, but only in quantity when it is accompanied by a little galena. On the upper Sunshine workings pyritic ore with a little galena, not at all resembling a silver ore, runs 175 oz. in silver besides $20 in gold per ton. Up to the present the cost of mining and smelting has been about $50 per ton, so that only the richer ore could be shipped. A dump of about 4,000 tons of second grade ore has accumulated at the mine, which yields by repeated sampling 60 oz. silver and $8 or $9 per ton gold. It is estimated that the new mill at Five-mile will reduce the cost of mining and extraction to about $10 per ton. If these expectations are realized, not only will the dump yield handsome profits, but large masses of mineralized rock containing stringers of quartz and net-works of quartz veins will become ore. Character of the ore. Cost of mining and treatment.

An aerial tramway about 8,000 feet long connects the mine with the South Fork wagon road at Eight-mile creek, about 3,000 ft. below. This tram is used to ship ore and to bring up mine timber, wood and supplies; even the boiler, air compressor and hoist were brought up on it. A second tramway, 15,000 feet long, is being constructed from the mill

to a point on the first to convey ore to the mill. A third tram is to be constructed from the highest working of the mine to the upper terminal of the first tramway.

THE SILVER MILL AT FIVE-MILE.

Mill at Five-mile.

The mill in course of construction to treat the Nettie L. and Silver Cup ores is located at Five-mile on the South Fork of Lardeau creek, about a mile and a quarter above Ferguson. The mill is 216½ ft. long by 76½ ft. wide, or 95½ feet. with the retorting furnaces and stack. It is being built by the Union Iron Works of San Francisco. All the timber used for the mill, houses, offices, etc., is being cut and dressed in a sawmill on the grounds. The machinery is being installed in two symmetrical units, so that ore from each mine may be treated separately throughout the whole process. As this is the first silver mill erected in this district, a brief description of it will be given. The ore is delivered from the respective mines into separate grizzlies through which the fine ore passes to bins, while the coarse rolls to the crushing floor, where there are two Blake crushers. The ore is then fed automatically into two stamp mills of ten 1000-pound stamps each, operated by a 75 h.p. induction motor. The pulp from the mortars is automatically sampled and passed to two sets of Spitzkasten hydraulic sizers, the coarse pulp going to four 10-ft. Dodds riffled buddles ; the fines to four vanners. The sulphides are then dried on a drying floor, whence they are delivered by elevators and screw feeds to 2 Howell-White revolving roasting furnaces, at the same time being automatically mixed with salt delivered from the salt grinders. The lead driven off by the roasting may be recovered if desired. The ore is then conveyed to a cooling floor, and afterwards dumped into ten 5-foot amalgamating tanks, through the bottom of which steam is injected to assist in amalgamation. The charge is next run to five 8-ft. settling tanks. After leaving the settlers it is strained, the quicksilver being elevated and run back to the mercury tank supplying the amalgamating pans, and the amalgam taken to the retort-room, where there are two amalgam furnaces. The quicksilver driven off from the furnace is elevated and returned to the mercury tank. Provision may be made for saving the copper if sufficient quantity is present. The power plant, in a separate building, is supplied with two Pelton wheels, electric generators, transformers, etc. The power is supplied by water brought by a 3,700-ft. flume from Lardeau creek, and delivered at the power house under 145-feet head.

Treatment of the ore.

THE TRIUNE MINE.

The Triune mine is situated a short distance south-east of the Silver Cup, only a small ridge and the head of a gulch separating them. In elevation, it is about 1,000 feet higher than the Silver Cup terminal. It is one of the most picturesquely situated mines in British Columbia. The tunnels run into the face of a cliff under a small glacier, a rope being used to assist in the ascent to the lower tunnel. The upper tunnel is reached through an up-raise from the lower. A considerable amount of work has been done; the lower tunnel has been driven in 300 feet, the upper tunnel 150 or more; the total amount of work done aggregating possibly 1,200 lineal feet. Triune mine.

The country rock is slate with a strike of 272 feet and a dip of 70 degrees north, but suffering local disturbances. With it occur a large number of dykes of the diabase schist. The main lead is a strong vein of somewhat variable width, in places as much as 8 feet wide, but usually not exceeding 4 feet. It is found in the slate with a diabase dyke near the foot wall, the vein sometimes even traversing the dyke. A second parallel vein occurs in a band of slates on the south side of the dyke, with the dyke as a sort of a hanging wall. The lead consists of solid mineralized quartz or stringers and veinlets of quartz reticulating through the country rock. Hence there are often small horses with veinlets running through them. As the ore is not abundant on the surface of the lower working, it evidently occurs in the form of chutes, as on the Silver Cup. In other respects it is similar in character to the Silver Cup. The upper part of the vein is possibly somewhat richer in grey copper than the lower, but it is also richer in blende and poorer in lead, which is the reverse of what might be expected if much enrichment by surface waters had taken place. The first-class ore is stated to carry $12 to $18 in gold; over 200 oz. in silver and 30 per cent of lead to the ton. The following information regarding the distribution of values through the minerals of the ore was furnished by Mr. Dunn, the superintendent at the mine:— Two veins.

The pyrite will assay $20 in gold per ton. On the surface where the ore is oxidized to 'carbonates' the gold value amounts to $50 per ton. Pure galena will assay $200 per ton in value of all the metals.

A condition rather uncommon for this latitude is found in the upper workings of the mine, that is approaching the bed of the glacier. The ground is here saturated with water in the form of ice. The temperature must remain below freezing the year round, for in midsummer the ground remains frozen and the walls are coated with frost crystals. The water travels downward by melting and freezing, for if a tunnel Conditions due to frost.

is not in use, it fills almost to the top with ice, and stalactites and stalagmites and pillars of ice are formed. When the frozen ore is taken out of the mine and melts, it is stated that it loses 50 per cent in weight, and is reduced to a slime, difficult to handle. Snow-slides have made a permanent camp impossible, so that the mine has not been operated in winter. Snow-slides also overturned the tramway, more than a mile and a half long, which was put up last year to connect the mine with the wagon road. These disadvantages attendant upon its unique situation, have made an ore carrying less than $100 to count as of second grade. Notwithstanding, it is estimated that at the close of the present season, the output of the mine will have reached a total of $40,000. It might be mentioned in passing that a dyke of diabase near the Triune cabin is somewhat heavily mineralized with quartz, siderite, galena, copper, etc.

Triune a probable extension of Silver Cup.

The Triune is situated on the south-eastern continuation of the mineral belt on which the Silver Cup is situated, and it is quite probable that it is on the same general lead. As the Triune is at a higher elevation and the dip is northward, the lead outcrops farther south than at the Silver Cup. It is not to be inferred that ore is necessarily developed throughout the whole distance, for it has already been stated that it is localized in chutes. This mineral belt extends over Silver Cup mountain, the Cromwell and other claims being situated on it. It probably runs along the range past the upper part of American, and Haskins creeks, but on account of the snow it was impossible to trace it up. A number of quartz veins occur on this mountain, some showing free gold. Some quartz stringers occur containing feldspar as if they were an acid facies of pegmatite.

Gold veins on Silver Cup mountain.

A number of other claims are situated on this belt in the neighbourhood of Ferguson, but they have not had as much development, and their description would add nothing new regarding the character of the ore and conditions of mineralization.

Lime-dyke mineral belt.

The lime-dyke series of rocks forming a belt along the head-waters of the tributaries of the Lardeau, and West Fork of the Duncan, is well mineralized, but on account of the altitude and distance from transportation, development has necessarily been slow. Were it not for the metamorphism which some of the rocks have undergone, and the prominence of limestone, there is little difference between the rocks and ores of this belt and those of the mineral belt just described. They contain numerous diabase and porphyrite dykes and sheets; bands of the green schist are also met with. The rocks are compressed into folds, so that while the strike is fairly constant, the dip varies from north to south. The possible influence of the folding upon the ore bodies should be borne in mind in exploiting the ores of this

district. Somewhat auriferous silver-lead ores, and siderite-bearding quartz veins are found in this belt also.

The Badshot, one of the best known groups of claims, is situated on the west side of Gainer creek in the south base of the first "lime-dyke." The veins occur in the "dyke." The bluish limestone is shot through with veins and stringers of quartz and somewhat ferruginous calcite, generally having a low dip northward. The Badshot vein, several feet wide, dips into the mountain at an angle of about 28 deg. north. Its outcrop along the side of the dyke is plainly visible. The vein matter consists of somewhat decomposed calcite, quartz, galena, and tetrahedrite. An incline shaft, about 70 feet deep, has been sunk in the vein. A galena vein 18 inches in width and said to run 85 in gold, 225 oz. in silver, and 75 per cent lead, has also been opened up. Galena and tetrahedrite were the only metallic minerals seen in this ore. Badshot claim.

Some ore was shipped during the summer from the Mohican, opposite the Badshot on the east side of Gainer creek. On the Ophir-Lade group situated in this belt, the quartzose ore is said to carry high values in free gold.

TROUT LAKE DISTRICT.

Some mineralization has taken place in the Trout lake valley. Quartz veins somewhat mineralized, occur near the Beaton wagon road. A rather strong vein of mineralized quartz occurs on the Lake shore below Abrahamson creek. On the mountain slopes southwest of the valley, isolated groups of claims have been staked, practically along the whole length of the valley, some of them furnishing very promising-looking samples. From the position and number of these locations, this may be considered to form a third mineral belt. That the locations have not been more numerous may perhaps be explained by the difficulties in the way of prospecting, due to the vegetation and to lack of facilities for getting supplies into this part of the district. The Lucky Boy claim on the shoulder of the hill south of Trout creek, about three miles from Trout Lake city, is being developed and is shipping some ore. Several open cuts and one or two inclines have been run on the main vein, which varies from a few inches to several feet wide. In the main stope it pitches south-westward at rather a high angle. But for the most part it is almost horizontal, with perhaps a slight south-westerley dip, cutting almost at right angles the formation, (schist or altered silicified phyllites), which dips north-eastward at an angle of about 85 degrees. There are several parallel fissures which are not so well mineralized. Some inclusions of country rock occur in Trout lake mineral belt.

Lucky Boy mine.

these and there is evidence of replacement. The quartz is somewhat drusy, and the ore often occupies these druses or occurs scattered through the quartz, in kidney or almond-shaped masses, or as small veinlets. The ore consists of galena, tetrahedrite, zinc-blende, calcopyrite, pyrite and a little native silver. On the surface it weathers to lead and copper carbonates. On the Horse Fly, adjoining the Lucky Boy, the ore occurs in limestone. On the Ruffed Grouse, Copper Chief and Willow Grouse claims, some distance above the Lucky Boy, the same minerals occur. The sulphides reticulate through the quartz as if formed later, or collected by concentration, so that in places it resembles brecciated ore, with the fragments cemented by sulphide. Pyrite is here more plentiful, and masses of pyrrhotite and some molybdenite also occur. The relationship of the metallic minerals to one another is interesting. The galena is found both in and surrounding tetrahedrite; the blende encloses both. Chalcopyrite encloses and forms veins in the foregoing, and pyrite and galena form the matrix for the others. The order of development would seem to be: galena, tetrahedrite, chalcopyrite and pyrite, galena, blende, but from the way in which the chalcopyrite surrounds and eats into the tetrahedrite, it looks as if it was formed by alteration of the latter, and from the frequency with which it occurs as a thin seam between tetrahedrite and pyrite, as if the action of the iron sulphide on the tetrahedrite might have induced this reaction. The practical bearing of this lies in the fact that since the tetrahedrite was one of the first formed minerals, there is firmer ground for our belief that the rich mineral will continue at depth. Work was progressing on the Ethel on the north-west side of Glacier creek.

Tetrahedrite.

Some good showings of ore are said to occur on claims up Five-Mile and Canyon creeks, but the season was too short to enable a trip to be made to them. Some ore was being packed to Trout lake from the American mine at the head of American creek, a claim located on the central mineral belt. The claims on the Trout lake district enjoy the great advantage of being near transportation facilities, permitting a lower grade ore to be shipped. The cost of freight and smelting ore delivered on Trout lake is from $16 to $18 per ton.

THE POPLAR CREEK DISTRICT.

Poplar creek district.

The basin of the Lardeau river, below Trout lake, is now usually referred to as Poplar creek district, since the excitement and rush into the district this summer was caused by discoveries about the mouth of Poplar creek. The district is not altogether new to prospectors; some of the most highly-prized claims, such as the Goldsmith,

were staked ten years ago and abandoned, and some prospectors have been at work ever since. When the construction of the railway from Lardo to Trout lake was decided upon, the district received renewed attention. The Lucky Jack, situated on the railway line, which has been responsible for the greatest part of the enthusiasm over the district this summer, was located in 1900 by Aug. Buffalo, and abandoned after two assessments had been done. Another claim, now well spoken of, is the Dominion at the mouth of Cascade creek, the first creek below Poplar, which was located by the same prospector, the same year, and is still held by him. But until recently, the Lardeau was regarded as purely a silver-lead district. Yet gold has been known to occur here for several years, but not until this summer did the public become agitated over the fact. In 1898 H. Rodgers and Henry Schmidt located the North Star and other claims on the north side of Rapid creek, the first creek above Poplar, about 800 feet above the Lardeau valley. It was located on account of a showing of galena, but was soon found to be auriferous. About 60 feet of work has been done on it every year since. In 1901 John Winquist located the Spy Glass, about 12 miles up Poplar creek, which, it is said assayed $120 in gold, besides high silver value. In 1901 Marquis and Gilbert located the Ochre and Ophir claims on the north side of Poplar creek about a mile from the mouth, and 640 feet above the Lardeau valley. In 1902 Marquis located Gold Park, adjoining these claims, and on it last June specimens containing visible gold were found. These were exhibited in Kaslo soon after and started the rush to the district which has resulted in the discovery of numerous quartz-veins yielding exceptionally rich specimens of native gold. All of the ground about the mouth of Poplar creek has been staked, some of it many times over and locations have been made from the second crossing below Cascade creek to beyond Tenderfoot creek. A town is springing up at the mouth of Poplar creek. First gold discoveries.

The rocks of this lower part of the Lardeau basin are similar to those found in the upper, and consist of greenstone and green schists, slates and phyllites, with a few limestone bands and dykes of the yellow-weathering diabase and schist formed by its deformation. The greenstone seems to be more heavily developed here than above, and the diabase dykes to be larger and more numerous. But time did not permit of making a detailed examination of the whole district. The veins occur on a belt of slates and dykes which crosses the Lardeau river from the north-west, above Tenderfoot creek, and extends south-westward, nearly parallel to the river, across Rapid, Poplar and Cascade creeks. On account of the snow the Silver Cup belt could Rocks of Lardeau basin.

not be followed south-east across the Silver Cup mountain, but there is little doubt that the Poplar creek belt is its south-eastern continuation. This supposition is based on the character of the rocks and ores, the strike of the rocks and the position of the belt relative to other formations. Thus the lime-dyke series is seen up Lake creek, showing the rocks to be angling toward the river. In Rapid creek, boulders of a conglomerate similar to that found in Trout lake, afford pretty good evidence that this band is to be found up Rapid creek, that is, it has crossed the valley and is now away to the south-west. The veins are similar in character to those of Fish river and Silver Cup mountain already described, except that at Poplar creek arsenopyrite is occasionally found. But the introduction of a new mineral at a particular point in a mineral belt is no rare thing. In this part of the belt veins are very numerous. In some places they form a net work They usually conform to two principal directions. One set runs about 290 degrees, that is, almost parallel to the formation, though the dip may vary, and the second set cross-cuts the formation running nearly north and south. The claims which had received most attention up to the time of my visit were the Lucky Jack, Swede group (Goldsmith), Gold Park, on Poplar creek; North Star on Rapid creek, the Maggie May and Handy groups near the railway at Tenderfoot.

Poplar creek belt is continuation of central belt.

Principal claims.

LUCKY JACK.

Lucky Jack mine.

The Lucky Jack is situated on the west side of the railway about a quarter of a mile below Poplar creek crossing. The main vein is exposed in the hillside about 100 yards from the track, standing out like a wall from the more easily weathered country rock. The country rock is a rusty-weathering greyish schist which proved on examination to be the diabase-like rock in a squeezed condition. It is more or less impregnated with pyrite in small grain and veinlets. The vein is of quartz, two to five feet wide, averaging perhaps three feet, standing almost vertical and with a strike of 338 degrees. A number of other veins occur on the property but most of these have the westerly strike. The quartz is milky to watery white, carrying a little arsenopyrite, galena, and pyrite with, in places, very coarse free gold, liberally splashed through it, in bunches, masses, fibers and plates. The gold occurs in the pure quartz, in the sulphides, surrounding sulphides and inclusions of country rock or along the walls. Fine gold also occurs in the vein, as in the tunnel which is being run in on the vein, quartz which contains no visible gold is said to pan well. This vein has afforded many magnificent specimens of native gold, some of the finest ever found in the province. One specimen which we photographed was about 2 feet long

Free gold specimens.

and 1½ feet high and consisted of quartz with coarse gold liberally scattered throughout the entire mass. The owners estimate that specimens containing about $2,000 in gold have been taken from the vein. The values are not evenly distributed; in a large part of the vein no gold is visible though it is said to pan well. The occurrence of sulphides and inclusions of the country rock appear to be favourable indicators of values. Probably the intersection of cross veins will also cause an increase in value. The arsenopyrite is said to assay as high as 325 ounces in gold. Even with the eye a large quantity of free gold can be detected in the arsenopyrite. A tunnel had been started on the vein, and as far as it had gone the character of the vein remained unchanged.

SWEDES' GROUP.

On the south-east shoulder of the mountain, between Poplar creek and the river, about 1,400 feet above the valley, are the Gold Hill and Goldsmith claims, known as the Swedes' group, and just east of these is the Crown King. Goldsmith claim.

A large number of quartz veins occur on these claims having a course of about 285 degrees and varying from a few inches to six feet in width. A number of cross veins are also found. They are mineralized here and there with spathic iron, weathering to limonite, galena and pyrite. At many points they will pan gold. On the Goldsmith claim on Poplar creek slope a quartz vein 18 inches wide dipping slightly southward occurs in pyritized slates. It is almost parallel to the slates but strikes a few degrees more northerly. The richest specimens yet found at Poplar creek were taken from a point on this vein but at the time of visit the spot was covered up to avoid the necessity of maintaining a guard. One specimen obtained here was said to weigh five pounds, of which two and a half pounds was estimated to be gold. North-east of this vein, in a dike of the porphyry a galena vein, which varies from two inches to a foot in width, was exposed for about fifteen feet. A shallow hole has been sunk which shows it to be widening from eight inches at the surface. It is heavily mineralized with galena and some blend, copper and iron pyrites. It is stated to carry high values assaying as much as $5,000, mostly in gold. The galena weathers to white sulphates and carbonates leaving free gold.

On the Crown King, veins are also numerous. For some little distance a vein occurs every few feet. The country rock itself appears to carry gold values. The owners had started to dig in what appeared to be some weathered diabase schist, but this earthy material was found to Crown King.

pan well. Some stringers of quartz one-eighth of an inch to two inches in width occur in it containing a little galena. A pan of this quartz and decomposed rock matter was washed and a large quantity of fine gold and a number of nuggets were recovered.

GOLD PARK GROUP.

Gold Park.

The Gold Park group is situated on the north side of Poplar creek, opposite the Swedes' group and about 640 feet above the town. Several quartz veins occur from a few inches to several feet in width carrying the usual minerals and at some points, as below the trail on the Ophir, crystals of arsenopyrite half an inch long. The course of the veins is usually westerly. The country rock is slate on the north and the rusty-weathering schist on the south. Veins occur in both, but the main lead seems to be in the schist. Near the veins the country rock is impregnated with pyrite and arsenopyrite. Free gold has been found in the veins, in fact it was specimens from this group that started the first rush to the camp.

NORTH STAR GROUP.

Rapid creek claims.

This group is situated north of Rapid creek about 800 feet above Lardeau valley. The country rock consists of thin bands of slates with the usual dip and strike between dykes and sheets of diabase and greenstone. Several veins occur, some striking with and some cutting across the formation. Those striking with the formation may cut across the dip of the rocks and in places cut both dip and strike. The quartz is in places well mineralized with the sulphides. About 300 feet of work has been done. At the greatest depth attained the character of the vein was the same as on the surface. The result of development on the Maggie May and Handy groups near Tenderfoot creek is said to be very encouraging.

SPYGLASS GROUP.

Spyglass claim.

About twelve miles up Poplar creek and 3,400 feet above the town, Winquist has located the Spyglass claim on a lead which occurs under conditions somewhat different from those already described. It occurs in a band of slates included within the granite. Ascending the creek a band of granite about a mile wide is crossed before coming to the Spyglass cabin. The claim lies about 800 feet above the cabin in a band of slate. The main mass of granite lies about 1,000 feet to the west. The slate is altered to glossy mica schist and is cut by tongues of

granite and pegmatite. The lead lies in the schist between two of these, striking with the formation, 308 degrees, angle 43 degrees west. The lead consists of a band of quartz from two to three feet wide distributed through and between the laminae of the schists, and replacing them. A great deal of pyrite occurs in the rock and ledge matter. The quartz is somewhat cavernous, and crystals are developed. Within the lead is a pay-streak six to twelve inches wide, heavily mineralized with blende, tetrahedrite, galena, copper and iron pyrites, native silver and probable argentite. Free gold is reported to have been found. The ore runs very high in silver, and, it is said, in gold. Beautiful specimens impregnated with native silver may be obtained from this mine.

PLACER MINING.

Experiment in placer mining.

A number of placer claims have been located on the Lardeau river. A bar below Poplar creek and above Cascade creek, on the north side of the river, 2,600 feet long and 400 feet wide, has been taken up by Messrs. Stead, Gilmore and Moyer, who have commenced operations. Their hydraulic plant consists of a Krough centrifugal dredging pump, operated by a 45 h. p. Case traction engine, and nine sluice boxes provided with riffles, false bottoms cocoanut matting, etc. On account of the coldness of the water, mercury is not used and satisfactory results are obtained without it. The pump has an intake of eight inches and will handle boulders two-thirds this size. The nominal capacity for twelve men working a ten-hour shift is 500 yards. Work was only commencing and surface rootlets and large boulders were causing some difficulty, but with a pit provided with a grizzly for the intake pipe and a device to intercept the roots, it was expected that these sources of annoyance would be removed. Several pans of dirt from different parts of the bar were washed, which yielded good colours from the size of a pinhead down. Tests made by the company have led them to suppose that the gravel will run from 75 to 80 cents per yard and some $1.25. The results of this experiment are being looked forward to with interest, as, if successful, it will lead to a great deal more placer mining being done.

Encouraging outlook.

Regarding the degree of success which may attend operations in Poplar creek district, nothing very definite can as yet be said. This discovery of gold is an important one. The veins are numerous and strong, are persistent horizontally and there is good ground for believing, persistent also in depth. In places some of the veins are of exceptional richness. As deep as they have been tested the character of the ore remains unchanged. One most encouraging feature is the extent of mineralized rock and the values that can be obtained from

rock containing only small stringers of quartz, such as that mentioned on the Crown King. Another is the comparatively uniform distribution of values in veins like the galena vein on the Goldsmith. In many respects the ore reminds one of that of the Cariboo at Camp McKinney, which has been operated with good results for many years. A large quantity of what should be good pay ore is exposed on the surface, and some very rich spots occur; but information was not available on which to base an estimate of the run of the mine. The values are not and cannot be expected to be uniformly distributed and what effect the leaner ore will have on mill runs has to be ascertained by actual tests. The prospects are that some of the veins will yield very satisfactory returns. The district as a whole is worth and will no doubt receive careful exploitation. But the success of mining enterprises depends not only on the amount and value of the ore, but upon the business management. It is manifestly unfair to expect a mine to pay satisfactory dividends on over-capitalization of any kind, and it is to be hoped that the promising properties in this district will not be handicapped at the outset by mistakes of this kind.

GENERAL REMARKS.

Mining belts.

Mineral occurs throughout the length of the Lardeau district, principally along three belts, a south-western zone on the south-west side of the valley and toward the granite contact, a central zone stretching from the north-west of Camborne to southeast of Poplar, its south-eastern limit not yet determined, and the lime-dyke zone stretching south-eastward from Fish river across the head of Lexington and Pool creeks and along and near the Lardeau-Duncan Divide, its north-western and south-eastern limit not yet determined. Some mineralization occurs outside these zones, but these constitute the main lines of mineralization. The ores occur in the sedimentary rocks, viz., slates, phylites and limestone, and in the rusty-weathering diabase schist, but no important mineralization was observed in the green schists, or irruptive rocks, except in a few individual cases. The mineral-bearing zones are characterized and may be recognized by dykes of the yellow-weathering diabase (the larger more coarsely crystalline dykes do not produce this yellow coating so readily) which divide the sedimentary rocks into bands of varying width. The veins occur along, near, and in the dykes. The veins have two principal directions, approximately parallel to the strike of the rocks, and nearly at right angles to it. They are usually almost vertical, but vary in the direction of their dip. They are of a composite fissure type. Their direction is largely determined by that of fissuring, but besides fissure filling there has been consider-

able replacement of the country rock. In places, to some extent, the bedding planes of the rocks have also been utilized for the deposition of ore. The veins have been formed by aqueous mineralizing solutions which have apparently brought up their load of mineral matter from below. The character of the ore is not directly dependent upon the nature of the country rock. Small horses and inclusions of country rock are often numerous in the leads. The relationship of the dykes to the deposits seems to have been largely physical—determining the direction and circulation of the ore-bearing solutions, though perhaps the iron and carbonates of the dykes may have been reached chemically with the ore bearing solution. The veins may have a connection with the granite intrusion as some of the quartz veins have characters resembling those of the acid series of pègmatite dykes. The magma from with these pegmatites were formed became more acidic and aqueous as distance from the parent granite was gained, and the gangue of the veins is often rich in feldspar and sericite as well as in quartz. Mode of formation of the veins. According to mineral contents, the veins can be roughly divided into two groups, the silver-lead veins, rich in metallic sulphides, and the gold veins, poorer in these sulphides. Except in this one respect the veins are very similar. The silver-lead veins carry gold values and are sometimes rich in gold. The relationship between the two classes of veins is not clear: they may be of the same age and may have been formed by the same processes. On the Criterion, a galena vein is younger than one quartz vein, but may be older than a second; there is some ground for the opinion that they are closely related and they may have been formed during the same general period of mineralization. The vein-stone is quartz with some calcite, siderite, feldspar and a little sericite. The metallic contents, are galena, blende, tetrahedrite, copper and iron pyrites, arsenopyrite, argentite, native silver and gold. The veins are found on the highest summits and in the deepest valleys. The largest number of locations have been made at the higher elevations, probably on account of the better exposures. Vein minerals. On the lower slopes and in the valleys the difficulty of prospecting is greatly increased by wash and vegetation. Mining in such locations however, can be carried on at a lower cost. The values are not evenly distributed, but are localised in chutes. They are often concentrated round carbonaceous rock inclusions and along carbonaceous wall-rock and sometimes in it. Some sulphides, particularly zinc blende, are often a good indication of values. Chutes are generally located at the intersection of veins. Other indicators of values will no doubt be found when further development has been done. Distribution of values. A particular effort should be made to find, if possible, a key for recognizing pay quartz by the naked eye where the values are in fine gold. The indications are

that values will continue in depth; they are unchanged to the deepest level reached in the Silver Cup; the richest mineral, tetrahedrite, is one of the first formed, and blind leads, which cannot have been affected by surface enrichment, carry ore as well as outcropping leads; and the horizontal veins have the same characters as the vertical ones.

GROUND STILL OPEN FOR PROSPECTING.

Where to prospect.

Although all the ground at Poplar creek itself is staked, there is still a great deal of promising territory to be prospected for gold. The same belt is mostly open for prospecting north-west of Poplar creek to Silver Cup mountain. On Silver Cup mountain and between it and Camborne there is still some free ground. Anywhere along this belt, gold may be found. Free gold was discovered this autumn on the Winslow, north-west of the head of Seven-mile creek. While it is not certain that the whole length of this belt is auriferous, it is worth examination. The belt south-east of Poplar creek is little known, but may prove auriferous. The south-west belt between the valley and the granite contact is mostly open for prospecting. Some promising silver-lead ore containing gold values, has already been found in this belt. The lime-dyke belt may also be prospected for gold. Numerous quartz veins similar to those in the gold camps occur in it, under similar conditions and it is altogether probable that some of them are gold-bearing. The Ophir-Lade group is said to contain rich free gold ore.

Quartz veins and some galena veins occur between Fish river, the Columbia and Revelstoke, but little is known of this district. The quartz veins seen by the writer appeared rather lean and no free gold was detected. Still, a closer examination is necessary before this part of the country can be pronounced barren and, so far as known, prospecting may be attended with success.

OTHER ECONOMIC MINERALS.

Iceland spar.

On a dump of the You-Know-Me claim at Whiskey point, on the North-east Arm of Upper Arrow lake a small piece of calcite so clear and unchecked as to belong to the Iceland spar variety was picked up. If a quantity of this clear unchecked calcite could be found it would be a most valuable discovery. Iceland spar is in great demand for optical purposes and the present supply of the world is practically exhausted.

Asbestus.

Some fibrous serpentine occurs on Silver mountain apparently in altered porphyrite. Some fibers are 2 inches long but rather brittle.

Geological Survey of Canada
ROBERT BELL M D D Sc (cantab) LL D F R S ACTING DIRECTOR
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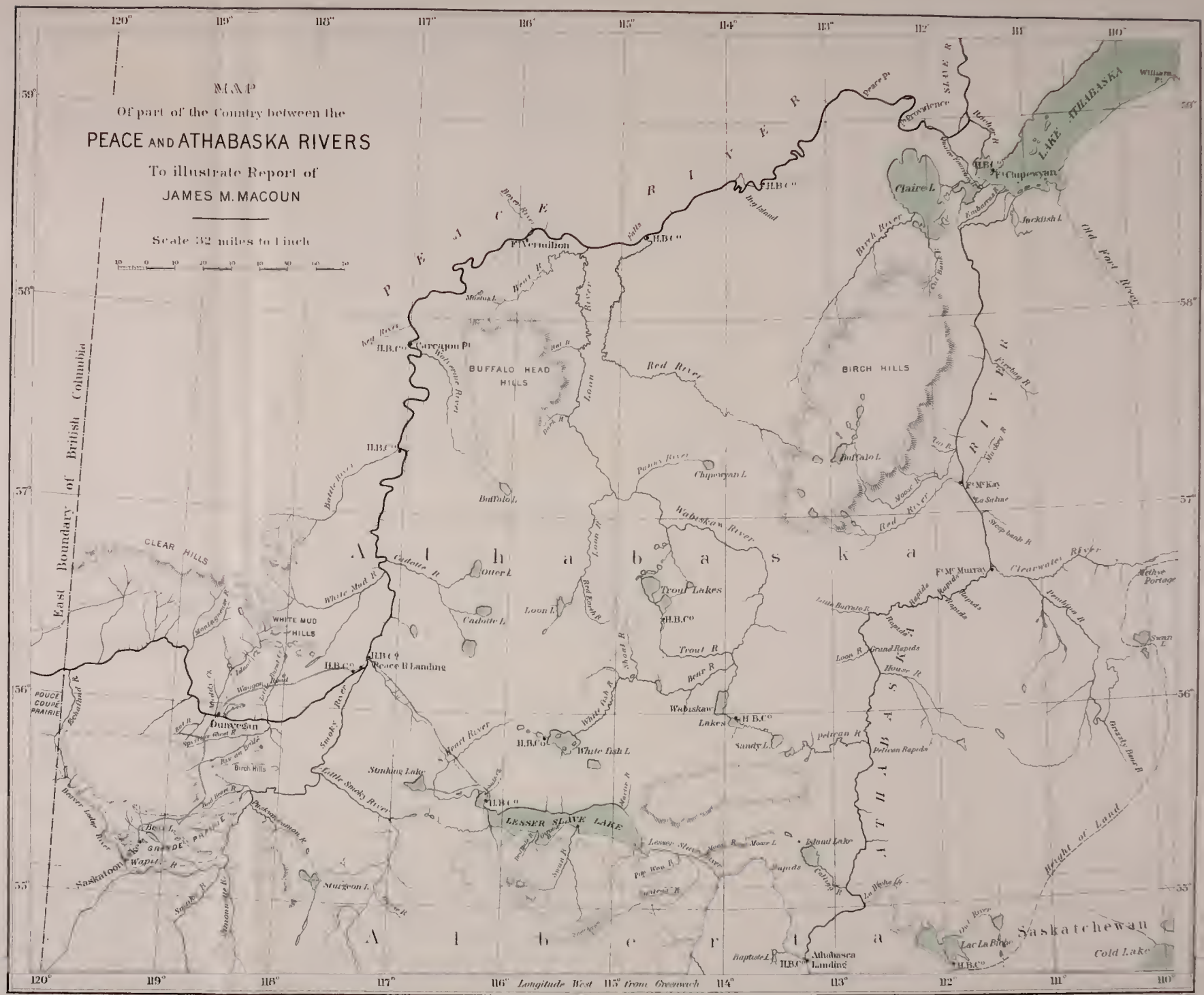

C O Senécal, B A Sc Geographer & Chief Draughtsman.

To accompany Parts A and B, Vol. XV.

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Should pliable fibres be found, the cost of transportation is still too great to make a deposit of asbestus in this locality of present commercial value.

Fine specimens of clear quartz crystals are found on the Towser claim below the Silver Cup mine, showing the usual prism and pyramids and the right hand trapezohedron.

Acknowledgements.

Thanks are due to the prospectors and mining men generally for the kind assistance rendered in prosecuting the work. Among those to whom we are particularly indebted are Mr. Cory Menhinick, Mr. A. H. Gracie, Mr. John Knox, Jr., Messrs. Jas. and V. Lade, Messrs. Green and Wilkie, provincial land surveyors, Mr. Geo. Attwood, Mr. Donald G. Forbes, Mr. Barclay Crilly, and many others.

Peace River Country.

Mr. J. M. Macoun.

Report on Peace river country.

Pursuant to your instructions, I left Ottawa on the 4th of May, and travelling by the usual routes reached Edmonton on the 11th. I was joined there by Mr. William Spreadborough, who acted as my assistant during the summer, and together we drove to Athabasca Landing, where we remained until May 23, when we were enabled to take passage on a Hudson's Bay Company's York boat bound for Lesser Slave lake. After a short delay on the lake, caused by the ice not yet having broken up, we reached the trading post at the head of the lake on June 2. Horses and wagons having been hired there, we drove to Peace River Landing, where I expected to be able to buy horses, but finding none for sale, I was very glad to hire a pack-train for the season, at a reasonable rate, and by this means I was enabled to traverse a wide extent of country, and during the summer I visited every piece of open prairie of more than 5,000 acres in extent and examined every piece of cultivated land in the Peace river region.

A small steamer, owned by the Roman Catholic mission, went down to Vermilion in June, and, taking passage on this boat, I was enabled to see the river-valley from Peace River Landing to Vermilion and my stay at the latter was sufficiently long to permit of my examining the country for fifty miles around that place. As my full report will be published in advance of this summary statement, none but the briefest reference to the results of my season's work will be necessary. I found the valley of the Peace river all that it has been reported to be, but the cultivatable area in the valley itself is so small that it is not worth considering in a report on the whole region. On the upper

Full report published.

Peace river plateau, which is from 800 to 1,000 feet above the river and from 2,300 to 2,500 above the sea, the only part that is likely to be touched by a railway for many years, is about 7,000,000 acres of prairie or bluffy country. The wooded parts differ hardly at all from the prairie, as regards soil. This is, almost everywhere, a rich black loam resting on an impervious clay subsoil. This soil is of great fertility but of varying depth. Its fertility is shown by the analysis made of it by Prof. Frank T. Shutt of the Experimental Farm, Ottawa. He reports: 'It was found to have a very slightly acid reaction. Tested for alkali, only traces of common salt were found, though careful search for injurious sodium and magnesium compounds was made. A qualitative examination for lime, showed that the soil was by no means deficient in this element. A partial analysis of the air-dried sample furnished the following data:

Character of soil.

	Per cent.
Moisture	3·44
Organic and volatile matter	11·82
Nitrogen	·471

We have in these results ample and emphatic evidence as to the richness of this soil in humus compounds and nitrogen, equalling in these respects much of the fertile prairie soil of Manitoba and the North-west Territories. Time has not allowed any determination of the potash and phosphoric acid, but in judging from past experience with soils of a similar humus and nitrogen content, this soil in all probability is well supplied with these constituents.' The country south of the Peace river, including Grande Prairie, is probably a little warmer than that to the north of the river between Dunvegan and Peace River Landing.

Cattle-raising.

The whole of the upper country is well suited for cattle-raising during the summer, as the ground is covered with luxuriant grasses and other fodder plants, but the winters are long and hay for about four months must be made.

Timber available for house-building.

Though the greater part of the country has been burnt over, there is still an abundance of poplar and spruce for house-building and fencing purposes, and of course, for fire-wood, but there is no timber suitable for railway construction, except for ties.

In the vicinity of Vermilion, the climate is much better than in the upper Peace river region. This is due chiefly to the fact that the country is about 1,500 feet lower than the Grande Prairie and the district about Dunvegan. Wheat ripens here in about three years out of five and barley and oats are seldom touched by frost. The soil too is better suited for continued cultivation, for though somewhat lighter

than that described above, it is of great depth and very fertile. A large mill operated by the Hudson's Bay Company furnishes a market for wheat which is at present wanting in the upper country, the surplus flour ground at Vermilion being sent down the river for the northern trade.

A careful study of the vegetation was made during the season and upon that some of my conclusions are based. Collections of plants, birds, insects and small mammals were made, which constitute a pretty complete representation of the flora and fauna of the region. Mr. Spreadborough, who has been with me for so many years, proved, as usual, an efficient assistant. Conclusions based on study of vegetation.

From Lesser Slave lake I returned to Ottawa in the autumn by the route followed in going out in the spring.

ON THE COAL BASINS IN THE ROCKY MOUNTAINS, SHEEP CREEK AND CASCADE TROUGHS NORTHWARD TO THE PANTHER RIVER.

D. B. Dowling.

Mr. Dowling devoted the early part of the year to writing a report on the coal deposits of the Souris river in Assiniboia. His field-work for the past summer was not commenced till the beginning of June. He writes: I left Ottawa June 3, calling at Winnipeg for Mr. Fred. C. Bell, my assistant for the season. As the horses to be used had been wintered on a ranch near Blairmore, we went to that place first. The rivers being all very high and many of the bridges gone, I found we would be obliged to send the horses north by the roads through the settlements, and cross the Old Man river at McLeod. Our point of departure with loaded pack train was Okotocks, a station on Sheep creek, on the McLeod branch of the Canadian Pacific Railway, twenty-six miles south of Calgary. A rough wagon road is built up this valley through the foot-hills to Mr. Lineham's lumber camp, just outside the first range of mountains. Pack trails, which we were able to follow, run from this point into the mountains. Sheep creek.

Through the foot-hills the valley widens gradually to the east, and it appears to be pre-glacial. The present stream cuts through wide terraces and near the mountains it runs in a gorge excavated through shales. On the road, about five miles west of Okotocks, large erratic blocks of quartzite appear on the smooth surface and the absence of eastern drift is noted. Near Lineham P.O., coal has been mined for local use, from a seam exposed on the bank of the south branch of Sheep creek. Another outcrop was noticed in Tp. 19, R. 4, on the hillside west of Maccabee creek, which appears to be on the west Coal seams in foothills.

side of an anticline, and may represent the same seam or coal horizon. The coal from this mine has been examined by Dr. Hoffmann, and as it proves to be a good quality of coking coal, Dr. Hoffmann's analysis and his remarks upon it are added here :

'Coal from the Sheep creek coal mines, south fork of Sheep creek, section 2, township 20, range 3, west of the fifth initial meridian, district of Alberta, North-west Territory. Seam said to average about four feet in thickness. Geological position, Cretaceous. Received from Mr. H. Gruner.

Analysis of coal.

'Structure, for the most part very fine, lamellar, with occasional interstratified, more or less disconnected, lenticular layers of dense, pitch-black, highly lustrous coal ; compact ; in parts shows traces of slickensides ; hard and firm ; does not soil the fingers ; is, here and there, intersected by thin plates of calcite ; colour, black ; lustre, on the whole, resinous ; fracture, uneven, occasionally more or less conchoidal ; colour of powder, blackish brown ; it communicates a very pale brownish-yellow colour to a boiling solution of caustic potash.

'A proximate analysis, by fast coking, gave :—

Hygroscopic water	3·08
Volatile combustible matter	39·37
Fixed carbon	54·50
Ash	3·05
	100·00
Coke, per cent	57·55
Ratio of volatile combustible matter to fixed carbon, 1 : 1·38.	

'It yields by fast coking a firm compact coke. The gases evolved during coking burnt with a yellow, luminous, smoky flame. The ash has a brownish-yellow colour ; exposed to a bright red heat it does not become agglutinated ; at a most intense red heat it becomes more or less fritted.

Coking coal.

'Experiments have been made on a large scale in the preparation of coke from the above coal, employing a Coppée's coke oven, and with very encouraging results, the product being of excellent quality. The sample sent for examination has a steel-gray colour and bright lustre ; is hard and dense and apparently capable of supporting a considerable pressure without crumbling and may be regarded as a most useful metallurgical fuel. It was found to contain : moisture, 0·17 per cent, ash, 10·70 per cent.'

Other seams, which I did not see, have since been reported by Mr. John Lineham as having been opened near the river in the canyon in Tp. 19, R. 5, nearer the mountains. These are of a much higher grade of coal and a sample from near Lineham's upper lumber camp, probably in section 19, said to have come from a ten feet seam, unfor-

tunately contains a large per cent of ash, but this may not hold good for the whole seam. It is otherwise an excellent fuel and may be classed with the anthracite coals. Dr. Hoffmann's analysis is as follows :—

An analysis by fast coking gave :—

Hygroscopic water	0·53
Volatile combustible matter	14·99
Fixed carbon	64·55
Ash (grayish white)	19·93
	100·00

It yielded by slow coking, a non-coherent ; by fast coking, a compact, firm, coherent coke.

Ratio of volatile combustible matter to fixed carbon, 1 : 4·31.

West of this, the beds all slope toward the mountains and the rocks seem to form an ascending series. Above the coal-bearing rocks there is a thick group of coarse sandstones with beds of conglomerate, followed by beds of dark, nearly black, shale. These rocks dip sharply to the west and cross the river in a band about a mile wide, at the eastern edge of Tp. 19, R. 5. They are followed by sandstones, perhaps 2,000 feet thick, and then by a gray shale which extends up the river through the canyon to a point beyond the lumber camp. These latter rocks appear very much like the Pièrre shales of the plains, and, as the foot-hills here are capped by a sandstone formation, it would seem that some of the Laramie rocks might be found near the foot of the mountains.

First range of mountains.

There is some local disturbance in the shales near the contact with the limestone of the Rocky mountains but they pass beneath the latter and the section here has the appearance of that given by Mr. McConnell for the gap on the Bow and Ghost rivers. That is, the limestone, after the great Rocky mountain uplift, has been shoved to the eastward over the cretaceous rocks. The limestone dips toward the west, but at the centre of the range there is a sharp dip down, so that they are nearly vertical, and then there is a break, the rocks on the west side being at first nearly horizontal and finally dipping under the cretaceous of the trough of the head waters of Sheep creek. The lower part of the outer face of the mountains is of a shaly limestone, probably Devonian or Silurian, capped by thick-bedded limestones of the Devono-Carboniferous. The sketch below will better illustrate this.

The Cretaceous rocks exposed here are a continuation northward of the wide basin on the Highwood river behind the Livingstone range.

SECTION 1.

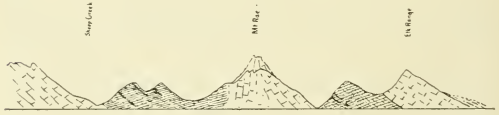
Through the first range from east to west.

Cretaceous area in mountains.

This, when followed north is mapped by Dr. Dawson as being divided into two distinct basins by the Misty range. In the southern part, it is probably a sharp anticlinal fold with a syncline of Cretaceous rocks on either hand, but northward towards the Elbow valley, several breaks occur in this fold and it loses its simple structure. Northward from the Elbow river the crown of the anticline is broken by faults and the western limb of the fold is shoved over the eastern and comes in contact with the Cretaceous. Another fault, west of the main one, brings up another block forming Tombstone mountain and several small areas of reddish rocks which look like remnants of the Cretaceous, but are of small extent. The valley in which the Elbow river flows owes its origin to a fault which runs east and west through the first range from the vicinity of Tombstone mountain and on either side of this it seems evident that there is a change in the structural form of the Cretaceous areas.

On Storm creek the structure probably changes in much the same way as on Sheep creek. On the stream flowing north towards the Kananaskis the beds are in a monoclinal ridge with the limestone of the Elk range overriding them. From the summit on the Elbow river a sharp synclinal fold is seen to develop toward the south and some folds in the Sheep creek area, about the centre, suggest the same formation. The diagram, Sec. 2, represents a sketch-section through these ranges looking from the north.

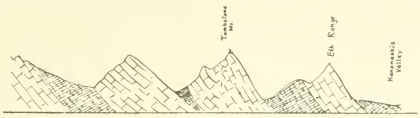
Sections through mountains.



SECTION 2.

Sheep creek to the Kananaskis.

The fault-blocks north of the Elbow river, viewed from the north, would have somewhat the appearance suggested in the next figure.



SECTION 3.

North of Elbow river.

In the above diagrams the Cretaceous rocks are shaded darker than the limestone.

The coal seam that has been opened up is perhaps the lowest in the series. It is on the south-western side of the valley and near the eastern edge of the Cretaceous. The pack-trail that comes over the summit from Mist creek follows along the north side of a ravine running down to Sheep creek and in the bed of this stream float coal was discovered and traced up to the seam.

A short tunnel was put in on what proved to be a seam of about nine feet in thickness. It dips 50° to the S. W. The lower part measures six feet of bright coal, but the upper part is very much crushed and falls to dust. This character, however, is found to vary very much in the mines to the north, and crushed portions of the seams are expected. An analysis of samples from the tunnel was made by Dr. Hoffmann and shows the coal to be lower in fixed carbon than true anthracite. Dr. Hoffmann's analysis is appended. Anthracitic coal.

'MEMO.—*Re* sample of fuel from a seam on the south branch of Sheep creek, section 11, township 17, range 7 west of the 5th initial meridian, district of Alberta, N.W.T., collected by Mr. D. B. Dowling, 1903.

The sample of the fuel, a semi-anthracite (in common parlance, anthracite), examined, gave, by fast coking, as follows :

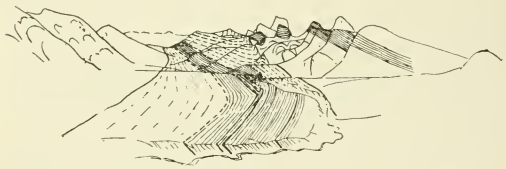
Hygroscopic water	1.30
Volatile combustible matter	11.14
Fixed carbon	77.13
Ash, white	10.43
	100·00
Coke, non-coherent	87.56

Ratio of volatile combustible matter to fixed carbon, 1 : 6·92.

Cascade Coal Basin.

Cascade coal basin on Bow river.

The continuation of the Sheep creek coal areas northward is supposed to join the coal measures which cross the Kananaskis and to form part of the Cascade trough. The connection was not traced up this summer, but the Cretaceous probably occurs high up in the ranges. South of the Bow river the Cretaceous rocks are in an elevated plateau, partly dissected into ridges running east and west from the limestone which is pushed up against it on the west. This has been brought up by a combination of sharp folds along a line of weakness, at which faulting has also taken place. The amount of throw has not been sufficient to allow of an overlap of the limestone upon the Cretaceous, as in the sections north of the Elbow river. The west-to-east displacement has been taken up, however, by folding and in the hills south of The Gap, by a bending-up of the Cretaceous beds as well. The synclinal form which was accepted by Dr. Dawson as being the structure for the whole trough is true for the extreme ends only, or for the southern part and that north of the Cascade mountain, which will be mentioned further on. For a long distance north from The Gap the bend in the beds is not part of a complete fold. The sketch here reproduced is intended to illustrate roughly that part of the basin extending from the bend in the Cascade river at Cascade mountain, southward to the Cretaceous plateau near the Kananaskis.



Sketch of Cascade Coal Basin looking South from Cascade Mountain

Folding in mountains.

The beds to the south are seen to be nearly horizontal, but near the fault-contact they are bent or brushed up. Between The Gap and Canmore, most of the folding has taken place in the limestone, so that less displacement was necessary in the Cretaceous. From the Three Sisters mountain just south of Canmore, to the north end of Rundle mountain, the folding in the limestone on the west side of the fault is in sharp, almost vertical, waves and indicates a greater east and west displacement and probably greater pressure. The effect on the Cretaceous rocks is a steepening of the slope at which they dip and also a

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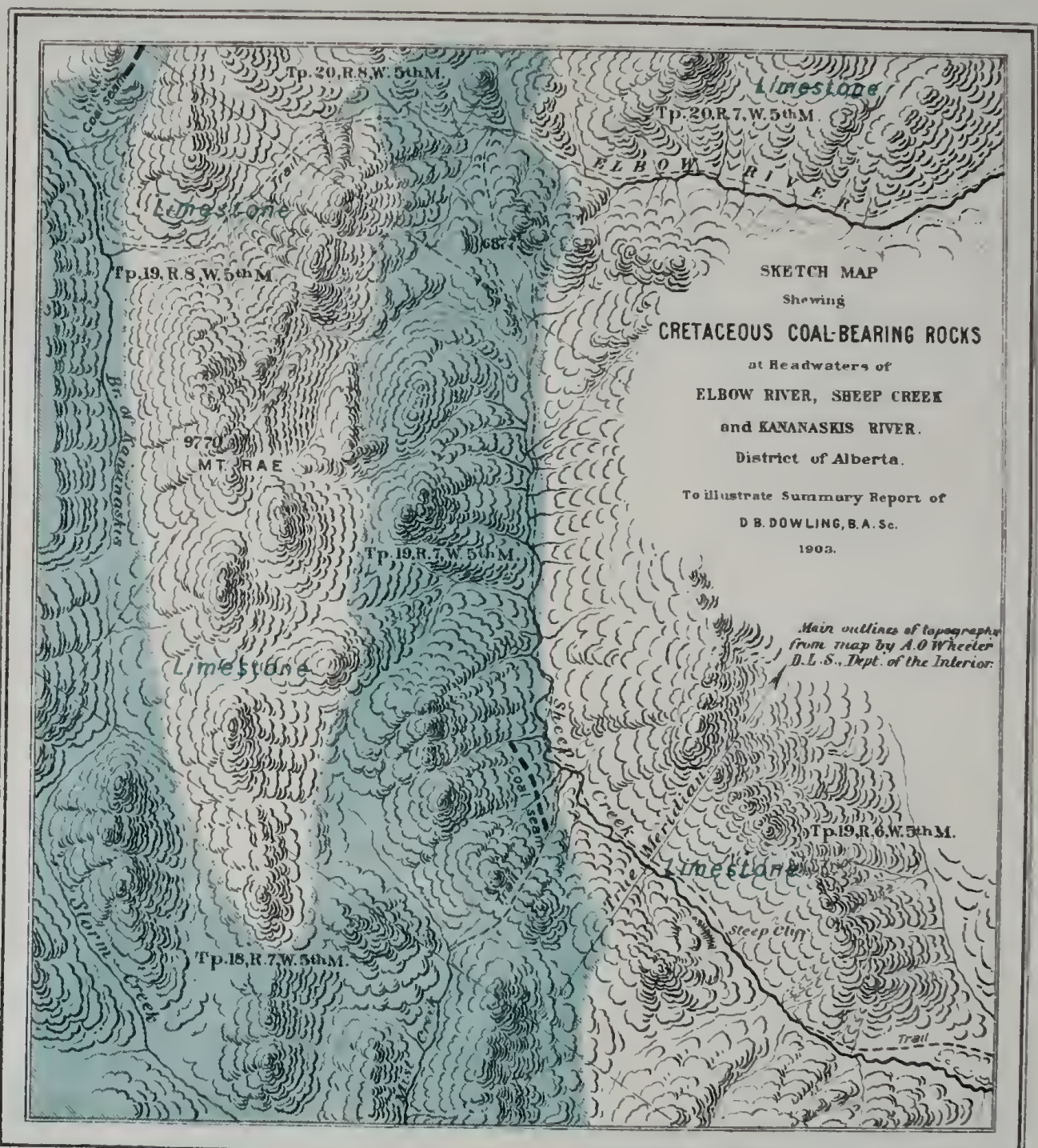
1906.



Drawn for photolithography by O.E. Prud'homme.

To accompany Part A.A. Vol. XV

Scale of miles and chains

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series of foldings which run diagonally along the bedding planes downward towards the south. The southern limit of the area in which these folds are developed and the dip increased is defined by a line running from the edge of the Bow river, a mile below the Canmore mine, to the base of the slope at the Three Sisters.

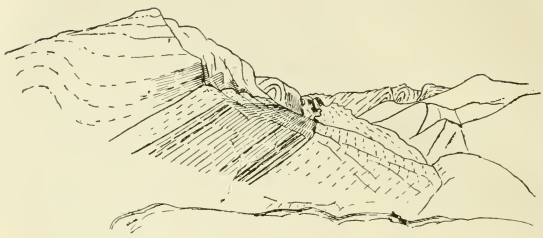
Mining operations prove that the coal often pinches out along the line of the minor folds, where they have become flattened by the pressure. The bends in the seams near the eastern edge of this area are in longer waves and form saddles and troughs which are mined out in the general operations, the coal being merely more crushed or the seam thinner. At the Canmore mines a tunnel, which is being put in at a mile south of the town, runs in on an almost horizontal seam; but this is found to turn up sharply to the vertical and come to the surface. To the west of this, the beds are again dipping down and some of the seams in the mine may represent a return downward of the western part of this wave.

From Canmore to Anthracite there are no exposures of coal, but it would seem that the Cretaceous rocks form a continuous series, as the succession of beds in both places is similar and the dip about the same. There is, however, a change in conditions that has an important bearing on the character of the coal. An extra pressure has been induced in a part enclosed within a fold which runs at an easy slope downward to the south from a point north of the mine. A change in the general strike of the beds is also inaugurated here, and the cause of this fold is connected in some way with this bending of the plane and also with the fact that here is the point of maximum downthrow.

Anthracite in a fold of the beds.

The mining operations have been confined to the inner side of this fold and it is probable that the coal, when followed south along the strike, may after the fold is passed, return to the character of that at Canmore.

The denudation of the valley by the Bow river has removed a great thickness of strata below the bed of the stream and it seems impossible to follow the fold in the southern part of the mine; but to the north, where the trough is shallow, prospecting shafts show a bending of the upper part of the western side to the west, thus indicating a tendency to turn down again. As this point is some distance from the Cascade river, there appears to be a good chance of finding all the seams again and tracing them northward to the banks of the stream where the first mining was done. The anthracitic character would in this part probably be lessened.



Sketch of Cascade Mountain Coal Area.

Cascade coal basin north of Bow river.

Northward from the bend in the Cascade river, the limestone series is pushed up along a fairly straight line of break, which seems to have followed very near the plane of bedding of the upper part of the Cretaceous. The Devonian beds have been brought up to an elevation of about 7,000 feet in the eastern face of Cascade mountain, but they become gradually lower along the contact toward the north. A block of six or eight miles of the coal-bearing rocks remains in the slope of the mountain, but north of this there is a return to the trough form, as at the southern end on Mist creek, and the fold in the mountain to the west is quite plain. The coal rocks are in this part all denuded away.

Coal on eastern face of Cascade mountain.

In the gorges on the face of the Cascade range, the outcrops of the coal seams have been prospected by Mr. J. C. Gwillim for the Canadian Pacific Railway Company and as many as fourteen seams were found in the coal measures which comprise about 2,000 feet of beds. Many are small but several will be thick enough to work and tunnels are now being run in on these seams from the face of the hill at the south end, near the base of Cascade mountain. None of the seams may be expected to be free from crushing and the local folding, but the southern part will probably be the best. In the gorges, several sections across the measures were obtained and these all show more or less folding. Toward the northern part of the block, a wide syncline is developed and this probably passes into the complete fold. A break, however, occurs across the range and the trough to the north has been bent into a much sharper fold and the coal-bearing beds, which would be in the centre of the trough, are denuded.

In the sketch above, it is endeavored to show roughly the attitude of the beds and the fold which forms a continuation of the Cascade

range. This after approaching the eastern side and narrowing the valley so that there is but a ribbon of Cretaceous left, sinks beneath a wider basin of these rocks, extending north and west to the Sawback range. In this there is very little depth of Cretaceous rocks remaining, and only the tops of some of the hills in the centre contain the coal measures. Two distinct lines of anticlinal folds run northward through the field and the character of the contact of the Cretaceous rocks and the lower ones on the west side of the field depends on the position of the underlying ridges. On the south side of the Panther river, the Cretaceous barely comes in contact with the lower rocks at the Sawback fault, as they are denuded from the top of an anticline, just east of this fault. This anticlinal ridge runs beneath the field south-eastward and is probably the one suggested in the western part of Cascade mountain, as shown in the last sketch.

The explorations of which the results are outlined above, were plotted in the field on the topographic map made by the Department of the Interior and thus surveying operations were restricted to measuring sections on the streams and wherever exposures occurred.

Acknowledgements due.

I am indebted to Mr. O. E. Whiteside for information relative to the Canmore and Anthracite mines and to Messrs. J. C. Gwillim and H. H. Aldridge of the Canadian Pacific Railway for information relative to their operations on the Cascade measures.

After closing the field-work for the season and placing the horses on a ranch for the winter, I proceeded east, stopping at Regina for a short time to obtain from the local government records of wells bored in the south-eastern part of Assiniboia.

Geology of the International Boundary.

Dr. R. A. Daly.

Area covered.

During the past season I continued the geological survey of the ten-mile belt adjacent to the forty-ninth parallel of latitude on the Canadian side of that line. The section covered is continuous with the section mapped in 1902 and lies between the Salmon river in West Kootenay and the western boundary crossing of the Kootenay river. The area surveyed in detail in 1903 covers about 350 square miles. The total length of the ten-mile belt to be thus surveyed on the Canadian side of the boundary line between the Great Plains and the Pacific is 450 miles. Records on the more or less detailed geology of just half that distance are now in hand.

I left Ottawa on July 17 and returned in the middle of October. In accordance with the arrangement of last year I was attached to the camp of Mr. W. F. O'Hara, D.L.S., to whom was intrusted the work of cutting the boundary slash along the southern limit of the belt over which my investigations extended. Owing to the configuration of the country, however, it was found impossible to carry on the geological work necessary to the development of the east and west structural sections if I remained in Mr. O'Hara's camp. I therefore hired a packer and special pack-train of four horses for about six weeks. With this small outfit I was enabled to travel rapidly and with a much greater thoroughness in exploration, with also a greater economy of time and therefore of expense to the government, than if the services of the main pack-train had been called upon for transportation as in the two previous years.

Throughout the season I was ably assisted by Mr. A. G. Lang, of Waneta, B.C., who left nothing to be desired in the efficiency and helpfulness of his work,

General Topography.

The belt of country studied lies entirely within the southern Selkirk mountain system and bears the most rugged topography to be found in the whole 250-mile stretch along the 49th parallel between the Cascades and the main range of the Rocky mountains. The strength of the relief is conditioned by the comparatively low altitude of the master valleys of the region and by the number and considerable elevation of the mountain summits. The floor of the broad Kootenay river valley is 1,750 feet above the sea; that of the Salmon river valley, 2,100 feet above the same datum. At least twenty distinct peaks in the belt are over 7,000 feet in altitude; for the highest 7,590 feet has been measured. These higher summits belong to the "Quartzite Range", a local member of the Selkirk system and the sierra dividing the drainage of the Columbia and Kootenay rivers.

Three groups of branching canyons occur on each slope of the range. The east-flowing Boundary creek, Corn creek and Summit creek with their respective branches occupy the canyons of the Kootenay versant. Sheep creek, Lost creek and the South fork of the Salmon drain the no less imposing trenches on the western side of the main divide. A seventh canyon system is drained by the head-waters of Priest river, flowing south in the middle of the belt. Except on the flood-plain of the Kootenay, the country below the 6000-foot contour is heavily forested and is further made difficult of access, especially where the trees begin to thin out at the higher levels, by a dense growth of rhododendron, alder and other "brush". It was therefore gratifying

to find that each of the main valleys excepting that of Corn creek carries a more or less passable trail. The old government (Dewdney) trail for sixteen miles up Summit creek canyon has been put into good condition by the Bayonne Mining Company. The Boundary creek trail has been similarly cleared nearly to Boundary lake by the Continental Mining Company, operating south of the boundary line, and was this summer partly replaced by a wagon-road. From the lake the trail was continued by Mr. O'Hara's party over the divide to the South fork of the Salmon. It is to be regretted that the Dewdney trail is not kept open throughout, as a means of communication between the Kootenay and Columbia valleys, thereby, too, permitting of a more thorough prospecting of the range than has yet been accomplished. As usual the geological traverses were largely confined to the ridge-summits, where alone large exposures of rock can generally be found. For this reason our camps were kept at altitudes greater than 4000 feet above sea during most of the season.

Scenery.

The scenery of the belt is that characteristic of alpine mountains, already imposing at the Kootnay river, but becoming more and more wild, in places even savage in its ruggedness, as the line of divide is approached. Looking from any of the higher summits, sharply pointed "horns" dominating rocky razor-back ridges, high precipices flanked with long screes or slopes of rock-débris fallen from the cliffs, steep canyon-walls reaching their thousands of feet down to the torrential streams slowly deepening their valleys, made the foreground. Across the tumbling mountain-sea the yet loftier, glacier-covered masses of the Valkyr and Valhalla ranges in the northwest, the Slocan mountains in the north, the Alps of the Purcell range in the northeast, and the wonderfully ragged granitic piles of Idaho to the southeast and south, made a type of scenery in most welcome contrast to the less extended views obtained last season from the lower, forest-covered domes and rolling ridgeland west of the Salmon river.

Glaciation of southern Selkirks.

True glaciers are wanting in the belt, and the patches of old snow in ravines and on the shaded northerly slopes are small and unimportant. The region abounds, however, in evidences of former heavy glaciation. Observations made last season on the 125-mile boundary belt across the Gold ranges and "Interior Plateau" corroborated Dawson's conclusion that an immense south-flowing ice-cap of the last glacial period submerged all but a very few high mountain-summits in the broad central zone of the British Columbia Cordillera. The maximum height at which signs of that glaciation may be found immediately west of the quartzite range, was proved to be about 6,400 feet. It was accordingly a matter of surprise and interest to find that the

same limit just east of the divide on the same range unmistakably reaches to 7,200 feet above sea level. It seems highly probable that this difference of level is to be explained by a more pronounced accumulation of ice on the eastern versant of these Selkirks than by a late warping of the earth's crust once covered by the ice-cap to a uniform contour. The striae on summits of 7000 feet trend to the south south-east, showing that the upper layers of the ice were practically unaffected in direction of flow by the adjacent deep, east-and-west canyons. The ledges in the canyon bottoms, are grooved and striated downstream apparently by the late glacial ice-streams joining the great trunk glaciers of the Columbia and Kootenay valleys. The net result of glaciation in the belt has been to remove the pre-glacial veneer of weathered rock, to polish and score the fresh rock beneath, and to remove the débris from the country. In consequence, comparatively little drift covers the mountain slopes or canyon bottoms.

Lack of fossils.

In accordance with the programme of work adhered to during the two previous seasons, nearly all the time in the field was devoted to the problems relating to the distribution, structure and history of the bedrock terranes. Again this study was seriously affected by a truly amazing rarity of organic remains. To anyone acquainted with the geological litterature of British Columbia, such remains must appear of the very first importance. Much has been written concerning the lithological and stratigraphical characters of British Columbia formations, but the final correlation of the latter has been delayed in an extraordinary way on account of the generally unfossiliferous nature of the stratified rocks. The search for fossils has, therefore, been pursued with special care wherever sedimentary formations have been met with in the boundary belt. Such rocks were found this season in unusual thickness and in splendid exposure; yet not a single fossil species useful for geological correlation was discovered. The experience agrees with that of Dawson, McEvoy, Brock, McConnell and other geologists working west of the Rocky mountains proper, in disclosing a marvellous barrenness of fossil remains in the Canadian Cordillera, which therein, seems to stand in contrast with, for example, the Appalachian mountain system of Eastern America.

On lithological grounds the formations found this summer are perhaps to be correlated best of all with those of Dawson's Selkirk section made along the line of the Canadian Pacific Railway and about 150 miles to the north-northwestward. His section includes the Shuswap (Archean), Nisconlith and Selkirk Series (Cambrian and Cambro-Silurian). Yet it is still too soon to make the correlation final and, indeed, I consider it safest in this brief preliminary notice of field work not to

attempt any but the most general statement of formational divisions in the area studied; in like manner, the questions of geological equivalents must be left open until the rock collections have been systematically studied and the formation limits accurately plotted on the topographic maps.

Favorable conditions for structural and lithological study.

Compensating interest in the geological examination was, however, found in the local structural relationships of the formation. Probably nowhere in the 300-mile stretch along the 49th parallel from Kootenay lake to the western slope of the Cascade range are the conditions so favourable for a lithological and stratigraphical study of the sedimentary rocks which are among those that may be called staple in the British Columbia Cordillera.

Geological formations.

With the exception of a narrow belt along the western wall of the Kootenay valley trough, the eastern half of the belt covered in 1903, is underlain by a great series of crystalline schists—biotite schist, sericite schist, phyllite, quartzite and quartz-schist, with many bands of yellowish-weathering silicious marbles—cut by thick sills and dikes of dioritic rock, metamorphosed into an amphibolitic condition and by a batholith of coarse porphyritic granite which crosses the boundary from Idaho and forms the ridge of Rykert mountain at the western slope of the Kootenay valley trough. The western half of the belt is for the most part underlain by a younger conformable group of formations, including thick bands of coarse conglomerate, arkoses, volcanic breccias and flows, quartzites, sandstones and slates with rare, thin intercalations of fine-grained crystalline limestone. The two series are separated by an unconformable contact running northward from a point half a mile west of Priest river. This unconformity signifies an enormous break in the physical history of the region and is one of its principal features of structure. The older rocks east of the contact had already been folded into complex, lofty mountains and then greatly wasted down by secular erosion before the lowest and oldest member of the group west of the contact had been formed. Since the required sections have not yet been plotted, a statement as to the respective strength of the various rock-bands cannot be given, but it is known that the western series must total at least 30,000 feet in thickness.

Great unconformity.

Both series were powerfully affected by that mountain-building force to which the Selkirk range owes its existence. Pressure was applied from the eastward with such intensity that the stratified rocks of the entire area were tilted up and for the most part overthrown so that the dip of the beds now ranges from 70° to 85° to the east. The structure is thus essentially monoclinal and on the first approach,

suggests that the formations met with are successively older as one crosses the belt from east to west. That the true order is just the reverse was first suggested by the finding of the great unconformity. It was finally proved by the orientation of repeatedly discovered and excellently preserved ripple-marks in the quartzites and sandstones of the Quartzite range.

Thrust-faults.

While the generally monoclinal attitude characterizes the sedimentaries west of the great unconformity, the structure is complicated by the dislocations due to three master-faults. Two of these run transverse to the (meridional) strike and represent nearly vertical thrust-planes separating three great blocks, into which the monoclinal mass has been divided during the energetic mountain building. The middle block has been displaced half a mile to the westward with reference to the northern block which lies north of Summit creek canyon. The southern block has been thrust three-fourths of a mile to westward with reference to the middle block, the thrust-plane in this case crossing the boundary line at a low angle.

Rotated thrust-fault.

The third thrust-fault crosses the Dewdney trail in Lost Creek canyon at a point three miles in an air line from the summit of the Quartzite range. It lies in the plane of bedding and thus belongs to a different category of dislocation. In the process of lifting the mountains, the quartzitic formation was fractured on a weak zone. The thick block of slates, sandstones and quartzites overlying that zone was driven bodily over the back of the block lying to the eastward, giving a normal overthrust. Either simultaneously with that movement or, as is less likely, immediately following it, both blocks were so rotated about a north-and-south subterranean axis that both strata and thrust plane were overthrown into a position now giving a high easterly dip for both the plane and the bedding. In this way there has been produced a duplication of about 10,000 feet of strata on the western side of the divide—a duplication that goes far to explain the great width (about seven miles) of the quartzitic zone composing this part of the Selkirk range. That there is no other important duplication and that the breadth of the zone is due to the immense thickness of the steeply inclined, monoclinal strata, can be unquestionably affirmed. Three different east-and-west structure sections on ridges giving excellent, often even spectacular rock-exposures, agreed in affording an undoubted conclusion as to the structure. Each rock-band has its own peculiar petographical character and relations, so that duplication either by faulting or folding could be easily recognized. With the exception noted the formations become successively younger

in passing from the Priest river unconformity to the western limit of the section of the boundary belt covered this season.

Origin of the Kootenay valley.

The great valley of the Kootenay river is, within the ten-mile belt, underlain by an unfossiliferous rock-series which has lithological characters differentiating it from all the rock-terranes to the westward. This series is largely composed of gray, heavily bedded quartzites with thin micaceous partings. It forms the western extension of the so-called "Cambrian" Quartzite formation which, according to McEvoy, covers most of the district of East Kootenay. The quartzite has been faulted down against the much older crystalline mass just noted in the (eastern) part of the belt situated between Priest river and Rykert mountain. West of the Kootenay flats, the dip of the quartzite averages about 60° to the southeast; east of the river the same formation reappears from beneath the river alluvium with an average dip of 10° to the east. This sharp discordance of attitude is well marked for the whole ten miles along the valley between the boundary line and Creston junction, and points to the fact that the Kootenay valley is located on a principal zone of fracture-displacement. McConnell has found similar evidence on the shores of Kootenay lake. The valley owes its origin either directly to the subsidence of a long narrow block of the mountain-built crust of the earth (then a fault-trough or "graben") or, as is more probable, it is the result of river-excavation on a zone of rock rendered weak by the shattering and faulting. In comparatively recent geological time, the normal river-profile of the valley was altered and Kootenay lake came into existence. At one time it extended with its full width of from two to four miles far to the southward of the boundary line. The fifty square miles of alluvial flats and sloughs between the line and the outlet of the river is a true delta-area. The river is still building up its flood-plain which forms some of the richest arable land in British Columbia.

Granite stocks and batholith.

Either at the closing stage of the paroxysmal uptilting of these mountain-built strata or in still later geological time, the base of the range was punctured by four considerable bodies of granite. Two of these, as exposed by denudation, are located wholly within the ten-mile belt and occur on the main divide close to the Dewdney trail. Their combined areas total only about three square miles. The third body, with an area of seven square miles, is exposed on the floor and walls of Lost creek canyon as well as on the ridge to the northward. The fourth is much the largest of the bodies, covering at least 100 square miles in the lofty mountain region north of Summit creek. Only the southern edge of this great "batholith" enters the ten-mile belt. In the case of every one of these bodies the superficial extent of the visible granite is

less than its subterranean horizontal extent. In several instances it can be shown that the area exposed is in direct relation to the depth of canyon-cutting which has laid bare the once deep-seated granites.

The Lost creek granite body bears the look of an enormously enlarged east-and-west dyke whose intrusion was affected by the previous existence of an east-and-west joint system traversing the tilted sedimentaries. The eastern limit of this granite is located at the great meridional thrust-fault above mentioned. It seems probable that the intrusion is also in organic relationship to the hoisting of the block on the west side of the plane of thrust.

Mode of intrusion.

The other three intrusions have, in the main, no discoverable connection with either zones of faulting or joint-systems, or any axes of general deformation whatsoever in the older formations. The numerous radiating apophyses do often follow pre-existing joint-planes in the schists or sedimentary rocks, but neither the horizontal plan nor the vertical profile of the granite body as a whole is in any case determined by structural planes in the invaded formations. These granites, like a score of intrusive stocks and batholiths encountered to the westward in the boundary belt, seem unquestionably to have eaten their way upward into the stratified and schistose formations which have thus been extensively displaced by the granite magma itself. How the displacement took place is a problem of first-class importance as it bears directly on the origin of the igneous rocks of the whole Cordillera. A general discussion of the various possibilities in the way of explanation was published this year in the April and August numbers of the American Journal of Science. The conclusion was that the process of intrusion in such cases is primarily mechanical, consisting in a combination of the contact-shattering of the invaded rocks with the "overhead stoping" of the shattered rocks. The experience of the past season has tended greatly to strengthen my belief in the hypothesis. The collars of shattered rock wrapping around the intrusive bodies vary from a quarter of a mile to nearly two miles in width. The contact metamorphism of the schists, slates and sandstones within the collar is quite extraordinary in the degree of alteration suffered by those rocks. The intensity of the action and the clearness of proof that the metamorphism is to be attributed to the influence of the intrusive magma, are impressive in the highest degree.

Gold and silver bearing quartz veins.

During the period of mountain-building and later, during the intrusion of the granites, the bedded rocks in all parts of the belt were extensively jointed and broken. The resulting fissures have been filled with quartz, often bearing traces or notable quan-

tities of auriferous and argentiferous sulphides. The veins have specially great width and length in the Quartzite range. A large number of these veins were sampled and studied. On account of the present lack of assays and of other preliminary aids to description, it is yet too early to present a report on the economic probabilities of the quartz bodies. A fair amount of prospecting has been carried on in the belt but without such success so far as to warrant extensive mining development at any point. As usual elsewhere in British Columbia, only a negative interest has for the most part been taken by prospectors in the discoveries of low-grade auriferous veins, their attention being perforce devoted almost exclusively to the problem of finding concentrated values. This season's experience accords with that of last year in pointing to the advisability of further prospecting in the belt for low-grade gold deposits among the larger quartz veins. It also seems clear that free-milling gold is not to be expected in the vast majority of the veins. The common sulphides, chalcopyrite, pyrite, chalcocite, and galena with their decomposition products bear the precious metals. The three last mentioned sulphides occur in small pockets or bunches in the bands of silicious marble on the head-waters of Priest river. For some years the mineral claims of the "Copper Camp" located on the strike of this zone of crystalline limestone, have been much talked about by sanguine prospectors, but the showings everywhere in the "camp" are so poor that further development on the claims seems most unlikely to pay.

Gold-quartz of the Bayonne Company.

A much brighter outlook belongs to a gold-quartz claim now being worked by the Bayonne Mining Company. The property is located on the extreme northern limit of the ten-mile belt, about five miles up the West Fork of Summit creek and at an altitude of about 6,900 feet above the sea. The lead consists of a three to six feet quartz vein following a weak zone in the granite batholith. The vein occurs about two miles from the nearest contact of the granite with the schists. For a width of from one to twelve feet on each side of the vein, the granite is thoroughly kaolinized and it is much decomposed outside the zones of kaolin. The ore-dump contains the greatly oxidized quartz-bearing small grains of free gold, along with chalcopyrite, galena, pyrite, malachite, azurite, limonite and quartz druses. A 300 feet tunnel and a fifty feet winze represent the state of development at the present time. It is stated that the quartz gives $250 to the ton as the result of averaging six assays. It is also claimed that both the kaolin and the decomposed granite may be profitably worked. The abundant sulphides in the dump indicate, however, that the ore will not prove free-milling in depth. The mine has good water-power

available in the vicinity. This quartz occurrence is especially interesting, as gold-bearing veins in granite are very rare throughout the boundary belt so far examined.

Occurrence of magnetite.

A deposit of magnetic iron ore aggregating eight feet in thickness, though interrupted by small lenses of quartzite, was noted in the structure section carried along the ridge overlooking the South Fork of the Salmon river just north of the boundary line. The deposit is interbedded with the slates and quartzites in the upper part of the great stratified series forming the main mountain range. The bed is noteworthy because of the apparent purity of the ore and on account of its mode of occurrence which suggests persistence of the ore-body along the (meridional) strike. It was found in its proper place in the stratigraphic series, though with greatly reduced thickness, as a similar cross-section was made on the ridge north of Lost Creek and seven miles north of the former section.

The Winisk River, Keewatin District.

Mr. William McInnes.

Country explored.

Mr. McInnes left Ottawa on May 22, for the purpose of making a geological examination and survey of the Winisk river, which flows into the west side of Hudson bay about a hundred miles east of the Severn, in the District of Keewatin. As it was necessary to carry supplies for the whole summer, the route from Dinorwic station, on the Canadian Pacific Railway west of Lake Superior, was chosen as the easiest and quickest for loaded canoes. This route has been described in considerable detail by Dr. Bell in his report for the year 1886, and by other explorers, so that it will be necessary to refer to it only briefly here. Following Lake Minnitaki and the English river to Lac Seul, the latter lake is ascended north-easterly to its head and the Root river and one of its tributaries from the east are followed to the height of land between the waters flowing westerly by the English river into Lake Winnipeg and those flowing directly into James bay by the Albany river. While descending St. Joseph or Osnaburgh lake on June 13 the swamps adjoining the lake were found only partially thawed out and the minimum thermometer recorded 22° Fahr. on the night of the 12th, the maximum reaching 64° during the day and rising to 72° on the 15th.

Route followed.

Lake St. Joseph.

Osnaburgh House.

At Osnaburgh post, near the foot of the lake, with an elevation of about 1,200 feet above the sea, Mr. Williams, the Hudson's Bay Com-

nany's agent, maintains a small garden. Owing to the sandy nature of the soil in the neighbourhood of the post, the best results could not be expected. Mr. Williams informed me, however, that barley ripened well and that potatoes, peas, beans, carrots and large onions were successfully grown, but that Indian corn was hardly filled out sufficiently for table use when struck by the frost. Timothy was a splendid crop.

Albany river.

From the foot of Lake St. Joseph the Albany river was followed for about 125 miles to Fort Hope, a post of the Hudson's Bay Company situated at Eabemet lake, which lies just to the north of the Albany and discharges into it. The river for this part of its course is a succession of alternating lake-like expansions and stretches of rough rapids, some of the latter passible only by portaging. Brook trout (*Salmo fontinalis*), from three to four pounds in weight, were caught plentifully in these rapids and sturgeon of good size are taken by the Indians all along. About Fort Hope post on Eabemet lake the soil is very sandy and not well adapted for horticulture. Mr. Gordon, the postmaster has, however, successfully grown all the common garden vegetables, including vegetable marrow and potatoes, though Indian corn failed to fill out. For the past two years grasshoppers have devoured almost everything green in the garden. These locusts, which Mr. E. M. Walker has identified as *Melanoplus bivittatus* and *M. femoratus* (Say) Burm., were found also in great numbers in open places about Weibikwei lake in latitude 52° 15' N.

Brook trout.

Fort Hope.

Locusts.

Horticulture.

The Indians do no farming and the only cultivated land seen was in the immediate vicinity of Fort Hope post, where, in addition to the company's plots, Rev. Mr. Richards, Anglican missionary, cultivates a small garden. Lumber for building was being whipsawed into deals measuring 12" by 2" by 20 feet, from white spruce that grows plentifully about the lake.

Route to Attawapiskat lake.

In order to reach the Winisk river, the route northwards from Eabemet lake, taken by Dr. Bell on his trip to the Attawapiskat river in 1886, was followed. At Machawaian lake, Dr. Bell's course was left and the more direct route, missed by him, and leading directly to Lansdowne or Attawapiskat lake was taken. Ascending a small stream flowing into the western bay of Machawaian lake and crossing two small lakes, the route leads over the divide between the Attawapiskat and Albany rivers by a portage 74 chains in length, traversing a muskeg or swamp with occasional ridges of transported gravel and boulders. Manitush (leech) lake, at the north end of the portage, is two miles long and discharges southerly by a small stream, barely

navigable by canoes, into Martin-drinking river. Four portages are made on this stream before reaching Wintawanan lake, into the south-west bay of which Mud river flows from the west. A well travelled Indian canoe-route leads up this stream by a series of large lakes to the head waters of the Attawapiskat river and to the foot of Lake St. Joseph. The Martin-drinking river though not large, is navigable by canoes (with a few portages) to its mouth in one of the southern bays of Lansdowne lake.

Character of country.

The country traversed between the Albany and the Attawapiskat is a high, rolling plain, rising in the centre about 1,000 feet above the sea and sloping gradually to the north and south. It is characterized by large areas of muskeg, out of which rise low ridges of gneiss and also of sand and gravel. West of Machawaian lake a much higher and more broken country is seen. This, the Indians say, extends westerly, parallel with the upper course of the Albany, for a considerable distance, is well drained and has high hills and larger timber.

Route to Winisk river.

From the north-easterly bay of Attawapiskat lake, a small tributary brook, with three small lakes along its course, was ascended to the divide, across which a portage leads to the head waters of the Wabitotem river, flowing into Weibikwei lake on the Winisk river. For 13 miles north of Attawapiskat lake no exposures of rock *in situ* were seen, the country being, for the most part, covered by sand and gravel, rising in ridges 80 to 100 feet above the level of the lakes, and with smaller areas of muskeg between. A ridge of slightly schistose, hard, chloritic diorite, specked with iron pyrites and striking east and west, is the first rock seen *in situ*. As the last exposure of biotite-gneiss seen was on Attawapiskat lake, 20 miles to the south, and the first to the north occurs on Mistassin lake, six miles to the north, the Huronian belt may be of any width within the limits thus set. Between Mistassin and Weibikwei lakes the gneiss has generally a stratiform character and lies at low angles, often nearly horizontal, the typical rock being a rather hard, red, banded, biotite-gneiss, cut by a coarse white pegmatite-like rock.

Huronian belt.

Forest growth.

The dryer parts along this route have everywhere been burned over and are now covered with a second growth of Banksian pine, white birch, poplar, spruce and tamarack. The two last mentioned occur exclusively in the muskeg areas.

Weibikwei lake.

The distance from Fort Hope to the head of the Attawapiskat lake, by the course followed, is about 70 miles, and thence to the foot of Weibikwei lake is about 65 miles. Weibikwei lake has an extreme length of seventeen miles and is eleven miles wide. Nowhere in its

whole area, however, is there a large expanse of open water, as it is made up of several north and south channels, usually not more than half a mile wide, and about 30 feet deep, lying between long low islands of drift. The land about the lake is depressed and the islands merely low ridges of sand, gravel and boulders lying on a substratum of boulder clay.

Timber.

Forest fires have swept the main land excepting in a few places, where spruces remain. Many of these are 12 inches in diameter with trunks of 30 feet clear of branches. Tamaracks and Banksian pines of good size are found in the unburnt areas and cedars of small size fringe the shore. Sturgeon and whitefish are caught in considerable numbers by the Indians, together with speckled trout, doré (or pickerel), and pike. No gray trout occur in the lake.

Fish.

Winisk river.

The Winisk river passes through the northern end of the lake, flowing into the north-west bay and discharging from the extreme north end. Just below the first rapid a channel that diverges from the river about 15 miles above the lake, rejoins it. This channel carries more than half the water of the united stream. The last white cedars were seen at the north end of the lake, and the last Banksian pine about half way down its western side, and some distance to the south of the lake the last black birch*, mountain ash or rowan, and mountain maple were passed.

Northern limit of Banksian pine, &c.

Gneiss.

The Winisk, for the first eight miles below Weibikwei lake, flows in a succession of rapids over flat-lying ledges of biotite gneiss. The Winiskisis (Little Winisk) leaves the main river at this point and flows off towards the north-east to rejoin it seventy miles below, forming an island of that length and fifteen or more miles in width. Thirteen miles below the head of this island, another channel, the Tabasokwia, splits off on the western side and flows around an island about twenty-three miles long by twelve or more in width.

Branches.

Slope of river.

The descent of the river for the upper 45 miles of its course below the lake is about 7 feet to the mile, with a vertical fall at only one place near the foot, where the Boskineig (smoky) fall has a sheer drop of about 15 feet. Exposures of biotite granite-gneiss, striking north-westerly, occur frequently all along this part of the river.

Nature of country.

The country on both sides of the stream is low and flat, the immediate banks rising only a few feet above the surface of the water and gradually ascending to a general level not more than 50 feet above the bed of the river. The brulé of Weibikwei lake continues and the trees on both sides are a second growth of about 30 years.

* Mr. McInnes examined this tree carefully and considers it identical with the black birch of central Ontario, *Betula lenta*, although this region is far north of any other locality where it is known to occur.

Glaciation. The low bosses of gneiss are all well glaciated in a general direction varying from south to south-west, with here and there, striæ that are probably later, having a direction of about south-east. Below Boshkeneig fall, the banks become higher, the river flowing in a channel 8 to 10 chains wide between nearly vertical banks of till or boulder-clay. The first pleistocene marine clays containing fossil shells (*Saxicava rugosa*) were found at this point, though stratified clays of similar character were noted for about 10 miles further south. The elevation is estimated to be about 350 feet above the sea.

Marine clays.

Last gneisses. Occasional outcrops of gneiss are seen at intervals for 15 miles further, below which point there are no exposures until the limestones of the Hudson bay basin are reached, 140 miles below.

Till. At no place in this distance has the bed of the river been worn down to the solid rock, the great mass of boulders washed out from the thick mantle of till probably affording the necessary protection.

Green forest. The old brulé, noted above, extends only to the last ridge of gneiss. The character of the banks and of the neighbouring country is very uniform. The banks consist of an exceedingly tough, impervious boulder-clay that holds up the water and creates behind the narrow belts of trees along the immediate banks (that are drained into the river valley) a great, level plateau-like country, practically without drainage and consequently moss-covered to a great depth, and supporting a stunted and deformed growth of black spruce and tamarack.

Tributaries. Tabasokwia branch rejoins the main river from the west 68 miles below Weibikwei lake and the Winiskisis from the east, at 77 miles. The first tributaries of importance are the Asheweigkaiegen and the Atikameig, flowing from the south-west and south-east respectively, into an island-studded expansion about a mile wide, 94 miles from the lake. The former of these, which is slightly the larger, the West Winisk of the maps, is one chain wide and from 2 to 5 feet deep, with a moderate current of about 2 miles an hour.

Last birches and balsams. The last balsam firs were seen here and the last white birches 10 miles down. The average width of the river is now about a quarter of a mile and the banks rise about 45 feet above it; the country extending far to the east and west of the stream is a flat, moss-covered plateau with small spruces and tamaracks scattered upon its surface.

Brooks. At 126 miles the river, which to this point, with a slight bend easterly, and then westerly, has kept a northerly trend, turns off abruptly to the east and keeps that course, inclining slightly to the south for 70 miles. Near the elbow, two large brooks come in from the west, the

Panipatowanga and the Pikwakwud. By the lower stream there is a canoe route to the Fawn branch of the Severn river. Twenty miles further on, a large brook, known as the Winoni-micheken, or fat-wier river, comes in from the north. At 9 miles below this, the river divides around an island six miles in length, known as Atik-minis.

Character banks.

The banks have been gradually increasing in height, and are here about 50 feet above the river. They still preserve the same character, presenting above high water level almost sheer walls of boulder-clay. This clay can be readily recognised as of two ages—a lower, exceedingly tough, compact till, with a great number of large boulders, and an upper, more friable, buff-coloured clay, with small pebbles and only an occasional large boulder. Marine clays of varying thickness cap these banks all along and yield many species of fossil shells.

Limestones.

The first rocks of the Hudson bay sedimentary series are seen at 194 miles from the lake or 42 from the coast. They occur as flat-lying, fine-grained, somewhat arenaceous limestones, forming the bed of the river. Four miles below, the river breaks through a gorge of these rocks, affording a section of about 30 feet of limestones and dolomites.

Silurian fossils.

Fossils collected from the limestones are found by Dr. Whiteaves to be similar to those of the Fawn branch of the Severn and of the Attawapiskat and Ekwan rivers and therefore Silurian. The strata occur in a succession of gentle minor undulations, but they preserve a general dip that accords closely with the slope of the river-bed, so that it is estimated that only about 70 feet in all of strata are exposed along the stream.

Older series.

At a point 26 miles from the mouth of the river, a compound anticlinal, whose axis strikes south 70 degrees east, brings up the upper beds of a lower set of rocks, consisting of quartzites and slates, that apparently underlie the limestones unconformably. The trend of the anticlinal would carry it easterly to Sutton mill lake, where rocks of the Nastapoka series were noted by Mr. Dowling in 1901, and it seems not unlikely that these Winisk beds may belong to the same series.

Limestone cliffs.

Below the point at which these rocks occur and nearly to the mouth, frequent exposures of nearly horizontal beds of limestone are seen, forming low cliffs underlying the boulder clay. Along this part of its course, the river is about 30 chains wide, expanding in numerous places to three-quarters of a mile, with many islands.

Peat-moss.

The boulder-clay banks rise to 85 feet above the level of the water, with the same irregular layer of marine clay on top, the whole capped,

where fresh sections are afforded, by from 6 to 10 feet of sphagnum moss that shows very little evidence of decay. Back from the banks, the same moss-covered plain, with scattered spruces and tamaracks, extends for long distances, probably to the next river valleys on either side.

Age of trees. Sections of trees growing along the river showed a very small annual growth. A black spruce 10 inches in diameter was found to have 270 rings of annual growth and one 6 inches in diameter 110 rings. Two 12-inch trees growing on a dry knoll showed 120 and 148 rings, respectively.

Routes east and west. Twenty-four miles from the mouth, a river of considerable volume comes in from the east, by which there is a route to the Ekwan river. It is known to the Indians as the Mattawa. The Mishamattawa, 10 miles further down on the west side, is used as a canoe-route to the mouth of the Severn river, by way of the Shakameh river and the coast of Hudson bay.

Islands. Northern limit of trees. For 25 miles up from the sea, the river has an average width of about three-quarters of a mile, increasing to over a mile in places and is dotted with a continuous line of islands. These islands support a growth of large spruces, down to within 12 miles of the mouth. Below this, they are covered with grasses and small bushes, with only an occasional grove of large balsam poplars. On the mainland there is the same stunted forest down to within three miles of the sea. A level, sandy, treeless plain, sparsely covered with grasses and various other plants, forms a fringe along the coast.

Estuary. For the final 40 miles, the general course of the river is north-east. The eastern shore then bends eastward to form the coast line of the bay, and the west shore takes a course almost directly north for 8 miles to Wabukwinniashi or White-bear point, whence the coast trends westward. The estuary and neighbouring ports of Hudson bay are quite shallow. The receding tides, though having a fall of only about 6 feet, leave a wide margin of mud flats, studded with large boulders.

Buildings. The only buildings at the mouth of the river are a small log shanty that serves as a winter outpost for the Hudson's bay company and a very creditable frame church built by the Roman Catholic mission at Albany, from lumber cut by whip-saws on the spot.

Larch saw-fly. Tamarack trees along the river were suffering from the depredations of a dark green worm that Dr. James Fletcher identifies from description as larvæ of the imported larch saw-fly (*Nematus Erichsonii*) that has been gradually spreading over north-eastern America. The

trees were found to be slightly attacked about the mouth of the river on the 1st of August, the defoliation gradually increasing up river to the Tashka rapid, 192 miles from the mouth, where they were quite stripped of needles on August 13 and gradually decreasing again southwards. The trees about Weibikwei lake were quite untouched on the 21st of August.

Length of river.

The total length of the Winisk river from Weibikwei lake to the sea is about 240 miles and its probable length above the lake over 100 miles. The descent from Weibikwei lake is in the neighbourhood of 700 feet.

Temperature.

The average morning and evening temperature on the river between the middle of July and the 22nd of August was 57° Fahr. and the average noon temperature 69° Fahr. There was no frost until the night of the 22nd August and none of any severity till the 3rd of September, when ice was formed on standing water.

Fauna.

The Canada grouse or "spruce partridge," ducks of many species and various waders breed along the river and a few flocks of wild geese were seen. Moose are not found beyond the southern end of Weibikwei lake, in north latitude 52° 52'. Caribou range over the whole district. Black bears are fairly plentiful and white bears occasionally come ashore from the drift ice at White-bear point. The common fur-bearing animals occur, though beaver and otter are not plentiful. White foxes were taken last winter as far south as Lake St. Joseph.

Fish.

At the mouth of the Winisk, the Indians were taking white-fish and brook trout of good size in large quantities. Further up on the river, whitefish were seen in large schools and sturgeon, doré, pike and suckers were also caught. The Indians throughout this district are fish-eaters, depending for subsistence largely upon their nets and mécheken or trap-weirs which they build with great skill, fencing off the smaller rivers and impounding all fish coming down with the current.

Christian Indians.

The 500 Indians trading at Fort Hope, as well as those scattered along the river and its tributaries, are for the most part christianized. They are divided about equally between the Anglicans and the Roman Catholics, the latter reaching the Indians by periodic visitations from the Mission at Albany, while the former maintain a resident clergyman at Fort Hope.

Glaciation.

Over the whole country examined, evidences of glacial action are plain and wherever the direction of movement is indicated it is, in a general way, southerly. The transported material clearly shows, too,

by its composition, a northern origin. From Weibikwei lake for 55 miles down the Winisk river, the course of the glacial striæ is about S. 30° W. with occasionally a set running S. 15° E. On the Wabitotem river, the movement was S. 40° W. Along the Albany river, between Fort Hope and the Opichewan, the striæ have a very regular direction, S. 68° W.

The volume of water carried by the Winisk, computed from two sections across the bed of the river, made about 30 miles from the mouth, at the beginning of August, when the water was low, was estimated to be 25,000 cubic feet per second.

Astronomical observations.

During the summer, 35 latitudes were taken as checks on the micrometer and track-surveys and the magnetic declination was ascertained at a number of points. On the way out a micrometer survey was made of the Albany river from Fort Hope to the Opichewan, a distance of 26 miles. The Canadian Pacific Railway was reached by way of Lake Nipigon. Brook trout of good size were caught plentifully in the rapids along this route. Mr. McInnes arrived at Ottawa on the 22nd of September.

Fossil shells.

In addition to the fossils obtained from the limestones, a collection of Pleistocene shells embracing 11 marine species, was made from the clays exposed along the Winisk river, of which Dr. Whiteaves has furnished the following list: Pecten Islandicus, Muller, Mytilus edulis, L., Cardium ciliatum, (Fabricius), Scripes Grœnlandicus (Gmelin), Macoma calcarea (Gmelin), Macoma Balthica, L., Mya truncata, L., Mya arenaria, L., Saxicava rugosa, L., Buccinum tenue, Gray, Buccinum.

Fresh-water shells.

The following mollusks, determined by Dr. Whiteaves, were found living in the Winisk river: Limnæa stagnalis, L., L. palutris, Muller, L. catascopium, Say, Planorbis trivolvis, S., P. bicarinatus, S., Unio luteolus, Lam., Anodonta marginata, S., Spherium striatum, Lam.

The Nagagami River and other Branches of the Kenogami.

Mr. W. J. Wilson.

Following your instructions to make a topographical and geological survey of the rivers and canoe-routes which converge at Mamawématawa and vicinity, I left Ottawa on May 27, accompanied by Mr. Owen O'Sullivan of this department. We proceeded to Montizambert on the C. P. Railway, where we procured canoemen and provisions and on June 1 we started for our headquarters at the Hudson's Bay company's post at Mamawémattawa, taking with us in three canoes nearly all the supplies we required for the summer. We followed a hitherto unsurveyed route by White lake, over the height of land and down the Nagagami river, a distance of 208 miles, reaching the English river post of the Hudson's bay company on June 20. Mr. E.E. Vincent, who is in charge of the post, kindly stored our provisions and gave us every facility in his power for carrying on our work.

Canoe route to Mamawémattawa.

Two of the Indians whom we engaged at Montizambert for the season's work would not remain in our service, and we were obliged to hire others to fill their places. This was not easily done, as all the good men were engaged "voyaging" for the company. We were unable to start at once on a long trip, as the Indians were awaiting the arrival of the first boat from Albany with supplies and clothing, so we spent the first week in making a micrometer survey of the lower part of the Nagagami river.

After securing a full crew, we set out on June 30 to make a survey and examination of the Little Current river, a western branch of the Kenogami, which we followed for about 180 miles*. After returning to the post for supplies we separated into two parties, Mr. O'Sullivan making a track survey of the Drowning river, another western branch of the Kenogami which he examined for 135 miles, while I made a micrometer survey of the Kabinakagami river a distance of 75 miles up to the portage across to the Mattawisquia river an affluent of the Missinaibi. I also made a track-survey of the large eastern branch of the Kabinakagami which I named Ridge river.

Routes surveyed.

We came back to the Hudson's bay company' post on August 20, when we repaired our canoes and prepared for our return journey. We were delayed some days on account of the difficulty of getting canoemen. The Indians at this time of year are getting ready for their winter's hunt, and as they could not get back before the second

* The distances along rivers given in this report follow the curves of the streams.

week in October, they did not care to undertake the journey. They were also afraid that in returning they might have trouble in crossing the lakes at the height of land, as in some years these lakes are said to freeze over by October 1, or earlier.

We left on August 31 and continued the micrometer survey of the Nagagami river from the point where we turned back in June up to the source of the river in Obakamiga lake; thence over the height of land into Big Rock lake, down Gum river, White river and Natamasagami lake, connecting with the Canadian Pacific Railway at the bridge over White river, one mile and a half west of Montizambert station. This was completed on September 28, when we left for Ottawa which we reached the following day.

THE LITTLE CURRENT RIVER.

General description.

The Little Current is a branch of the Kenogami river and enters the latter about fourteen miles south of the Forks or its junction with the Albany. In a general way, it runs parallel to the Albany its course being east-north-east except in one or two stretches where it flows almost due east. It is five chains wide at the mouth and about eight feet deep. Further up where it runs over flat dolomite strata, it is broader and at low water is so shallow that it will scarcely float canoes. There is a strong current nearly all the way with numerous rapids, often obstructed by large boulders. It flows through a comparatively flat country, no hills of any importance having been seen, until the lakes near its source were reached.

Like all the rivers flowing through the great costal plain to the west of James bay, the Little Current has no distinct valley, but flows in a canal-like ditch until the gneissic rocks are reached, when the channel becomes narrower and the adjacent country higher and more rolling. The clay banks in places rise fifty feet above the river, but generally they are much lower, usually ranging from five to ten feet. Along the river on both sides, there is a strip of well drained fertile soil on which is growing, when not destroyed by fire, fair-sized trees of spruce, poplar, balm of Gilead, tamarack, canoe-birch, and balsam-fir with mountain maple and numerous shrubs and small plants. In some places this strip is only a few chains wide, while in others it goes back a quarter of a mile or more. Beyond or inland from this the soil is covered with a deep layer of peaty moss saturated with cold water, the forest growth being open stunted spruce and tamarack. The temperature of a small stream trickling from this muskeg was 36° Farh. in July, while the water in the river was 70° Farh. From per-

sonal observation and from information furnished by the Indians who hunt on this river I infer that this is the character of the greater part of the country underlain by the dolomite. Where the rocks are Archæan the land is better drained and therefore more suitable for agricultural purposes. It is also better wooded, spruce trees reaching a diameter of two feet or more. Unfortunately, considerable areas have been burned at different times, so that small dense second growth covers much of the ground, the trees averaging from four to twelve inches in diameter. Large areas of muskeg.

Above the contact of the Palæozoic and Archæan rocks the river is narrower, and for fifteen miles rapids are common. In this distance there are ten portages, and as this part of the river is not much used by the Indians, the portage trails could scarcely be followed and we were obliged to clear them all afresh in order to get our canoes over. In some places the river runs in narrow gorges through the gneiss which forms steep walls thirty to forty feet high, the river itself being less than a chain wide. The uppermost portage is past a fall twenty-four feet high divided into two drops of equal height. It is also divided in the middle by an island. Above this fall, to the lake, Percy river is broader and deeper with slack water. Portages.

Twenty-five miles up, a branch two and a half chains wide enters from the north forming part of a canoe-route to the Albany river and at eighty-five miles the largest tributary enters from the south. It is three and a half chains wide at the mouth and four feet deep, but at this point the current is rather slow. This branch forms a canoe-route to Long Lake House and is described as a very rapid river with many portages. Where this stream enters, the main river is over six chains wide (435 ft.). There are also many smaller branches entering from both sides. At 120 miles from the mouth the river opens out into Percy lake eight miles long and one and a half wide. The longer axis has an east and west direction and the lake receives two streams of nearly equal size, one at the extreme west and the other at one mile to the east. We ascended the latter, which flows from the south, making a micrometer survey for six miles, but we found progress so slow by this method that we decided to abandon it and make only a track-survey. Mr. O'Sullivan, who did this work, reports as follows: 'From the end of the micrometer survey there are three miles of rapid water, then a narrow lake five miles long. This is followed by four miles of slack water to another lake, also five miles long and one mile wide. Above this, the river has a slow current for two miles to its source in a large circular lake, six miles across, with a deep bay to the south-east. All this country is rocky and swampy and was burned Percy lake.

probably fifty years ago. It is now covered with a second growth of poplar, spruce, canoe-birch and Banksian pine, the trees being from four to eight inches in diameter. About nine miles south-west from the outlet of the last lake, a comparatively high mountain stands out prominently.'

GEOLOGY OF LITTLE CURRENT RIVER.

Impure dolomite.

In ascending the river, the first rock exposure is two and a half miles above the mouth. It is a soft, argillaceous, reddish-brown dolomite, often interlaminated with beds of a greenish-gray colour and sometimes the rock is a mottled mixture of the two colours. It is seen in frequent outcrops for twenty miles up the river, and resembles very closely the rock found in ascending the Kapiskau river*. As far as examined these rocks yielded no fossils. Farther up, the rock is harder and varies in colour from a whitish-yellow to an olive-green. In places these rocks are highly fossiliferous and as complete a collection as time would permit was made. Dr. Whiteaves and Mr. Lambe have made a cursory examination of this collection and refer the rocks

Fossils.

to the Cambro-Silurian and Silurian periods. A list of these fossils with a description of the localities will be given in the detailed report.

Archæan rocks.

Eighty miles from the mouth there is an outcrop of hornblende granitite, extending across the river for ten chains, in a series of knobs mostly covered at high water. Above this, fossiliferous dolomites and limestones extend for four miles. The first large exposure of Laurentian age is at the eighty-eighth mile, where a gray granite-gneiss outcrops. The dip is N. 15° W. < 65°. This is followed by rusty-weathering, garnetiferous gneiss interfoliated with diorite-gneiss and in places with finely banded syenite-gneiss and mica schists. The last mentioned sometimes form a considerable portion of the rock. These rocks are generally well foliated and strike nearly east and west and dip north, at an angle of from 30° to 50°. They contain numerous veins of quartz-pegmatite, and coarse and fine grained diabase. Some of the pegmatite veins are almost pure red or white orthoclase. This is the general character of the rocks as far as the micrometer survey was carried. South of this, Mr. O'Sullivan reports: 'Laurentian rocks consisting of fine-grained granite-gneiss and mica-schist extend to the second lake. The rocks on the south-east shore of this lake are mostly massive mica-schists of Huronian type. The only two exposures on the opposite shore of the lake are a garnetiferous, muscovite-granite. The shore and

* Summary Report Geol. Surv. Can. of 1902, p. 222.

numerous islands of the third lake are very rocky. Massive biotite-schists and basic diorites, containing quartz veins, form cliffs in places thirty feet high.'

THE BIG DROWNING RIVER.

Mr. O'Sullivan, who surveyed the Big Drowning river, reports as follows :—

'The Drowning river runs parallel to the Little Current for seventy-five miles. It is six chains wide and averages three feet in depth. Its waters are swift, with a number of shallow rapids over dolomite ledges which had to be waded in getting our canoes up. The strongest of these has a fall of ten feet in half a mile.

'Seventy-five miles from its mouth, the river divides into two branches of nearly equal size, the one from the west, named the Kahapimegat, forming a canoe-route to Long lake. This branch which is very crooked and three chains wide, flows through a low swampy country for fifty miles; then the land rises gently for ten miles, when it becomes broken, high and rolling. Six portages were made to the 135th mile, from which I turned back.

'There are three elm groves near the mouth of the river, then for twenty-five miles, the banks are well wooded with spruce, poplar, canoe-birch, tamarack, balsam fir and Banksian pine, the trees being from four to eighteen inches in diameter. From the twenty-fifth to the fifty-fifth mile the country was over-run by fire some forty years ago and now a thick second growth of poplar and canoe-birch is seen. The woods along the Kahapimegat up to the ninetieth mile are much the same as those on the lower part of the Drowning river, some of the trees having a diameter of twenty inches. These larger trees extend only from twelve to fifteen chains back from the river; when the edge of the inland muskeg is reached. From the ninetieth to the 102nd mile the country was burned over some twenty years ago; thence good mixed timber covers the loamy soil as far as the river was followed. Forest growth.

'High clay banks extend for a distance of thirty miles from the mouth and attain in places a height of fifty feet.

'The first rock in situ occurs five miles up, where a soft reddish-brown argillaceous dolomite, lying almost horizontal is seen. The same rock is frequently met with between the eighteenth and thirtieth miles, banded with layers of a grayish colour. Fossiliferous rocks Silurian rocks.

extend from the thirty-fifth to the forty-second mile and the fossils collected indicate that the formation is Silurian. Rusty-weathering dolomite, carrying a considerable amount of iron was noticed in this stretch. No rock exposures were seen between the forty-second and the 119th mile. At the latter distance a mass of reddish-gray pegmatite-granite extends across the river. From this point to the end of the survey, a distance of fifteen miles, many exposures of Laurentian rocks were seen. Granite-gneiss, interlaminated with basic bands and a pegmatite-granite predominate. The general strike is N. 40° E. The dip is irregular but usually at a high angle.'

THE KÉBINAKAGAMI RIVER.

The Kébinakagami river enters the Kenogami at Mammawémattawa, near the Post of the Hudson's Bay Company, in latitude 50° 25'. In a general way, its course is north-westerly as far as it was surveyed. It receives several branches, chiefly from the east, as there is only a short distance between it and the Nagagami river on the west. At a distance of thirty miles up, the two rivers are only a mile and a half apart. The largest branch enters at one mile from the mouth. For a considerable distance the Kébinakagami is from two to three chains wide, with slack water except in a few places. The clay banks are from 10 to 30 feet high. Farther up, where the dolomite comes to the surface, the river is wider and in consequence shallow. From the forty-seventh to the sixtieth mile, the bed of the river is mostly a flat dolomite rock. In this distance, the stream is almost a continuous rapid, where it is impossible to pole canoes up and unsafe to run coming down on account of the smooth rock, shallow water and numerous boulders. In order to pass the worst places the men require to wade and drag the canoes up or lower them down slowly. At sixty-two miles up, the first outcrop of gneiss is seen and here the first portage is made. From this point to the portage across to the Mattawisquia, five portages are made to pass rapids and chutes. The first is half a mile long, but all the others are short.

Thirteen miles of almost continuous rapid.

The soil is the usual clay-loam and where drained is of excellent quality, but on the lower part of the river the land is so flat that there is little drainage, and muskeg prevails away from the banks. This continues up to the gneissic rocks, when the land is higher and the soil drier, though there are still considerable areas of swamp. For twenty miles up the river, the country was over-run by fire in 1901, and except small clumps of green woods in places along the stream, there is nothing standing except bare trunks of trees, and the country presents a most

Soil and forest.

desolate appearance. South of this burnt area, a second growth, probably fifty years old, covers the ground up to the first portage, and above this a recent fire has swept almost everything bare for three or four miles. Then follows green woods of small growth as far as the river was examined.

The large branch emptying into the Kébinakagami, one mile from its mouth, I have named the Ridge river. I made a rough track-survey of this stream for forty miles. Its general course is west and it resembles very closely the lower part of the other rivers examined in this region. It varies in width from two to three chains and has numerous rapids blocked with boulders. No rock exposures were seen, the banks being till and clay, containing marine shells. The water was so shallow that it was impossible to take a canoe beyond the forks from which I turned back. At this point the river divides about equally, the south branch extending a long distance up to a lake. This can be reached by canoes in high water. The other branch flows from the north-east and is not so long. I was not able to get a good sketch-map of these branches from the Indians, as none of them seemed to know the routes sufficiently well. The whole country drained by this river was burned, as far up as the forks by the fire of 1901, and only a few green trees are left. The forest growth on both these rivers is the same as that on the Little Current river. The Ridge river.

GEOLOGY OF THE KÉBINAKAGAMI RIVER.

In ascending the Kébinakagami river, the first solid rock is met with at the twenty-first mile from the mouth, and is the reddish-brown and greenish-gray argillaceous dolomite found on adjacent rivers. This rock is seen in a few exposures for the next twenty miles. South of this there are many outcrops of a brownish and light-yellow dolomite stained in places with iron and presenting an ochry appearance. The fossils collected from these rocks show that they belong to the Silurian system. The contact between the Palæozoic and Archæan rocks is between the sixty-first and sixty-second miles. At the latter a mass of dark syenite-gneiss, interfoliated with layers of lighter colour and finer texture, crosses the river where the first portage is required. The dip is S. 40° E. $< 30°$, but at the south end of the portage, half a mile distant, the dip is S. 20° E. $< 70°$. At the second portage the rocks and the dip are the same as at the south end of the first. Then follows a mass of diabase and diorite, a quarter of a mile wide. Southward, as far as the river was examined, the prevailing rocks are granite-gneiss, interlaminated with basic bands, acidic granite, syenite-gneiss and Contact of Palæozoic and Archæan rocks

finely banded biotite-gneiss. Where I turned back the strike is nearly east and west and the bands are almost vertical. These gneisses are cut by small pegmatite veins, or dykes composed chiefly of feldspar. There are also small quartz veins and masses of a lenticular form.

THE NAGAGAMI RIVER.

The Nagagami enters the Kenogami river one mile and a-half above the Hudson's Bay Company's post at Mammawémattawa. It is about four chains wide at its mouth and discharges a large volume of water. For thirty-six miles from the mouth it flows with a moderate current and occasional rapids, between clay banks, 10 to 40 feet high. At this distance, the flat dolomite comes to the surface and the river becomes wider, in some places measuring 8 to 10 chains. Before reaching the first portage, there are two rapids, each about a mile long, which are too shallow in low water to float loaded canoes.

High clay banks.

For the first ten miles, the forest was destroyed by fire in 1901, and above this there is a large second growth of the usual trees, with a few small trees of elm and black ash. The larger of these trees measure from 4 to 12 inches in diameter.

Portages.

At the forty-ninth mile, the first portage occurs. It is over exposed granite rock along the bank and is 19 chains in length. In less than a mile there are two more short portages, the river having a total descent of 27 feet. The greatest fall in the river is at Highwood portage, fourteen miles further up, where for two miles there is a series of rapids and chutes with a total drop of 160 feet. The portage is 156 chains in length, but it is divided into two parts by a small lake. The country is here well wooded, some of the spruces measuring over 2 feet in diameter. There are also large canoe-birch, poplar and tamarack trees, but the south end of the trail has been recently burned. The soil is a clay loam and is of excellent quality. High-rock portage, one mile long, is six miles further up and here the fall is 102 feet. Almost adjoining this is Jackpine portage with a drop of 23 feet. Two miles and a-half south of this portage, at the seventy-eighth mile, the trial line of the projected Grand Trunk Pacific Railway crosses the river. This is 130 miles north of the Canadian Pacific line at Montizambert, measured along the canoe-route. There are altogether thirteen portages up to Nagagami lake, but none of them exceed half a mile in length, except the three named, and some are only a few chains long. For the greater part of this distance, close to the river the land is low and swampy, but at some distance back, there are undulations and low hills which afford better drainage. Old second growth timber prevails over most of this tract, but there is some good spruce and poplar near the lake.

Trial line of the projected G. T. P. Ry.

Nagagami lake is six miles and a-half long by four and a-half wide, and in places, not far from the western shore, it is 40 feet deep. Above the lake the river is much smaller and is very crooked with numerous rapids and boulders. In places the overhanging trees almost meet from opposite sides. Between Nagagami lake and Obakamiga lake, a distance of twenty-eight miles, there are nine portages. Elbow portage is one mile long and has a fall of 35 feet, and Loop portage, two miles further south, is 48 chains long with a fall of 33 feet. All the rest are short. Looking southward from Nagagami lake, the country is somewhat hilly and seven isolated peaks are visible rising 500 to 700 feet above the lake. To the east, one or two low hills are seen but north and west the country is comparatively flat. The country between the lakes is wooded with the usual trees, but large areas have been burnt thirty years ago or more and are now covered with a dense growth of small spruce and poplar. Nagagami lake.

The Nagagami has several tributaries. The largest on the west side rises near the height of land and enters the main river twenty-two miles from the mouth. The chief branch, the Nagagamisis, flows from the east and falls 30 feet in a foaming cataract over jagged rocks into the river one mile below Highwood portage.

Obakamiga lake is about twenty miles long and extends south to the height of land. It is largely surrounded by granite hills, some of which are bare and some covered with a small second growth of timber interspersed with clumps of the original forest. A portage, three quarters of a mile long, is made from Obakamiga lake across the height of land into Big Rock lake, the latter draining into Lake Superior. Obakamiga lake is 56 feet higher than Big Rock lake. The canoe-route then follows a small winding stream, named Gum river for eleven miles. There are three portages in this distance. One, the Wigwam, is 131 chains in length and about midway it has a small lake up in it. The land is generally low and thickly wooded with fair-sized spruce and poplar. The Wigwam portage is over a sandy tract with a scattered growth of Banksian pine. The country below the portage is of the same character as above it. There is a considerable proportion of burnt land and some second growth. The Gum river below the Wigwam portage is only 20 to 30 feet wide and very crooked. There are large areas of good soil and others of sandy terraces covered with Banksian pine. Obakamiga lake. Forest growth.

The Shabotik river is about a chain wide where the Gum river enters it, and from this point to White lake, a distance of fifteen miles, there is only one short portage. From the portage to the lake the river is broader than before with slow current. The soil along this stream is Natamasagami lake.

generally good and there are some large spruce and poplar trees. White or Natamasagami lake is over thirteen miles long and is surrounded by low rocky hills, some of which are well wooded and others recently burnt and bare.

GEOLOGY OF NAGAGAMI RIVER.

At thirty-five miles from the mouth of the Nagagami, the first dolomite is seen *in situ* in the bed of the river, and a short distance farther up there is a cliff, twenty feet high, along the west bank. The rock here is of a grayish-drab colour, rather soft and intermixed with reddish-brown and mottled bands. It is of an argillaceous character, containing twenty-seven per cent of magnesium carbonate and thirty-one of calcium carbonate. In ascending the river, the rock becomes a purer dolomite of a light yellowish colour and fossiliferous, with ochry bands. The fossils are of Silurian age.

Impure dolomite.

Between the exposures of Sedimentary and Archæan rocks there is only a distance of 110 chains, but here, as on the other rivers examined, the contact is covered by clay. The first outcrop of the Archæan is at the north end of the first portage and consists of a granite-gneiss with veins of epidote, dipping S. 20° W. $<$ 20°. At the south end of the portage, the rock is a chloritic-quartz-syenite and this extends up to the next portage, twenty chains distant. Then follows a dark gray schist, well foliated and striking N. 85° W., with the layers vertical. This continues for twenty-six chains to the third portage, where it changes to a pyritiferous schist and forms the matrix of a conglomerate. The pebbles, which form a large portion of the mass, are largely granitic and are all elongated in the direction of the strike. They vary in size from mere specks to a foot or more in diameter. A few are nearly round but more are angular. This conglomerate is about five chains wide measured across the strike. Immediately south of this the rock is a fine-grained schistose greenstone, the vertical laminæ striking S. 85° E. There are also bands of hard mica-schist with deep cavities on the weathered surface. These rocks extend for over a mile and are succeeded by typical mica-schist.

Outcrop of granite-gneiss.

Conglomerate.

From this southward to Natamasagami lake, the rocks are granite-biotite-schist, syenite, mica-diorite-gneiss, garnetiferous pegmatite, granitite, syenite-gneiss, quartz-syenite-porphyry, aplite, etc. The strike varies considerably, but is generally nearly east and west and the dip is usually at a high angle or vertical. The gneisses are frequently cut by dykes of pegmatite, quartz and diabase. A good example of the latter is seen at a short portage north of Jackpine portage where a

Kinds of rocks.

dyke, eight feet wide, cuts the gneiss at a small angle, and stands out very prominently.

The rocks, as far as seen, on the east shore of Natamasagami lake are granite and biotite-gneiss for a considerable distance from the north end of the lake, but beginning about seven miles from Montizambert, for over three miles south the rocks are hornblende schist, acidic tuff, and basic hornblende-porphyrite.

Geological divisions.

The Silurian rocks extend, in a general way, about fifty miles south of the English river post, as seen on the Kébinakagami and Nagagami rivers and about eighty-five miles west on the Little Current. South and west of this the Laurentian gneisses and granite occupy a large area. A narrow band of Huronian crosses the Nagagami river at the Three Portages, and a small area of the same age occurs on Natamasagami lake, and another on O'Sullivan lake at the headwaters of the Little Current.

Glaciation

Fossiliferous clay, holding slender forms of *saxicava rugosa*, was found along the lower parts of all the rivers surveyed. Boulder clay underlies this Leda clay and contains the same kinds of boulders as were enumerated last year.* Striæ were noted on the Nagagami route, the Little Current and other rivers. There are two principal courses, S. 20° E. and S. 20° to 40° W. The evidence of southward movement is unmistakable.

TIMBER AND FAUNA.

Several groves of elm and black ash were noted in the area examined. With these exceptions the trees and the smaller plants are mostly the same as those mentioned in my report of last year, p. 239.

The following animals are hunted for their fur in this region: muskrat, marten, mink, beaver, otter, ermine, fisher, lynx, fox, bear and wolverine, and for food, moose, caribou and Virginia deer.

The principal fish are sturgeon, whitefish, pike, pickerel, speckled trout and suckers. Mr. Vincent informed me that sturgeon are fairly plentiful and are caught at English river post up to six feet in length; those four feet long are common. Speckled trout are very abundant, especially in the Nagagami and Little Current rivers. They rise to the fly freely and average seventeen inches in length.

A small collection of insects was made, a list of which will be published later. Among the butterflies is *Papilio machon* L. var. *Alaska*

* Summary Report Geol. Surv., Can., 1902, p. 226.

Insects.

Scudder. Dr. James Fletcher, Dominion Entomologist, says as far as he is aware this species has not been taken elsewhere than in Northern British Columbia and Alaska.

Mr. Owen O'Sullivan, as formerly, rendered valuable assistance and did his work most satisfactorily.

We are indebted to Mr. E. E. Vincent, English river post (at Mammawémattawa) for aid in our work, as acknowledged on a former page, and to Mr. S. B. Barrett, in charge of the Hudson's Bay Company's post at Montizambert for kind hospitality.

The Temagami District.

Dr. A. E. Barlow.

Office work by Dr. A. E. Barlow.

The first of the year previous to the beginning of field-work was spent by Dr. A. E. Barlow and Mr. O. E. LeRoy in making detailed petrographical examinations of the more important rock-types collected by some of the staff during the preceding season. In addition to this, considerable progress was made with the details necessary for the completion of the report on the Sudbury nickel deposits. A geological map in two sheets, showing the area immediately surrounding the mines of the Canadian Copper Company at Copper Cliff, Ontario, was prepared on a scale of 400 feet to an inch. Besides this, two smaller sheets, each on a scale of 1 mile to an inch, were compiled to show the general geology of the area in the vicinity of the Southern Nickel Range. Of these, the westerly map, known as the 'Victoria Mines Sheet,' has been issued, showing the distribution of the various rock-masses. No attempt, however, was made on this plan to separate the nickel-bearing norite from the older green schists and diorite, as it was not possible, in the time at our disposal, to do this in detail over the whole area. During the progress of the work on this western area the great importance of such a division was realized, and accordingly, on the eastern map, known as the Sudbury Sheet, this separation was effected, showing in a very striking way the prevalence of the deposits of the nickel and copper-bearing sulphide along the borders of the norite. This map will shortly be issued, as well as the larger and more detailed geological map of the area immediately surrounding the Copper Cliff and Murray mines. Some time was spent in the determination of rocks sent by Messrs. Robertson and Carmichael of the British Columbia Department of Mines. In this connection it may be remarked that such determinations of isolated specimens, often obtained during a hurried visit to a prospect or a mine, and usually collected in very close prox-

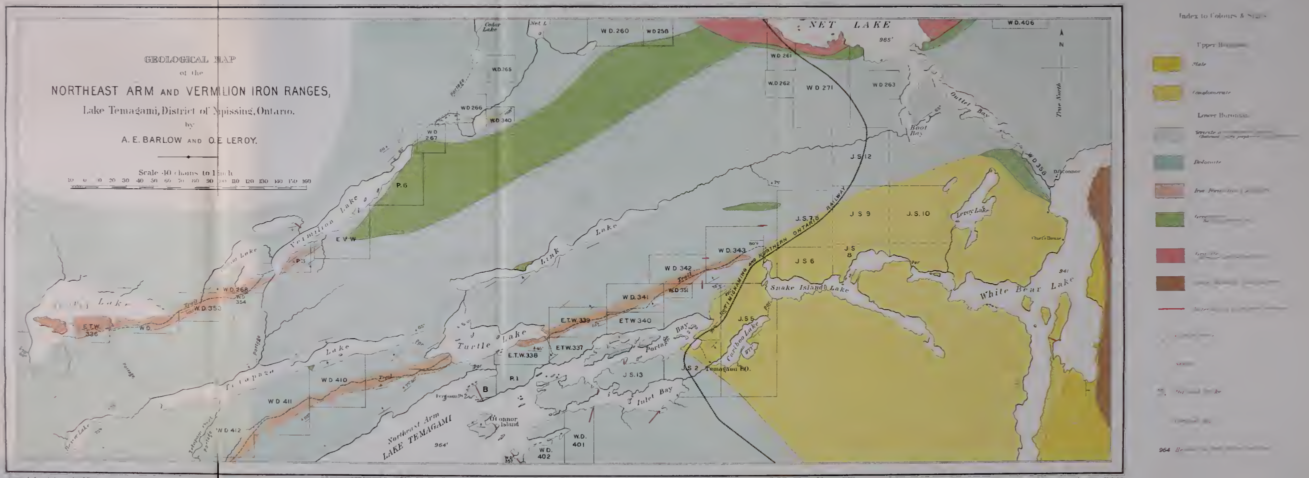
Progress of report on Sudbury nickel deposits.

Work done for Bureau of Mines, B.C.

Geological Survey of Canada

ROBERT BELL D.Sc.(Cantab.), M.D. LL.D. F.R.S. I.S.O., ACTING DIRECTOR

1904



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imity to the ore body, seldom afford very useful or accurate information in regard to the outcrop as a whole. A detailed examination of a considerable area, accompanied by critical petrographical studies of the different rock-types, is usually necessary before any very complete and accurate statement can be made with regard to the occurrences.

Geological excursion to Lake Superior iron district.

Through the courtesy of the acting Minister of the Interior, Dr. Barlow, in company with Mr. A. P. Low, also of this Survey, took part in an excursion to the iron ranges of Minnesota and Michigan. This excursion was under the personal conduct of Dr. C. K. Leith, Professor of Geology at Wisconsin University and author of the monograph issued by the United States Geological Survey on the Mesabi iron range. It was fully intended that Professor Van Hise would also accompany the party on this trip, but urgent business reasons prevented him from doing so. Dr. J. Morgan Clements, who is the author of the forthcoming report on the Vermilion iron range, explained the structural relations of the component rocks and ores outcropping in this area, while Dr. Leith furnished the results of his studies of the Mesabi iron range. Drs. Grant, Hobbs, Weidman, and also W. M. Merriam, geologist of the United States Steel Corporation, accompanied the party. In addition about thirty post-graduate students of Wisconsin, North-western and Chicago Universities were present. The excursion lasted from April the 19th to 29th, and it is believed was productive of results which will greatly assist us in the examination of the Canadian occurrences of similar iron-bearing formations, while at the same time a further knowledge was gained with regard to the structural relations of the enclosing rocks. One day was spent in examining the Vermilion range in the vicinity of the Soudan mine at Tower. Two days were spent on the Mesabi range and the principal mines at Biwabik, Eveleth, Virginia and Hibbing were visited. On the return journey, one day was spent at Ironwood and another at Ishpeming, examining the iron-bearing formation of the Penokee-Gogebic and Marquette districts. Two days were also spent in the copper country, extending from Houghton to Calumet. As a result of these examinations the belief is held* that the Vermilion iron range of Minnesota is very closely related, if not identical in character and age with the iron-bearing ranges outcropping in the vicinity of Temagami lake. Both have highly inclined attitudes with very brilliant associated jaspers. Both are enclosed by greenstones and green schists or sericite schists (altered quartz

*Dr. Barlow alone is responsible for the beliefs, opinions, comparisons, etc., mentioned in this report, as to the ferruginous rocks of the Lake Temagami district and its geology in general.

porphyries and porphyrites), but, while in the case of the Vermilion range the greenstone is, for the most part at least, basalt, some of that present in association with the Temagami ranges is intrusive, although portions are crushed amygdaloidal diabases and porphyrites. In the Temagami ranges, however, the iron ore is mainly magnetite with subordinate hematite, while in the Vermilion range these conditions are reversed and hematite prevails.

Departure for the field.

Mr. LeRoy left Ottawa for Temagami lake on May 15, Dr. Barlow leaving four days later. A few days were spent with Professor C. R. Van Hise and Dr. C. K. Leith in a preliminary examination of several of the iron ranges and in a general geological reconnaissance of the area between the Northeast Arm and Obabika lake. This completed, Dr. Barlow returned to Ottawa on May 29, leaving Mr. LeRoy in charge, with instructions to work out the geological associations of the Northeast Arm iron range. The month of June was taken up in details of office work, and in work on the Haliburton map-sheet. From the 4th to the 10th of July Dr. Barlow was working in Montreal with Dr. F. D. Adams, of McGill University, in connection with a report on the Haliburton district.

To insure a more accurate mapping of the Temagami iron ranges it was decided to seek the assistance of magnetic measurements in order to determine more closely the position of the iron formation. By permission of Dr. Haanel, Superintendent of Mines, and with the approval of the Hon. Mr. Sifton, Minister of the Interior, Mr. Erik Nystrom, assistant to Dr. Haanel, was sent with Dr. Barlow to do this part of the work. Leaving Ottawa on July 22, Dr. Barlow and Mr. Nystrom arrived two days later at Mr. LeRoy's camp on O'Connor island on the Northeast Arm of Temagami lake. A base line was cut out and chained, starting from a point almost directly north of a small island west of the Ferguson mine, Location B, and running thence to the Tetapaga river, a distance of about 125 chains. This line followed roughly the direction of the jaspilyte band, the bearing having to be changed three times in the distance covered. At an interval of every five chains, cross lines at right angles to the main line were measured from the starting point to within about 14 chains of Tetapaga river. Observations were made for both vertical and horizontal magnetic intensity at a distance of every chain (66 feet) along these lines, by means of the Thalen-Tiberg magnetometer. By means of these observations it was possible to trace the gradually curving iron formation throughout a distance of over $2\frac{1}{4}$ miles, even through intervening swamps where no outcrops occur. In many instances the comparatively thin covering of moss and turf was removed in order to check

Magnetic work in exploring iron ranges.

these observations by noting outcrops of rocks of the underlying formations. It was also possible by magnetic means to subdivide the iron formation into several smaller bands, which are fairly continuous over considerable distances and approximately parallel to one another. Besides these there are usually smaller lenticular masses of the jaspilyte, which are also rather closely parallel to the larger belts. The larger and more continuous bands of iron formations are separated from one another by considerable masses of the associated green schists, which are either altogether barren of the jaspilyte or contain only occasional thin laminæ of this characteristic material. The continuity of even the more solid bodies of iron formation is broken by the occurrence of thin layers of slaty or schistose rock. A somewhat more detailed magnetic survey was made of one of the mining locations which comprise the Northeast iron range, known as E. T. W. 339. For this purpose a line was run connecting the southwest and northeast corners of this lot. At right angles to this line and at intervals of every chain (66 feet) cross lines were run at right angles. Magnetic observations of both the vertical and horizontal intensity were made at distances of half a chain (33 feet) along these lines. By this means an accurate delimitation of the iron formation was effected over the whole lot. This work being completed, Mr. Nystrom returned to Ottawa on August 26. Maps showing the details of these magnetic observations have been prepared by Mr. Nystrom, and are filed for reference in the office of the Superintendent of Mines. The results obtained will be incorporated on the general geological plan of the area.

Detailed magnetic survey of Location E. T. W. 339.

Geological work on this district was commenced in 1887 by the writer of this report, who was then acting under instructions from Dr. Robert Bell, as his assistant. Only two months of the summers of 1887 and 1888 were devoted to this work, and by far the greater portion of this time was occupied in some of the many topographical detailed surveys necessary in a region concerning which but little had hitherto been known. The geology done was merely incidental, and necessarily subordinate in a way to the topographical survey, but as many observations regarding the nature and distribution of various rock-formations were made as was possible in reconnaissance work of this kind.

Work done in 1887.

In the survey of Temagami lake, one of the bands of iron formation was noticed on the Louis islands in the Southwest arm, and the characteristics of the outcrop were described.* The occurrence of

Discovery of iron formation.

* Annual Report, Geol. Surv., Can., Vol. X. (N.S.), 1899, p. 151, I.; (Publication No. 672).

magnetite on Temagami island in association with pyrite, pyrrhotite and chalcopyrite, was also noticed.† In 1888 this topographical work was continued, as was also the geological reconnaissance, and a number of the more important lakes and streams in the vicinity of Temagami were thus surveyed and examined. During the progress of these, the occurrence of iron ore was noticed on Vermilion lake,* and a belt of jasper and iron interbanded with one another was described as outcropping near the west end of Turtle lake. The full importance of these discoveries, however, was not at first realized, but renewed activity in iron mining and more complete descriptions of the Lake Superior occurrences turned attention to our own iron formations. The report, therefore, of the discovery of these iron formations, and the communication of the fact to the Bureau of Mines of Ontario, in the autumn of 1899, should have been accompanied by some such statement as the preceding one. The prospectors went into the field with the Geological Survey maps in their pockets, and in possession of the knowledge that in the localities specified and shown on the maps iron-bearing formations were known to outcrop. To Daniel O'Connor of Sudbury, the veteran prospector, belongs much of the credit for the tracing out of most of these iron formations, while at the same time his earnest and persistent advocacy of their economic importance has been one of the most powerful factors in directing public attention to them.

Report by Prof. W. G. Miller.

The first detailed report of the Temagami iron ranges is that written by Prof. W. G. Miller,‡ but as explained by the author, 'as the Director of the Bureau of Mines was anxious to have the report published as early as possible, time was not permitted, through pressure of other duties during the winter, for the making of a careful examination of all the specimens collected while in the field. It was thought, moreover, that a description of this material would find a more fitting place in a future and more detailed report.' Pressure of other work, however, has no doubt prevented Professor Miller from giving this further information and much more detailed areal geological mapping will be necessary before any authoritative and complete account of the relations of these iron ranges and their geological associates can be written.

Four distinct iron ranges in Tamagami district.

In the Temagami district there are four separate iron ranges, known as follows :—

1. Northeast arm range.
2. Vermilion range.
3. Ko-Ko Ko range.
4. Austen Bay range.

† Annual Report, Geol. Surv., Can., Vol. X. (N.S.), 1899, pp. 144 and 152. I.
* Annual Report, Geol. Surv., Can., Vol. X. (N.S.), 1899, pp. 145 and 152. I.
‡ Annual Report, Bureau of Mines, Ont., 1901, p. 160.

Magnetic concentration of magnetite-bearing jaspilyte.

The iron ore in all of these ranges, thus far encountered, is a silicious magnetite interbanded with variously coloured jasper and chert. In some instances a small proportion of hematite is present, but this very seldom exceeds 25 per cent of the whole. Some of the richer bands contain as high as 55 per cent of metallic iron, but these are exceptions, although large quantities of ore could be secured which would average between 40 and 45 per cent. This association of the magnetite and silicia is extremely intimate, and even the richest portions of the bands contain a high percentage of this latter mineral. It is possible, however, to bring this ore to Bessemer grade by magnetic concentration, as shown by J. Walter Wells.* A specimen of an average sample showing 42·89 per cent metallic iron was crushed to 0·10 of an inch, and finer, and passed through a magnetic separator. The 'heads' or first concentrates show 57·28 per cent of metallic iron. These 'heads' when passed through the separator a second time gave a product which assayed 65·20 per cent of metallic iron. In the many assays made no titanium dioxide has been found and only an average of about 0·01 per cent sulphur and 0·02 per cent of phosphorus. None of the higher grade secondary deposits of hematite have yet been discovered, but very little has been done in the prospecting of these ranges except their delimitation at the surface. Extensive stripping, together with the digging of test-pits, as well as diamond drilling, will be undertaken by some of the owners of the mining locations as soon as the railway reaches the shores of Temagami, which will be about the beginning of June next year.

Geological map.

A geological map has been prepared on a scale of 40 chains to an inch, and will accompany this volume which will show the outlines of both the Northeast arm and Vermilion iron ranges, as well as the distribution of the various associated rocks.

Limits of Northeast Arm iron range.

The Northeast arm range has received more attention and study, not only because of its proximity to the projected Ontario government railway, but also because, in extent and geological association it is one of the most promising. The iron formation proper of this range, or the silicious iron ores with their interlaminated jasper, starts about one-tenth of a mile west of the north end of Crooked or Snake Island lake, and passing beneath the waters of Turtle lake, ends in a swamp about 14 chains from the Tetapaga river. The whole band, therefore, is nearly $5\frac{1}{4}$ miles long. In this distance it varies in width from 200 to 500 feet.

Extent of Vermilion iron range.

The Vermilion range, commencing a little to the east of Vermilion lake, runs in a south-westerly direction for about three miles to the

*Annual Report, Bureau of Mines, Ont., 1903, p. 336.

west of Iron lake. To the northeast it is interrupted by a mass of greenstone, while the western end passes beneath the drift. It cannot extend much further in this direction, as a tongue of granite comes in a short distance west of this lake. The widest portion just south of Iron lake measures over 1,000 feet.

Preliminary examinations of Ko-Ko Ko and Austen Bay iron ranges.

Preliminary examinations of the Ko-Ko Ko and Austen Bay ranges were made, and both apparently occupy a similar geological horizon. The Ko-Ko Ko range is famous for the brilliancy of colour of the associated jaspers, while the Austen Bay band contains only a small amount of this mineral, being replaced to a great extent by darker and duller coloured chert. The Austen Bay band is much broken up by later intrusions, chiefly diabase and granite.

Conclusion by Van Hise.

The conclusions reached by Professor Van Hise and his associates, after their detailed examination of the Minnesota and Michigan iron ranges, is that a cherty iron-bearing carbonate is the chief original rock from which the iron-bearing formations and ore bodies have been produced. It is stated by Professor Van Hise that iron sulphide has contributed by its decomposition to the formation of these ores, but not to any large extent. Dr. Bell has shown* that there is little doubt the great mass of hematite at the Helen mine in the Michipicoten district, has resulted from the local decomposition and alteration of the carbonate of iron, mostly in quartzose and cherty layers, which occurs as a wide belt, traceable in the unaltered form, both east and west of the hematite mass. On the surface of the hill, where oxidation of the siderite has progressed inwards about half an inch, leaving that amount of brown hematite, it is found that grains of pyrite, which were scattered through the siderite, still remain unaltered, going to show that pyrites is changed with comparative slowness. This cherty iron-bearing carbonate is found in connection with the whole of the Lake Superior iron ranges, with the exception of the Mesabi, where iron silicate has evidently been the source of the ore. The changes, or metamorphism, in connection with these occurrences, and the production of bodies of iron have been mainly along two lines: 1st. The production of amphibolitic and magnetitic quartz rocks or schist, and occasionally also pyroxenic and chrysolitic rocks. These are the products of deep-seated metamorphism in connection with igneous intrusion. No workable ore bodies have yet been found in connection with rocks thus altered. 2nd. The development of ferruginous slates, ferruginous cherts, jaspilytes and ore bodies. These rocks are characteristic of the belt of weathering, but in many cases the production of the jasper has required

Metamorphism of original iron-bearing rocks.

* Summary Rep. Geol. Sur. for 1900, page 116.

two stages: namely, first, the formation of the ferruginous slates and cherts in the belt of weathering, and secondly, dehydration when the formations were deeply buried. In some cases the bodies are due to the oxidation of the carbonate of iron in place, but all the facts point unmistakably to the conclusion that the final and most important step in the production of the ore bodies was secondary enrichment by downward percolating waters below crests or slopes, where such waters were conveyed by the sloping troughs. The waters which followed the more circuitous routes carried iron carbonate: those more directly from the surface which did not pass through iron carbonate, bore oxygen. The two waters mingled and precipitated the iron oxide. Continuing, the waters ascended, and escaped, bearing the silica to be deposited elsewhere below the valleys.* Development of jaspilyte and ore bodies.

Studies of the Temagami occurrences have not yet gone far enough to justify any very definite conclusion, but the fact that outcrops of a cherty carbonate have been found in the area immediately west of Iron lake seems to throw some light on the question of the origin of these occurrences. A specimen of this, examined by Mr. Donald Locke, assayer to this department, showed iron 35·67, silica 24·95, sulphur 0·01, phosphorus 0·022, with no titanium. The information already obtained seems to show rather clearly that, in the main, at least, the conclusions reached in regard to the origin of the iron formation and iron ores of Michigan and Minnesota will apply to the occurrences in the vicinity of Temagami.† Cherty carbonate of iron found near Iron lake. Analysis.

The work of the past summer has shown clearly† that the iron formations of this area belong to a much older series than what has hitherto been described as Huronion in this district. On the geological map by Dr. Barlow the area occupied by the Northeast arm iron range is shown as occurring in the slate or middle member of the Huronian. This is incorrect. On the contrary the iron range with accompanying green schists, slates, dolomites and schistose eruptives, and intruded by granites, belong to a series which had been intensely folded, metamorphosed and considerably eroded before the deposition of the overlying conglomerate hitherto described as the basal member of the Huronian system in this region. The larger fragments in the conglomerate are principally pebbles of granite and greenstone derived from the degradation of this underlying series. The immediate junction between this older series and the unconformably overlying conglomerate is well seen at a point on the south shore of the Northeast arm Iron formation belongs to much older series than hitherto supposed. Unconformable contact between lower and upper Huronian.

* "Iron Ore Deposits of the Lake Superior Region." Twenty-first Annual Report U.S.G.S., 1899-1900, Part III, pp. 418, 419.

† In Dr. Barlow's opinion.

about fifteen chains west of the portage into Cariboo lake. Thence the line of junction runs in a northwesterly direction a little to the east of Farr's cabin, situated on the parcel of land known as Block A. Crossing the northeast corner of the lot marked on the map J. S. 5, it reaches the eastern limit of mining location W. D 343, about five chains north of Snake Island lake. Here the junction between the two formations is very well seen on a small hill over which the east line of the location runs. This hill was stripped of the overlying moss and turf and a photograph taken, which shows this unconformity very plainly. A short distance from this point the line of junction turns abruptly to the east and with this general direction reaches White Bear lake at the rocky point a quarter of a mile north of François White-Bear's house. Here the conglomerate rests on a much fissured and squeezed greenstone, the latter rock forming the extreme point jutting out into White Bear lake. The relationship between the two rocks is everywhere distinct, the conglomerate dipping at an angle of from 12 to 20 degrees in a southerly and southeasterly direction, while the foliation of the underlying schists shows highly inclined dips to the northwest, ranging in angle from 60 degrees to nearly vertical.

Location of line of junction between lower and upper Huronian.

The geological sequence in this area is therefore as follows:—

Geological sequence.

Lower Huronion*:—Greenstone, green schist, sericite schists, slates, dolomite and iron formation with intrusive granites.

Upper Huronian*:—Breccia or slate-conglomerate, slate, quartzite.

The schistose rocks of the Lower Huronian may be divided into the paler coloured and more acid varieties, which are deformed quartz-porphyries or porphyrites, and the more deeply coloured or basic schists resulting from the shearing of hornblende porphyrites, basalts and diabases. The extreme deformation of the more acid types produce sericite schists, which reveal little or no trace of their original structure. In places, however, the hand specimens secured showed clearly that they have resulted from the shearing and alteration of quartz-porphyries or quartz-porphyrites. In colour they are generaly pale yellowish green, although occasionally mottled with purplish, reddish or yellowish tints. In some cases the original phenocrysts are still microscopically apparent, chiefly feldspar in yellowish, reddish, or more rarely, pale greyish colours. The least altered variety of these porphyries shows the usual more or less rounded phenocrysts of quartz, together with orthoclase and oligoclase, embedded in a ground-mass which varies considerably in texture from being a finally cryptocrystalline to moderately coarse-grained micro-granitic. The quartz phenocryst exhibits characteristic invasions and inclusions of the ground-

Character of rocks of lower Huronian.

Quartz porphyries and porphyrites.

* Locally so called.

mass. By progressive steps this structure is gradually effaced until in the extreme schistose varieties nothing remains but comparatively coarsely granular quartz, sericite and calcite. Some of the more massive types have undergone considerable decomposition, and the original phenocrysts of feldspar can with difficulty be separated from the equally weathered ground-mass. These more acid types pass into porphyrites which contain little or no quartz. Some of the areas now occupied by chlorite and epidote suggest the original occurrence of hornblende. Iron ore, always ilmenite, either partially or completely altered to leucoxene, is also present in considerable quantities, while calcite or dolomite is always abundant. Such rocks are of a deeper green colour and are the immediate associates of the iron formation, forming steeply pitching troughs in which the iron formation is enclosed.

Hornblende porphyrite.

Some of the deformed greenstones have evidently been formed at or near the surface, for patches of the thin sections still show the micro-granitic ground-mass characteristic of a porphyrite, passing into areas where the ophitic or diabasic structure prevails. The resulting rocks are a hornblende porphyrite and uralitic diabase. Some of the associated green schists are deformed basalts. All of these have suffered greatly as a result of shearing and decomposition, so that the component minerals in most cases show the extreme of alteration.

Diabase and basalt.

Slates on Beaver and Tetepaga lakes.

Associated with the sericite schists, and interbanded with them, are some greenish gray, or grayish, slaty rocks occurring mainly on Beaver and Tetepaga lake. They show the development of mica on the cleavage planes, with bands of varying colour. In places, also, some dark-gray bituminous or graphitic shales occur. These were noticed along the northern border of the iron range of the Northeast arm, especially near the eastern end.

Band of dolomite.

A band of dolomite, fairly continuous, extends from Ferguson mine point to nearly the end of the Northeast arm. It is generally of a pale, greenish-gray colour and very silicious. The quartzose impurities are arranged in narrow, vein-like forms, which reticulate in all directions through the mass, so that when subjected to ordinary weathering processes these stand out in relief, leaving irregular, hollow interspaces. This band weathers to a deep orange yellow, thus rendering it very conspicuous.

Dip of rocks of Northeast arm.

All of these rocks in the vicinity of the Northeast arm have a prevailing dip in a northwesterly direction, at an angle of seldom less than 50 degrees and usually varying from 65 degress to vertical. It is believed this prevailing dip is occasioned by a series of monoclinal folds, which have undergone extensive truncation. The iron formation,

judging by the magnetic observations, extends to considerable depths below the surface and probably occupies a series of steeply pitching troughs with impervious bases formed of the schistose rocks.

Dykes of olivine diabase.

Cutting these rocks at various angles are dykes of olivine diabase. The oldest set of these dykes cuts the sericite schists but they have been subjected to similar deformation and decomposition. The examination, therefore, of the thin sections gives very little information regarding their original structure and mineralogical composition. A second set cuts across the foliation of the sericite schists, but has not been subjected to the severe stresses which have metamorphosed the enclosing rocks. They show, however considerable decomposition, and have not been noticed cutting the overlying conglomorate. Still a third set of precisely similar mineralogical composition cuts even the overlying slate-conglomerate. This olivine diabase is very fresh and typical. The presence of these dykes is considered a favourabla sign, as in favourable attitudes elsewhere they often form, with the enclosing rocks, impervious basins for the collection of the secondary deposits of iron oxide.

Lower Huronian granite.

The granite associated with the Lower Huronian cuts the greenstones and green schists, and is therefore later than these. It, however, furnishes most of the pebbles in the conglomerate at the base of the Upper Huronian. This granite is extensively developed along the south shore of Net lake in the vicinity of the Narrows. It varies greatly in texture and mineralogical composition, is gneissic in places and porphyritic in others. It is prevailingly a biotite granite or granitite, but the borders are more basic and contain considerable hornblende in addition to the biotite.

Upper Huronian previously described.

There is no need here for a description of the Upper Huronian, as it has already been fully described in a former report on this district.*

EXPLORATION FOR IRON ORE.

General rules for guidance in exploration of iron ranges.

The following general rules will perhaps be of value in exploring these iron ranges and may be helpful in suggesting some of the principles which should guide those in charge in their search for the secondary deposits of iron ores, which some believe, will yet be found. They have been taken from Van Hise's monograph 'On the Iron Deposits of the Lake Superior Region.'†

1. Exploration should first be directed to outlining accurately the iron-bearing and adjacent formations on a fairly large scale with

*See Annual Report, Geol. Surv.. Can.. Vol. X, Part I, p. 95 et seq.
†See Annual Report, U. S. G. S., 1899-1900, Part III, p. 421.

structure sections. This should be aided by a magnetic survey, especially of the iron formation itself. [This has already been done over part of the Northeast arm iron range and has given very gratifying results.]

2. Exploration should be confined to the iron-bearing formations with but few limitations.

3. Exploration should be confined to the parts of the iron-bearing formation showing ferruginous slate, chert and jaspilite. The presence of interbanded hematite is favourable to the existence of ore deposits. Even distribution of the iron oxide is an unfavourable sign, and uneven distribution a favourable sign.

4. Thick and pure iron formations are more likely to carry workable deposits of ore. Formations less than 100 feet in thickness have rarely yielded deposits of value. The presence of many layers of interlaminated material, such as slate or interbedded igneous rock, is unfavourable to the presence of merchantable ore deposits. However, this also has its limitation, as the broader bands of such formation may contain workable bodies.

5. The contacts of the iron-bearing formation, especially those at the bottom, are likely to be fruitful in ore.

6. The presence of an impervious formation in contact with the iron range is especially valuable. Such impervious base may be made up of slate, schist, or greenstone, or any combination of these with cross dykes.

7. Pitching troughs, or even pitching folds, are favourable to the deposition of large secondary deposits of iron oxide.

8. The more shattered and broken the iron formation, the more favourable is this to the production of ores.

9. In reference to topography, the favourable places for exploration are usually the minor depressions on the slopes of elevations.

10. Exploration should at first be shallow. Stripping and test pits should be sunk before resorting to the more expensive diamond drilling.

Temagami iron range possibly same age as Vermilion.

If my opinion previously expressed is correct, and the Temagami iron ranges are similar in character and age to the Vermilion range of the Lake Superior region, experience gained in the latter in the exploration for the workable ore bodies will be extremely valuable for our guidance in Canada. The deposits if found will likely be at the bottom of

the irony formation. As the dips are very steep the area of any given ore deposit which would reach the surface would be comparatively small. The exploration should begin at the bottom of the contacts, especially at the ends of the folds or fingers, and should pass away from these contacts. If a well-defined pitching trough be discovered in which the rock is heavily ferruginous jasper at its base, but showing no ore deposit at the rock-surface, diamond drill work would be warranted to test the bottom of the trough with the hope of finding ore deposits, which are very small where they reach the surface.

Possible existence of secondary hematite.

No very definite statement can yet be made with regard to the probability of the finding of large workable deposits of iron ore in connection with these iron formations. The discovery of a considerable quantity of hematite at both the eastern and western extremities of the range is considered a very favourable sign. The geological associations and the composition of the iron formation are entirely favourable. On the other hand, the subdivision of what was at first supposed to be a solid body of iron formation into several minor parallel bands, separated by interbedded porphyrite schists and slaty rocks, has caused some anxiety, but still many of these subordinate masses are sufficiently large to contain ore bodies of workable magnitude. It is suggested that the remaining lots not yet included in our detailed examinations should be fully explored, and accurately mapped, such work being accompanied, as far as possible, by extensive stripping before the more expensive diamond-drilling is undertaken. This would be comparatively inexpensive, as the underlying rock is usually covered by only a few inches of vegetable mould or moss.

Further detailed exploration suggested.

Dr. Barlow returned to Ottawa on September 3, while Mr. LeRoy remained in the field until September 27.

Canada Corundum Co.

In November (12 to 14) a rather hurried visit was made to the mines of the Canada Corundum Co. at Craigmont, Ont., for the purpose of illustrating the latest developments. Some photographs were obtained, showing the general progress of the mining or 'quarrying' of the corundum, as well as of the new and commodious mill which will be in operation early in the coming spring. This mill will be able to handle between 200 and 300 tons of ore a day, with an output of 20 or 25 tons of cleaned and graded corundum. The buildings are placed near the eastern extremity of the hill on which the mines are situated, the upper floors being approached by an easy down grade from the openings. A tramway has been built from the mill to a wharf situated on the main channel of the York river, thus affording the much needed shipping facilities. Most of the side of the hill on which the

New mill.

main openings are situated has been cleared of trees and shrubs and subdivided by a surveyor into 100 feet squares, the corners being marked by stakes suitably inscribed. Series of levels have been run for the purpose of making a contour map of this part of the property. In addition a competent geologist has been employed tracing out and mapping the various outcrops occurring in these squares, making notes in regard to any peculiarities of composition and especially of the presence and relative abundance of corundum. In places considerable stripping has been done, which has greatly assisted both the geologist and the miner in their work. It is intended that a detailed geological map showing contours will be prepared, which will no doubt be of immense assistance in laying out plans for future extension of mining operations. A report for the Geological Survey, suitably illustrated is now being prepared, which will deal rather fully, not only with the origin and geological relations of corundum in Canada, but will also furnish descriptions of the mining and concentration of this mineral. Geological map of property.

Prince Edward and Hastings Counties, Ont.

Dr. R. Hugh Ells.

The work of the season was devoted first to making surveys necessary to complete the Kingston sheet of the Ontario series, and later to the survey of the county of Prince Edward.

Beginning on June 24, surveys were made of the district lying between the St. Lawrence on the south and the village of Morton on the north, comprising that part of the country between the southern part of the Rideau canal and the Gananoque river, to determine the position of certain outliers of Palæozoic rocks which rest upon the granite and other Archæan rocks. Subsequently a number of roads were surveyed to the west of the Kingston and Pembroke railway in the townships of Olden, Hinchinbrooke, Sheffield and Kennebec, in order to determine the limits of the several formations in this direction. Surveys in the Kingston district.

On July 9, the surveys of the area south and west of Madoc, necessary to complete the county of Hastings were commenced, and this work was continued to the end of the month. Surveys in Prince Edward Co.

Crossing over to the county of Prince Edward on the Bay of Quinté, all the roads in this area were surveyed in order that map-sheet No. 110 might be compiled, and work in this direction was finished on August 28.

Trenton and Black River formations.

In the area between Madoc and Trenton, including the western portion of the county of Hastings, the delimitation of the boundaries between the Trenton and Black River formations, which are the only two belonging to the Palæozoic division seen in this district, was made as closely as the large amount of drift which occupies the surface for many miles would permit, and the outline of the underlying Archæan was also fixed. The line between the two former was found to be very irregular, but the horizons of each were fairly distinct, owing to the abundance of fossils at many places.

Prince Edward Co.

In Prince Edward county the rock-formation was found to be almost entirely of Trenton age. At one place an outcrop of granite was seen, rising through the Trenton limestone, which is lying against it at angles of 30 to 45 degrees. The limestone is somewhat altered along the contact, but the contained fossils are readily recognizable. The granite is largely composed of red feldspar with quartz, and the outcrop is nearly a mile in length, but not very wide. The locality is about 180 chains south of the west arm of the Bay of Quinté, near Ameliasburg post office.

Fossils.

Over much of this area the Trenton limestone abounds in fossils, but there appear to be no minerals of economic value.

Lake of the Mountain

An interesting feature is the Lake of the Mountain near Glenora, about five miles east of Picton. This lake is near the top of a plateau of Trenton limestone which rises to a height of about 200 feet above the Bay of Quinté. The elevation of the lake is about 150 feet, A considerable stream of water flows from the north side to the Glenora mills, and this has led many persons to suppose that the water of this lake is derived from some far-lying source through an underground channel. The fact however, that the surrounding area lies at an elevation of from forty to fifty feet above the surface of the lake, and that several small streams drain into it, will account for the outflow without the necessity of a remote source of supply.

Potsdam sandstone.

In the area north of Kingston Mills, towards Morton, outcrops of the Potsdam sandstone were recognized at several points resting on the granite and gneiss. The rocks overlying the sandstone are seen at Joyceville, about two miles south of Washburn locks on the Rideau canal, and consist of hard fine-grained, and sometimes cherty, limestones with thin shaly partings, which are regarded as the base of the Black River formation, thus indicating a well-defined break in the Palæozoic sediments, since there is no indication of either the Calci-

ferous dolomites or the Chazy shales in this area. The most westerly recognized outcrop of the Potsdam sandstone yet seen in the Kingston area is about five miles east of the village of Tamworth, where several small outliers occur, resting partly on red granite and partly on the crystalline limestone. There is a deposit of red hæmatite at this place, but no large ore-body has yet been disclosed. The hæmatite appears to be derived from the basal red beds of the Potsdam through a process of leaching, and a considerably body of the red oxide now occupies in part a swampy area of the vicinity, resting upon the underlying crystalline rocks. In this respect it somewhat resembles the hæmatite deposit at the Playfair mine, and in the event of fissures existing in the underlying rock similar deposits of hæmatite may also be found here. Of this however, there are no superficial indications, the excavations not having as yet penetrated below the surface deposits. While the oxide extends over a considerable space, it is rarely sufficiently solid to constitute a true ore of iron. Black's iron mine.

Among other places visited in the course of the work in this field was the zinc-blende mine on lot 3, range V, Olden township. This is near the north side of Long lake. The country rock at the mine is a coarsely crystalline limestone cut by granite and pyroxene, the general strike being N. 70° to 80° East. Richardson's zinc mine, Olden.

The blende is associated with galena and iron-pyrites, and occurs in lenticular pockets, which widen out in places into bunches of ore containing hundreds of tons. No true vein structure is visible, but the mineral is seen at several points and extends over a considerable area. The mining is done by an open cut which has a depth in places of about 80 feet, and the ore is graded into two classes as extracted ; the rich massive ore, which is said to contain as much as 48 per cent of zinc, being shipped direct as No. 1, while the lower grades are cobbed from the calcite mass and concentrated on the spot.

The mode of occurrence is quite distinct from that seen at the blende deposit on Calumet island in the Ottawa river, where it is found in a hard diorite mass with gabbro and granite. Some hundreds of tons have been extracted and a quantity has been sent to Swansea. While pockety deposits are always of an uncertain nature there appears to be a good prospect for a considerable development at this place.

The actinolite mines in Elzevir township occur in a hornblende schist rock which forms ridges running in a northeast direction. Portions of the rock are altered to an impure serpentine, and the mineral is in zones or bands ; sometimes in pockets, generally along the sides of the ridges, ranging from a few inches in thickness to several feet. It Actinolite of Elzevir

occurs in the form of crystals, of which both the stellar and the platy or tremolitic varieties are recognized. Some of the latter are in broad sheafs with a length of four to six inches by two to three inches in breadth. The smaller sizes up to one and two inches are regarded as the best for milling stock, the stellar variety being generally too brittle to be made into good fibre. The serpentine portion of the ridges appears to be almost devoid of the actinolite.

Faults.

Evidences of faults are seen at several places and the actinolite bands are often cut off by these breaks, the slicken-sides being well exposed. At the eastern end of the property a shaft has been sunk to a depth of about thirty feet along one of these faults, the underlying wall being a soft chloritic rock, in which stellar crystals are disseminated to a depth of several inches, while the south side of the shaft is a mass of the tremolitic variety. The dip of the slide here is S.25° E. < 65°–70°.

Output.

The amount of fibrous mineral from the output of this mine is stated to be about 35 to 40 per cent, and this upon milling will yield about ten per cent of mill-fibre. The value of this fibre, which is used for felts and for boiler coverings, is said to be $20 per ton. The fibre remaining after the first separation, is ground and makes what is known as 'Asbestal', extensively used as a wall plaster, and valued at $6 to $7 per ton.

The milling plant is located at the village of Actinolite (formerly Bridgewater), and is on the same general principle as the mills for the extraction of asbestus in the Eastern Townships mines, though much less elaborate in construction.

Another mill is located at this place, owned by Mr. Joseph James, in which is utilized a mixture of talc or impure soapstone with scrap mica, the resulting ground material being sold for a fire-proof roofing material.

The Recent Landslide on the Lièvre River, P.Q.

Dr. R. W. Ells.

Area of the landslide.

The locality in which this disaster occurred is on the west bank of the Lièvre river, about 13 miles above Buckingham village and 17 miles from its junction with the Ottawa, a short distance below the Little Rapids lock and dam. The slide comprises an area of nearly 100 acres, of roughly triangular shape, with a base on the river of 28 chains and a depth inland to the foot of the mountain of about 35 chains, including a rich tract of excellent clay land. At the back of the disturbed area

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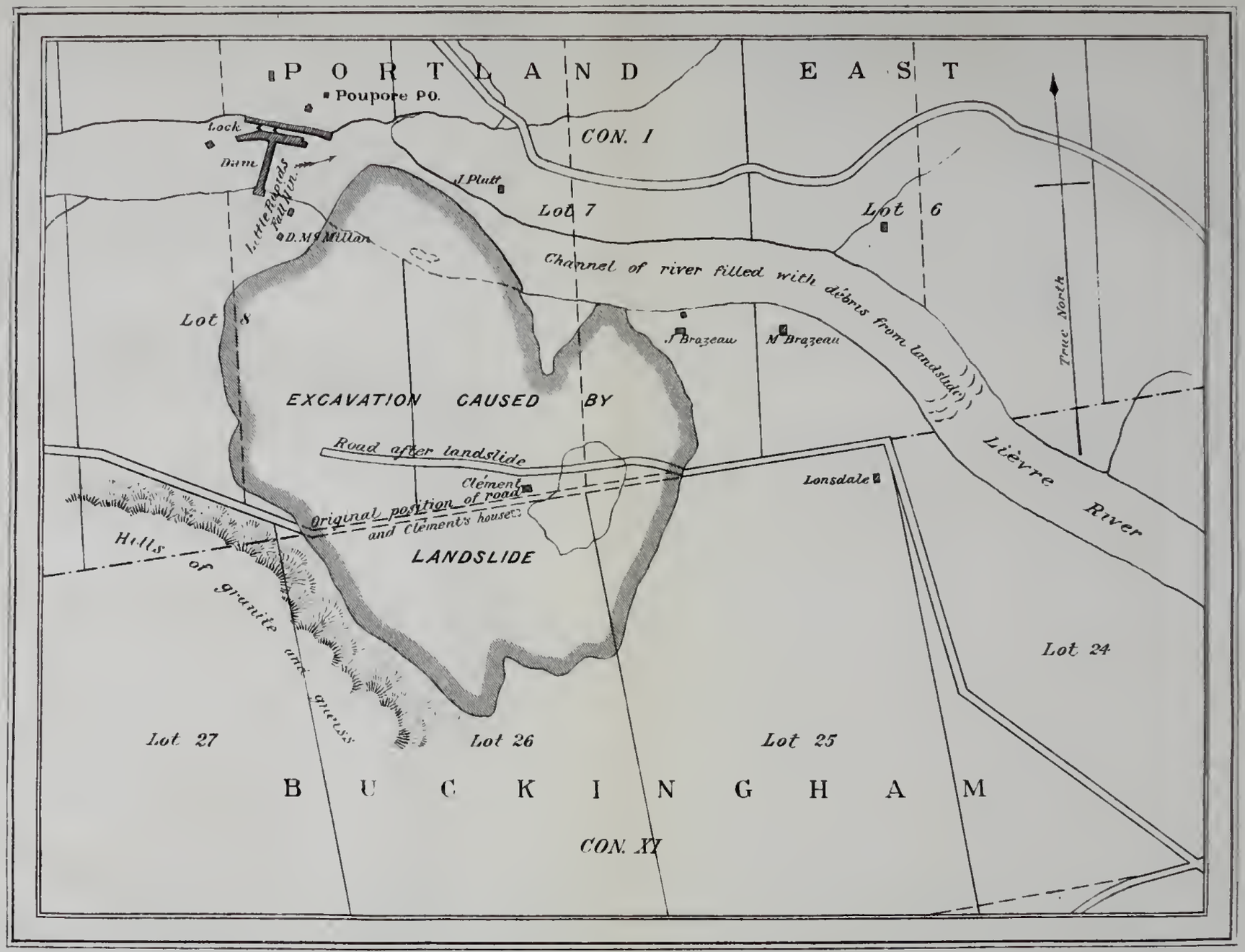
ROBERT BELL M.D., D.Sc. (cantab), LL.D., F.R.S., ACTING DIRECTOR.
1904.



Drawn for photolithography by P. Frèreault.

To accompany Part A A, Vol. XV.

PLAN of the RECENT LANDSLIDE on LIÈVRE RIVER near BUCKINGHAM, P.Q.

No. 848

To illustrate Summary Report of
R. W. ELLS, LL.D.,

Scale: 12 Chains to 1 inch

10 5 0 10 20 30 40

is a ridge of granite and gneiss belonging to the Laurentian formation, having a slope towards the river in a north-east direction. The surface of the clay flat between the mountain and the Lièvre is nearly level.

In character these clays are usually arenaceous and sometimes silty, and the causes of this landslip, which is similar to several others which have taken place in the valley of the St. Lawrence, have been well explained in a report by Dr. Chalmers on a landslip that took place on the River Blanche, Portneuf Co., in 1898, as follows :—

Causes of landslides.

"(1.) The (local) silty and arenaceous character of the Leda clay rendering it capable of absorbing and retaining a large amount of water, and (2.) the increased precipitation during the season when these landslips occurred, which saturated the deposits and gave them greater weight than usual. These conditions doubtless produced unstable equilibrium of the beds, resulting in displacement and a flow of the semi-liquid portion. The more coherent clays, breaking down as described, and mixing with the soft material, produced a tumultuous mass of mud, clay and sand, which descended into the nearest valley."

Former landslides.

The same remarks will doubtlessly apply to all the localities in which these landslips have occurred, among which may be mentioned one on River Ste. Anne de la Perade, near St. Albans, 1894, and another on the River Maskinongé, evidently in 1840, and described by Sir W. E. Logan many years ago.

Character of the area in the Lièvre district.

The disaster on the Lièvre river occurred on the morning of Sunday, Oct. 11th. There had been heavy rains throughout the district for several days previous, so that the whole country was saturated, and numerous small streams descended from the slope of the ridge at the back of the clay flat. Along the foot of this ridge the clay is underlain in places by a deposit of boulders and other debris from the rocks of the mountain, so that there was a good opportunity for the water to penetrate beneath the mass of the clay to some distance. One of the small streams crossed the clay flat and flowed into the Lièvre, and for several days subsequent to the slide much water could be observed issuing from the sides of the break and forming pools on the broken surface of the area.

Cause of the disturbance.

It is evident therefore that the clay body became saturated or charged with immense quantities of water thus greatly increasing the weight of the mass. If then an interstratified layer of silt became liquified the pressure of the overlying clays would tend to force out the whole mass in the direction of least resistance, which in this case was the bank of the river.

Such was the pressure exerted that the clay was pushed entirely across the stream which here had a width of nearly six chains, and masses of it were deposited on the east bank to a height of from 20 to 30 feet. The portion of the river thus filled is about 30 chains in length but, owing to the fact that the river bed was also composed of smooth clay at this point, the increased force of the water caused by the damming of the stream, carried great masses of the clay, in one place with a hay-barn on the surface, down the stream for some hundreds of yards.

Amount of displacement.

The amount of displacement in the direction of the river was nearly five chains or by actual measurement indicated by the break in the main road which traversed the area, about 310 feet. The remains of this road could be readily traced at intervals across the whole extent of the broken ground showing many curious dislocations, small side throws and upheavals. The main displacement appears to have been at the northwest angle of the disturbed area from which the mass seems to have gradually swung out towards the river with the south-east angle as a pivot.

The mass of disturbed clay is broken across by numerous heavy fractures which have a general course at right angles to the direction of the movement. In places huge masses of the clay have been forced upward along these fissures and show beautifully striated and smoothed surfaces as the result of the movement. Along the south-east side of the area the displaced mass has formed an escarpment rising from the undisturbed portion to a height of, from 10 to 20 feet. This is just in the rear of Mr. Brazeau's house, the line of fracture crossing, to the back of his residence and demolishing his stables. Sharp crevasses evidently opened at this place as elsewhere and suddenly closed, since a number of cattle which were standing apparently on his roadway were engulphed and some of them buried out of sight.

Broken character of surface.

At one point on the river, about 100 yards north-west of this house there is a mass of the original clay flat, well wooded, and undisturbed, the moving clay having divided against a point about 350 feet inland and passed partly to the north and partly to the south. Along the flanks of this mass the striated sides of the clays can be well seen. Further inland, near the old road, there is a large mass of, from 4 to 5 acres which was bodily moved for a distance of about 200 feet and on which no disturbance could be seen, but deep crevasses of, from 15 to 18 feet surround it on every side. Near this block a house (Clement's) still stands in its original upright position together with a well of water which was not drained, while the sheds within a few feet to the north were tilted in all directions.

The outline of the break on the south side is fairly regular, but on the north side in the direction from the mountain slope to Duncan McMillan's house the fissure is quite jagged. Just before reaching the house which is on a knoll near the west end of the lock-dam, the break was deflected to the south and apparently followed a depression in the surface by which it reached the Lièvre just below the dam. Outlines.

The movement of the clay was apparently not along the glaciated surface of the underlying gneiss, as the rock is not exposed at any point in the disturbed area, but is seen at one point on the bared surface of the slope of the ridge where it shows ice markings in the direction of the present river course. Along this flank the whole mass has been torn away abruptly, bearing with it the standing trees with which this portion was covered, and carried directly outward for some distance. Some of these trees are as erect as before the slide occurred. Movement of surface on clays not on rock.

It would seem therefore that the real cause of this disturbance was the saturation of the clay beds, which are arenaceous in places, and then by the softening of some interstratified silty layer, which was apparently about twenty feet from the surface, the mass moved forward, sometimes in block, but generally in a much broken up condition. The movement was rapid and attended apparently with but little noise since the residents were quite unconscious of the disaster till the disturbance was nearly over. The supposition on the part of several persons that the cause of the disaster was the percolation of the water from the river, owing to the construction of the lock dam, is not maintained, since in that case the direction of the slide would have followed the course of the river, while in fact the movement was either directly across the stream or, in the upper part of the displacement, was actually up stream as the lock basin was completely filled with clay from the outflow.

The force of the water which was backed up-stream nearly to the foot of the High Falls will doubtless soon wash away the deposited clays from the river channel, so that within a few months the stream will be again flowing along its original course.

Surface Geology of the Southern Part of the Province of Quebec.

Dr. R. Chalmers.

Work in winter of 1902-03.

Dr. Chalmers spent the winter of 1902–03 in routine work in the office, chiefly in compiling the data obtained in the field in 1901 and 1902. The results are, however, incomplete, as far as they relate to the province of Ontario, and some further field-work is necessary before a full and detailed report can be prepared.

Instructions for season of 1903.

'The instructions I received from you in May last, concerning field-work for the season, were to examine the marine clays and sands, as well as the other surface deposits of the St. Lawrence valley, from the city of Quebec westward to Lake St. Francis, also those of the Ottawa valley as far west as Mattawa, limiting my observations on the north and south by the higher grounds which border these valleys. In following out these instructions, I began work in the Ottawa valley on the 3rd of June and continued it eastward towards Montreal, making that city a centre of operations for some time. From this point my examinations were extended to the hills on both sides and eastward to Three Rivers, Nicolet and Arthabaska. All the railways and a considerable number of the roads were travelled over, while the distribution and character of the different beds were traced out with as much care as time and circumstances would permit. About the middle of July, I made Quebec city my headquarters and continued to work in all directions from this as a centre for some weeks, occasionally however, following railways and roads to other points. Early in August, I received your further instructions in regard to collecting all available information relating to peat mosses, their distribution, extent, depth, the attempts to manufacture fuel or other products therefrom, together with descriptions of processes, etc., with the view of preparing a bulletin on the subject of peat. These last instructions involved to some extent a re-examination of portions of my field in greater detail and caused me to extend my operations down the Lower St. Lawrence valley as far as Rimouski and Ste. Flavie. The accomplishment of this work in the St. Lawrence valley below Quebec, occupied my time till the 5th of September, and the remainder of the month and part of October were devoted to an examination of the surface deposits and peat mosses in the Eastern Townships of Quebec and in eastern Ontario at points often hundreds of miles apart. As a result of this investigation it was found that while there are a large number of

Nature of field operations.

Work in regard to peat mosses.

General character of peat bogs in Quebec.

workable peat bogs in the region visited, in other localities, as, for example, in the counties of Huntingdon, Beauharnois and Chateauguay and further east in Arthabaska and Lotbinière, the mosses are often thin and form merely a veneering upon the sands and clays. Some of the last-mentioned peat areas are under cultivation, while others are covered with a scrubby growth of spruce and tamarack. In this work I was occupied till about the 15th of October. After that date I commenced investigations in the Ottawa valley west of this city continuing them as far as Mattawa. But first I visited the Perth and Brockville peat works. After that I proceeded to Renfrew, Pembroke and Mattawa and traced, approximately, the limits of the marine Pleistocene beds there. Field work closed on the 26th of October; but on the 14th of November I visited the Newington peat works, then in operation, and saw the whole process of cutting the peat in the bog, preparing the peat-bricks, drying them by superheated air, etc. The work seemed to be done quite conveniently and effectively at this establishment.

Though the summer was very unfavourable, I succeeded in getting over the greater part of the large field assigned me for the season's operations, and in certain places considerable detailed work was accomplished.

Classification of surface beds.

The surface deposits occupying the area under consideration, which is known as the great triangular area or flat country lying east of a line drawn from Brockville to Pembroke, with its apex at Quebec or Kamouraska, in the St. Lawrence valley, may be classified as follows, in descending order :—

1. Peat bogs and peat-covered plains.
2. Fluviatile and lacustrine sands.
3. Saxicava sand. } Champlain of United States geologists.
4. Leda clay. }
5. Boulder clay.
6. Decomposed rock.

Peat.

Peat.—The best developed peat bogs occur in eastern Ontario and in that part of the province of Quebec which lies east of Montreal, and especially north-east of Quebec city. The deeper mosses grow where the surface of the ground beneath is more or less uneven. A number of the last mentioned bogs in Quebec are quite large, some of them five or six thousand acres in extent, with a depth of twenty to forty feet. Spasmodic attempts have been made from time to time to work some of the peat bogs referred to, for fuel or moss litter, but they have, so far, resulted in failure, except at Brockville and Newington, already

mentioned. At the latter place a Swedish process is being employed by the Sahlstrom Fuel Syndicate, and briquetted peat fuel is to be produced when the works are completed.

Fluviatile sands with shells.

Fluviatile sands.—The fluviatile and lacustrine sands seem to be found mostly in the mouths of river valleys tributary to the St. Lawrence, and in the lakes or river expansions, also along the St. Lawrence river itself below the mouth of the Richelieu river. They were observed at Sorel, Nicolet, Three Rivers, Victoria Cove and Orleans island. At Sorel and Three Rivers they contain fresh water shells, (*Unio complanatus*, *U. ventricosus*, *U. luteolus*, etc.). Two of the Dominion Government dredges were engaged in excavating a channel on the south side of the St. Lawrence river at Sorel at the time of my visit, and in the material thrown up on the bank, shells were seen to be scattered indiscriminately. A coarse sandy clay from the bottom of the channel was noted, which also contained the same fresh-water shells.

Marine deposits.

Saxicava sand and Leda clay.—These deposits may be said to form a continuous sheet over the whole St. Lawrence valley, and were described in the Geology of Canada, 1863, pp. 915–928; also in The Canadian Ice Age, pp. 52–72 and by the writer.* In the New England states the name Champlain has been given to these deposits, as they do not seem to be so well defined or have the same sequence there as they have in the province of Quebec, where the sands and clays are generally separated by a clear line of demarkation. The same arrangement of the Leda clay and Saxicava sand, that is, the former beneath and the sands overlying them, holds good throughout the Maritime provinces.

Boulder clay.

Boulder clay.—The boulder clay, or till, of variable thickness, was met with everywhere beneath the marine beds; and, except in the hill country, to the south of the great plain, it forms only a single deposit. In the valleys among the foot-hills of the Notre Dame range, two boulder clays with interstratified sands and gravels occur, and here also we find two kinds of drift, namely, that derived from the range mentioned and that from the Laurentides. On the north side of the St. Lawrence river the drift is mainly from the latter source.

Raised shore lines.

Shore lines or raised beaches.—These are found on both the north and south slopes of the St. Lawrence valley and were identified and briefly described as marine beaches by the writer in 1897. Further measurements of the highest on the south side of the valley were made which serve to confirm the work of former years, and support the con-

* Annual Report, Geol. Surv., Can., Vol. X. (N.S.), 1897, pp. 67–69, J.

clusion that the ancient crystalline rocks sustained a greater uplift in the later Pleistocene and since that time, than did the stratified rocks. The old shore lines rise gradually, though with some irregularity, from an altitude of 345 feet at Ste. Flavie to 750 feet at Ste. Henedine, to 756 feet on the east side of the Chaudière valley, and 845 feet at the head of Beaurivage river. On the flanks of the crystalline rocks further west, the altitude is 865 ft, rising still further west to 885 feet. This highest shore line continues westward at about 890 feet to Danville, beyond which, as far as the International boundary, it is about 865 feet (at Abbotts Corners 864 feet). Below this shore-line, others occur, some of which are well marked. They have been produced during the recession of the sea, for all are supposed to be marine, and they face the open plain of the St. Lawrence valley.

The highest shore line on Kings mountain, near Ottawa, was re-measured and found to be 910 feet above sea-level.

Agricultural character.

Agricultural character.—The St Lawrence valley or plain has long been settled and under cultivation. Large portions of the land are of excellent quality for farming purposes. Originally the soil must have been of extraordinary fertility, rivalling that of our western prairies. Certain areas are occupied with clay, while others are sandy. In others again a mixture of sand and clay constitutes the soil: or clay below with a thin layer of sand upon it. The clay soils are considered the best, especially those with a slight admixture of sand: but the surface sands, when not too deep, yield good crops. These are, however, always better when resting on a clay subsoil. Generally speaking, it has been found that the clay lands maintain their fertility the longest. In some parts of the valley, hay crops have been raised on land of this kind for a great number of years without any fertilizers being added, and the soil is still in good condition.

Methods of farming.

Much of the land in the St. Lawrence valley is, however, imperfectly cultivated. Several causes have brought about this condition of things. The seigniorial system, which prevailed in central Quebec, accounts to some extent for it there. In other parts of the province the farms have been divided and subdivided among the members of families, generation after generation, till each has only a narrow strip or patch to cultivate, which barely affords its owner a subsistence. Agricultural operations under these and other conditions, which might be enumerated, must be seriously handicapped, to say the least, and it is not surprising that little or no advances are made in improved methods of farming.

Geology of Yamaska Mountain.

Mr. G. A. Young.

Yamaska mountain.

As a contribution to petrography, I have, during the past summer, made a study in the field of the rocks of the Yamaska mountain and also prepared a topographical map of the locality. This mountain lies about thirty-five miles due east of Montreal and was known to form one of those isolated hills of related igneous rocks for which Dr. F. D. Adams has proposed the name of Monteregian hills. The horizontal section of Yamaska mountain is nearly oval. The major axis lies in a nearly north and south direction, and is about three miles in length, whilst the minor axis measures about two miles and a half. The hill rises abruptly from the surrounding plain. On the north and south sides the slopes are precipitous, and it is on the northern side that the mountain reaches its greatest elevation of about thirteen hundred feet above the surrounding country or fifteen hundred feet above the sea-level.

Divided by denudation into two ridges.

The agencies of denudation have acted in such a way that the mountain is divided into two ridges, a northern and a southern, and connected through the interior by a line of small, partly separated peaks which are lower than either of the rims. The higher points are thus rudely arranged in the form of the letter H. The mountain is composed of a core of igneous rocks with a collar, averaging about half a mile in breadth, of more or less altered slates and sandstones. Where the elevation is broken down on the east and west slopes, the igneous rocks of the core approach the foot of the mountain very closely; elsewhere the bordering sedimentaries usually form the higher peaks. The line of contact, whilst conforming to the general outline of the mountain, is very irregular.

Nature of rocks.

The sedimentary rocks of the collar are presumably of Upper Cambrian age and on lithological grounds are supposed to belong to the Silury formation which is composed chiefly of red and green shales or slates and of beds of sandstone. The clay rocks have, under the influence of the igneous intrusion, in most cases become greatly hardened, so that they have resisted the forces of degradation and in their turn have served as a shield to the igneous core. The metamorphism seems to have been greatest along the north and south rims, which, roughly speaking, are at right angles to the general strike of the strata. These rocks now lie in an overturned anticlinal, whose axis runs in a northerly direction, to which the major axis of the moun-

Geological Survey of Canada

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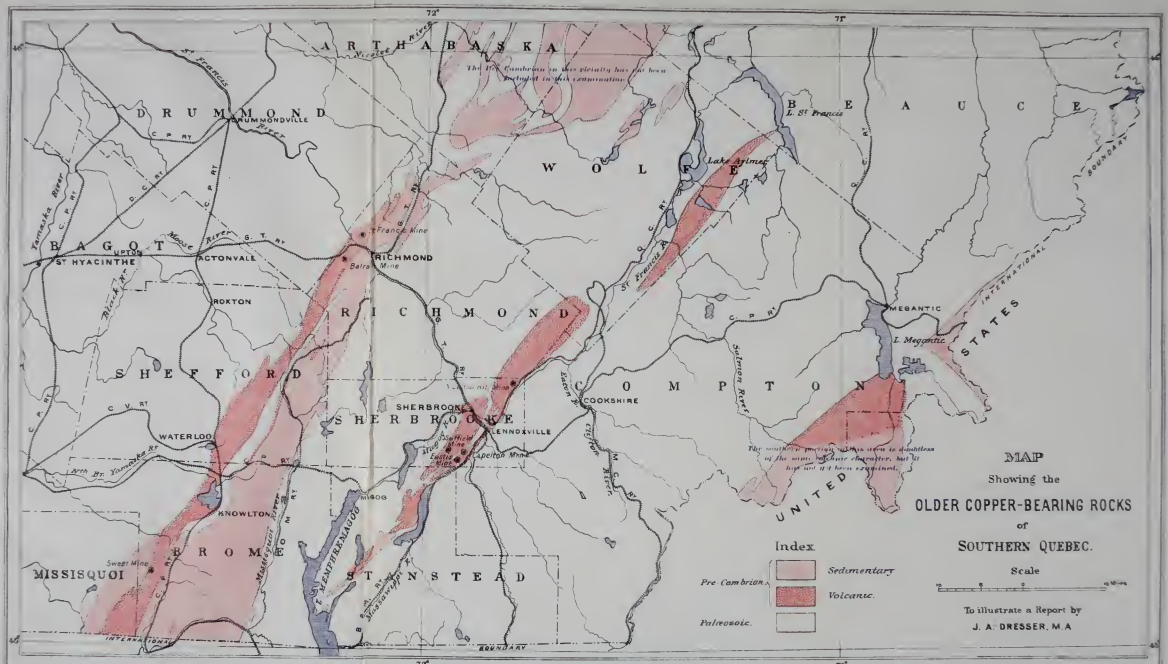

Drawn for photolithography by L. N. Richard.

To accompany Part AA, Vol XV

No. 862

tain is roughly parallel. The strike of the strata varies somewhat on either side of an average value of about twenty degrees east of north (true). The angle of dip changes rapidly from point to point, indicating local flexures. This folding took place previous to the intrusion of the igneous rocks which seem at this point of weakness to have forced their way up from below to form a volcanic neck such as Dr. Adams has described in the case of the neighbouring Mount Johnson. No evidence was found in the field which pointed to any other origin than that of a volcanic neck which had been developed without sensibly disturbing the surrounding strata.

Mineralogical composition.

The rocks forming this volcanic neck belong to the foyaite-theralite family. Mineralogically they do not differ greatly, but the relative proportions of the several constituents vary widely. Of the minerals composing the rock, feldspar, hornblende and biotite play the chief parts and the feldspars appear to be mainly plagioclase. The presence or absence of nepheline has not yet been definitely determined. The rocks range from syenitic varieties, composed chiefly of feldspars with considerable biotite, through essexite, in which hornblende, more or less completely replaces the biotite : the feldspars at the same time decreasing in amount into finally an extreme type composed almost entirely of hornblende and often containing considerable iron-pyrites. These various types are usually coarse-grained rocks, but at other places they become firmer and porphyritic. The essexite phase sometimes becomes finer in grain along the southern boundary, where it is in contact with the sedimentaries. Those rocks which have been classed as essexites often have flow structures due to the parallel arrangement of the eminently tabular feldspars and sometimes they are also banded. The direction of flow varies quite rapidly. It is sometimes vertical, but more often inclined, and in one locality is horizontal.

Distribution of types.

The distribution of the various types of rocks is fairly regular. The light-colored, feldspathic forms occur as a border along the western and northern sides. In most places it appears to grade into the more basic essexites which occupy the greater part of the mountain, but which, towards the east, pass into a nearly pure hornblende-rock. At one locality on the eastern border, the hornblende-rock passes rapidly into a syenitic type. These different types appeared in the field in the great majority of cases to pass insensibly into one another, but at two localities the syenite was found sharply cutting the essexite. This apparent anomaly may be due to the fact that, as shown by included fragements of the surrounding rocks, the neck appears to have been still in a process of enlargement till the upward movement of the magma was finally arrested. The various types of rocks are thought

to have originated mainly through a process of differentiation which took place in a more deeply buried reservoir. Their present relations are believed to be due to the movements attendant on their upward flow.

Dykes.

A very limited number of dykes was found, usually either a short distance from the contact or just at the border and cutting the sedimentary rocks of the collar. These dykes appear to be of three classes; a very fine-grained, light coloured feldspathic variety, probably a bostonite; a second which appears to be a fine-grained trachytic modification of the syenite; and a third, a very fine-grained, porphyritic form of the essexite. As these dykes were never found cutting one another their relative ages are unknown.

The Copper-Bearing Rocks of the Eastern Townships, Quebec.

Mr. John A. Dresser.

Existence of copper long known.

The occurrence of copper in the Eastern Townships has been known at least since 1840. In that year Logan visited Carbuncle mountain at the head of Brompton lake to examine a reputed occurrence of tin ore which, however, proved to be copper. This was two years prior to the establishment of the Geological Survey of which Logan was the first Director. (Life of Sir W. E. Logan, Kt., by B. J. Harrington, Ph. D., Dawson Brothers, Montreal, 1883.)

Since 1847, when the first explorations were made in the Eastern Townships by the Geological Survey, the copper deposits have received attention in several of the Annual Reports. The most important of these are the Reports for 1863 by Sir W. E. Logan, 1866, by James Richardson, and 1888 by Dr. R. W. Ells.

Early development work.

In the early sixties copper commanded a much higher price than it has reached at any period since, and at that period a large amount of prospecting and considerable development work was done. In the majority of cases, however, there does not seem to have been a very thorough testing of the many copper localities which had then been discovered. A severe and continued depression in the copper markets followed, so that for many years, less attention was given to this as well as to other copper-bearing districts. There has, however, been a steady and consequently a more healthy growth of interest in this class of ore deposits in recent years, owing to some advance in the price of copper, to improved facilities for transportation, to more economical methods of smelting, and to the constantly

growing use of sulphuric acid, of which cupriferous pyrites is an important source. Thus during the past twenty years, the mines of the Eustis Mining Co. at Eustis, and of the G. H. Nichols Chemical Co. at Capelton, have been steadily working, until under able management, they have attained their present large extent and prosperous condition. Other once abandoned properties are also receiving attention in recent years, and it seems likely that under skilful direction and careful management, they may produce successful results in a good many cases.

Copper-bearing rocks of pre-Cambrian age.

A large part of the copper-bearing rocks of the Eastern Townships are shown to be of pre-Cambrian age by the later maps of the Geological Survey. These occupy three different areas, as indicated upon the accompanying sketch-map which is copied from the Survey's geological map of the Eastern Townships.

The western and central areas have produced all the copper yet mined in the Eastern Townships, with the exception of that obtained from the once famous Acton mine and from others farther eastward, which are related to it, in mode of occurrence, and from the Lake Memphramagog district. Throughout these two belts of pre-Cambrian rocks, copper has been found to occur in many places. Richardson gave a list of about four hundred localities in an appendix to the Geological Survey Report of 1866.

Object of recent investigations.

The work of the past two seasons has been done with a view of finding if possible what different conditions may exist in the mode of occurrence of the important and unimportant deposits, where such differences in value are known. The results show that a part of each belt is made up of volcanic rocks, and that all the deposits of any known, or probable, importance occur within these volcanic portions. No deposit of any likely value has been recorded in the sedimentary portions which usually flank the volcanic ridges in these pre-Cambrian belts.

Sutton area.

In the Sutton area the volcanic ridge forms a central part, scarcely more than two miles in width at the International boundary line. Pinnacle mountain at St. Armand stands just within its western edge, and the eastern limit is near the line between St. Armand and Sutton, or nearly due north of Richford, Vermont. Continuing northward, the volcanic rocks comprise all the western portion of the pre-Cambrian on the Yamaska river, and retain about the same breadth as on the east side of the St. Francis river. In the Stoke, or Ascot belt of the pre-Cambrian, Stoke mountain, and the area for some miles south-west on the St. Francis river, which includes the hills of Capleton and Eustis, is almost wholly volcanic. In the township of Weedon, near

the head of the St. Francis river the same rock appears and extends almost to Lake St. Francis.

The Eustis mine.

The ore bodies have not been observed to form true veins in any instance. In numerous cases they show on surface exposures the ordinary outlines of much flattened lenses conforming to the foliation of the rock. The walls are not well defined and 'horses' and lean ore masses are not infrequent within the larger ore-bodies. The largest examples seen were in the Eustis mine where masses occur which are more than 100 feet in the least dimension. While they generally follow the dip and strike of the foliation, which affords a useful means of tracing these occurrences, at times they also cross the plane of schistosity of the country rock, generally at an oblique angle. They then have more nearly the character of true veins. Such bodies appear to cut the dip, more frequently than the strike, of the enclosing rock. The lenticular bodies also appear to be frequently arranged en échelon, since the lode, when lost is most frequently recovered, not by following through the pinched-out part along the strike, but by driving at right angles to it. The most experienced miners seem pretty well agreed upon the general accuracy of this course.

Copper belt of Lake Megantic.

Of the third pre-Cambrian area, that near Lake Megantic, little is yet known in detail. The wooded condition of the country at the time that the south-eastern quarter sheet of the Eastern Townships map was prepared, made it impossible that the area could be delimited at all definitely. As was shown in the Summary Report for 1902, the area is composed of volcanic rock similar in character to those of the other two belts, and these rocks are to some degree at least copper-bearing. The area appears to be a northern extension of the copper-bearing ridge of Berlin Falls and Copperville in New Hampshire. As in Stoke mountain and at Ditton, in the southern part of the Lake Mégantic area, alluvial gold occurs, which in both cases Dr. Chalmers considers to have been derived from the underlying rock. They probably occur in the vicinity of the more extensive deposits of alluvial gold in the valley of the Chaudière and its tributaries and have a greater extent towards the north-east. This view is further sustained by the fact that still farther to the eastward in Gaspé, many observers, notably Logan, Ells and Low, have reported the occurrence of rocks characterized by chlorite and epidote which have not yet been microscopically examined.

It is probable that such rocks are a continuation or recurrence of these copper-bearing traps, and that the watershed which determines the boundary between the State of Maine and the Province of Quebec

will be found to be a continuous ridge, or succession of ridges of these rocks, perhaps ultimately connected with the copper-bearing rocks of New Brunswick.

Probable extension of this belt.

Both in their mode of occurrence and the character of the country rock the pre-Cambrian copper deposits are evidently similar to those which characterize certain parts of the Appalachian tract from Alabama to Newfoundland. The Sutton belt is the direct northern extension of the Berkshire and Vershire areas of Vermont, and are similar in all essential respects to those of southern Pennsylvania, North Carolina, and the well known deposits of Ducktown, Eastern Tennessee.

Mines of the Acton district.

Two other areas of copper-bearing rocks in the Eastern Townships are those of the Acton district and of the vicinity of Lake Memphramagog. In the Acton district copper occurs in the Sillery and Trenton formations in connection with small intrusions of igneous rocks. The Acton mine, about forty-six miles east of Montreal, is the best known and for a few years produced a large amount of high grade copper ore. Smaller mines as Upton, Wickham, St. Pierre de Durham, and Roxton, have produced more or less copper ore. The Upton deposit is further distinguished by the presence of a little native copper. All of these are now closed, but some of them seem likely to be worth reopening. The little work that was formerly done in most of them was of such a character as to save only a small proportion of the ore. The gangue is almost wholly calcite, and hence useful for a flux with the dry ores of the pre-Cambrian rocks. The ores are chalcopyrite, bornite, chalcocite and copper carbonate. They differ somewhat in the different individual deposits.

Lake Memphramagog area.

The townships of Bolton and Potton, to the west of Lake Memphramagog, contain several igneous hills of the general type of Mount Orford, which are intrusive through lower palaeozoic sediments. Where these have cut black Trenton shales, large bodies of pyrrhotite and pyrites and allied ores have frequently been formed. These are probably the largest ore bodies in the Eastern Townships. The Huntingdon mine, the Ives mine, and the Lake Memphramagog mine are the best known. Investigations with a view of discovering the most economic mode of smelting these ores are about to be undertaken at the mining laboratories of McGill University. These larger deposits are worth the most careful attention of those interested in copper mining.

Charlotte County, New Brunswick.

Dr. R. W. Ells.

Former work in Charlotte Co.

The work of the season of 1903 consisted largely of an examination of certain areas in Charlotte county, New Brunswick, with the object of determining more precisely the age of certain groups of rocks, which in the Report for 1870–71 on this district by Messrs. Bailey and Matthew, and later in the published map of this part of the province, issued in 1879–80, were left practically undetermined, though coloured provisionally, owing to the absence of sufficient data to establish their actual horizons. The geology of this part of New Brunswick is complicated by the presence of large areas of intrusive rocks, comprising granites, diabase, gabbros, and felsites, and by the alteration, in consequence, of large masses of slates and sandstones from their ordinary condition into schists and other crystalline rocks which now present many of the features of the pre-Cambrian series.

Assistants.

In this work I was ably assisted by Mr. R. A. A. Johnston of this Department and by Professor Ernest Haycock, of Acadia University, Wolfville, N.S.

Economic minerals.

Special attention was directed to the occurrence of mineral deposits, including the nickel ores in the vicinity of St. Stephen, the copper deposits of Letite and the Western isles, including Adams and Simpsons islands, and to other mineral occurrences such as the galena and iron ores found at several points in the area around the shores of Passamaquoddy bay. The relations and probable value of these were ascertained as far as possible and their geological position determined.

Examination in Ontario and Quebec.

Early in August, after *working* out the relations and the age of some of the more important rock-formations in Charlotte county, Mr. Haycock was placed in charge of the field operations in this part of New Brunswick and my own time was devoted to an examination of certain points in connection with the areas now being mapped in eastern Ontario. In addition to this, an examination was made of several important mining areas, both in Ontario and Quebec, including the asbestus and actinolite deposits, the micas and apatites, and the graphite. As regards the asbestus, this was considered of special importance in view of the great developments in this industry in recent years, the mining methods and the character of the output having been greatly changed since the date of the last report on this subject published by this Department in 1888–89. In this examination, all the asbestus mines now being worked in the province of Quebec, as

well as a number which have suspended operations, owing to various causes, were visited and a large amount of information was obtained from the study of the areas at Thetford, Black Lake, Coleraine, East Broughton, Ireland and Danville in the Eastern Townships, as also from those north of Ottawa. A study was also made of several of the chromic iron mines, in order to ascertain more precisely the mode of occurrence of this mineral. The actinolite mines of Elzevir township, Ont., which have been worked for about twenty years, were also examined and a special report on the asbestus industry in general has been prepared, bringing the work down to the present year.

Materials have also been obtained for reports on mica graphite and apatite in Ontario and Quebec, which are now among the more important of the mineral resources of these provinces; and the conditions as to the occurrence of these minerals, as shown by a number of new openings, have been further studied.

GEOLOGY OF CHARLOTTE COUNTY.

The Perry group.

One of the most interesting of the geological formations which occur in this portion of New Brunswick is that known as the Perry sandstone group. The formation receives its name from the town of Perry, in the state of Maine, on the west side of the St. Croix river, whence it extends across the boundary and forms a large area to the north of St. Andrews and continues eastward to Beaver harbour, beyond the shores of Passamaquoddy bay. It again reappears in this direction around the shores of Lepreau harbour and has here quite an extensive development. The rocks consist of conglomerates, sandstones and shales, generally reddish in colour, but occasionally, in the lower portion, some of the heavier sandstones and conglomerates become grayish. Plant stems are quite abundant in some of the shale beds, both in the rocks of Perry and near St. Andrews. These were carefully studied many years ago by Sir William Dawson and several papers relating to their character and age were published by him between 1861 and 1870, in which their horizon was placed as the upper portion of the Devonian system. The same conclusion had been reached at an earlier date by Dr. Jackson, and adopted by Prof. Rogers, after an examination of the material from the plant beds of Perry, Maine.

Probable Devonian age.

In the report by Bailey and Matthew, 1870-71, the opinion is expressed that the rocks of this group are referrable to the base of the Lower Carboniferous, rather than to the Devonian, from a supposed lithological resemblance to certain conglomerates which are found in Kennebeccasis bay, an arm of the St. John river, where these rocks are assigned to the Carboniferous horizon.

In Charlotte county, the Perry group can be well studied in the peninsula extending from the base of the Chamcook mountain to the point at St. Andrews where the exposures are practically continuous for a distance of about five miles. The beds are cut across by several dykes of green diabase which have altered the sediments at their contact. Similar dykes are seen on Ministers island to the east.

Perry conglomerates.

The lowest beds of the group at Chamcook mountain consist of a coarse, heavy conglomerate with pebbles, often of large size, for the most part derived from the felsitic rock of which the mountain is composed. These conglomerates are a conspicuous feature in many places at the base of this series of rocks, and they also occur occasionally as intermediate beds higher up in the series. They are well exposed in the bluff east of Chamcook harbour, on the islands and on the shore at the entrance to Digdeguash harbour and further east on Bliss island, L'Etang head and Pea point and again around the shores of Lepreau harbour, which is in the extreme eastern part of the county.

Thickness of formation.

The dip of the strata in the St. Andrew's peninsula is uniformly to the south or south-east, at angles from 10 to 25 degrees. At an average inclination of 15 degrees over a distance of five miles, since the southern margin of the basin is not here reached, the thickness for the beds at this place will be not far from 7,000 feet. No well defined faults or repetitions of the strata are seen in this section. This estimate of thickness far exceeds that hitherto made for any portion of the lower Carboniferous as developed in southern New Brunswick.

Trap dykes.

In the dykes no characteristic zeolites have been found, but small deposits of quartz crystals and bunches of calcite occasionally occur. The dykes are sometimes in the form of interbedded masses and sometimes cut directly across the sandstones.

Thickness of the conglomerate.

The outlines of this formation were carefully traced along the shores from the St. Croix river to Point Lepreau, and in some places, as at Pea point and L'Etang head, the basal conglomerate was found to have a great thickness, aggregating not far from 4,000 feet. At Lepreau harbour, where these rocks are well exposed, they apparently rest directly and conformably upon the Devonian shales and sandstones of the Mispec and Little river groups of the St. John Devonian basin. As they elsewhere underlie the basal beds of the lower Carboniferous, including the marine limestones of that series, it would now appear that the rocks of the Perry group, as a whole, represent the upper portion of the Devonian system of southern New Brunswick, as was early suggested by Sir William Dawson and others from the evidence of the

contained plants. The complete details of their distribution cannot be given in a brief summary report.

Rock of Letite.

Another group of rocks which required careful examination is the series of slates, schists, eruptives, and crystalline limestones which occur on Letite and Frye island, and thence south-westerly through the group of islands including Deer, Campobello, Grand Manan, and many other smaller ones which are a part of a somewhat extensive chain trending in this direction. Much doubt has been felt as to the age of these rocks, and they have been classed at different times as possibly Silurian, Primordial and even pre-Cambrian, and on the published map of the area, they were coloured provisionally as the latter. This determination was based on the presence of certain schists, associated with altered slates, diorites, felsites and other crystallines, the general aspect of which was like many of the rocks east of St. John, included in the Kingston group, these having been regarded as of Huronian age, since they, in part at least, underlie rocks which hold primordial fossils.

Fossils.

A careful examination of the Charlotte county rocks, however, showed that the so-called pre-Cambrian schists are merely altered slates which have been acted on by newer intrusives and affected by pressure, by which the schistosity has been developed. In places, the slaty schists reveal the presence of fossils in certain layers, in which also the schistose structure is developed and the fossil forms are drawn out along the schist planes. In this respect they closely resemble Silurian and Devonian fossils which occur in the vicinity of Memphremagog lake in southern Quebec.

Schistose structure.

The shearing has also developed a schistose structure in certain of the intrusive dykes, so as to impart to these the aspect of pre-Cambrian schists; but from the fact that most of these intrusives are frequently seen to cut the fossiliferous Silurian strata, it must be assumed that they are newer than the rocks which they penetrate. In fact, at the close of the Silurian and even in Devonian times, there has been, without doubt, a very extensive period of intrusion, faulting and metamorphism throughout all the area in southern Charlotte county. On this basis, much of the area which, in the published map, was coloured as pre-Cambrian must now in part be assigned either to the upper Silurian and Devonian, or indicated as a newer eruptive series.

Large collections of fossils were made from a number of points, including the upper part of Oak bay, the Mascarene shore, especially about the entrance to the broad inlet of the Magaguadavic river, on Frye's island, Letite and elsewhere. These collections have not yet

been fully determined, but sufficient has been learned from them to show that their general aspect is characteristic of the upper portion of the Silurian.

Mascarene series.

Of the peculiar group of rocks which have been described under the name Mascarene series, it may be said that they consist of a considerable thickness of purple slates and sandstones with green and gray beds, the latter predominating, which have been cut by numerous intrusives, both diabases and felsites. The action of these on the sediments is quite clear as they have altered the strata in contact at many points. The felsites, which are generally reddish, sometimes occur as great bedded sheets. In position the Mascarene rocks may be said to be intermediate between the Silurian of Letite and Back bay and the base of the Perry sandstone group. The presence of well defined plant stems in some of the strata of Mascarene tends to place them also in the Devonian.

The Western isles.

The rocks of the Western isles, including Deer and Campobello and many smaller ones lying in their vicinity, were all examined. For the most part, they consist of newer intrusives, comprising diabase, gabbro, felsites, and some granite, and with these are occasionally found areas of altered slates, now sometimes changed to schists, similar in character to those of Letite and showing, in places, the traces of fossils. There is no reasonable doubt that the rocks of the greater number of these islands must be referred to the Silurian or to the later intrusives. Some of the smaller islands to the east of Deer island show conglomerates of the Perry group and represent the extension of the broad development of these rocks which compose Bliss island and the shores of the east side of L'Etang harbour. There are no reasons apparent why the rocks of these islands should be coloured as pre-Cambrian.

Crystalline limestone of Fryes island.

The interesting band of crystalline limestone which occurs on Fryes island, and which, after crossing from the south to the north extends across the passage to L'Etang peninsula, and appears in a broad belt just west of L'Etang village, was carefully examined. It has been regarded as representing the crystalline limestones of the Laurentian, as developed about St. John, but from the fact that it is closely associated with slates, now schistose, of Silurian age, and in places contains fossil corals and other forms at several points, the geological position formerly assigned to it must now also be changed. The crystalline limestones show several stages of alteration, and in places where the alteration has not been so complete, an abundance of fossil shells with corals was found. The highly crystalline portion gradually shades off into bluish and less altered limestone, and the peculiar green and purple shales and sandstones of Silurian age are clearly a part of the

Silurian age.

limestone series. They do not resemble the crystalline limestones of Ontario and Quebec in their association with gneisses or quartzites, but rather the metamorphic limestones of Memphremagog lake and of Dudswell in Quebec, concerning the Devonian and Silurian age of which there is now no question. Even in the most highly altered portion of the limestones, there are indications of corals which have been flattened out by pressure and now conform with the general schistose condition of these sediments. Small deposits of galena, with fluor spar, are seen in connection with these rocks on Fryes island and a slight attempt was made many years ago to open these by mining. The quantity is, however, too small to be of much economic value, and no work in this direction has been attempted for a considerable time.

Eruptives

The broad belt of rocks coloured as Silurian on the published map, extending along the shore from the St. Croix to St. George, will of necessity be represented in greatly reduced area. In a section along the railway north from Chamcook, where good rock cuttings are exposed almost continuously for some miles, the rocks of this division are clearly eruptive, consisting of diabase, gabbro, granite and red felsite, all of which are newer than Silurian, and in part at least, later in date than the Mascarene series. There is no reason why these rocks should be included in a general Silurian colour scheme. They comprise a large portion of what, in earlier reports, were described as bedded felsites, the intrusive character of which is manifest upon close examination.

Surveys.

Surveys were made of all roads over a great portion of the country, but time did not permit the completion of this work during the season. Further detailed examinations will also be required to settle definitely the exact horizons of some of the slate belts, including that to the north and east of St. Stephen, and it is hoped that a close search will reveal the presence of fossils in some of the less altered beds. The fact that such fossils were found during the past season in most unpromising localities leads to the expectation that this hope will be realized and the actual horizon of some of these now doubtful beds will be ascertained.

Rocks of Beaver harbour

About Beaver harbour an interesting series of slates and conglomerates, with shales, occurs. These are associated, in part, with the usual masses of intrusives of later age, portions of these occurring as bedded flows. The shales are often plant-bearing, and are referable to the Devonian, and a portion of the intrusive rocks are intermediate between these plant beds and the base of the Perry conglomerate seen at Pea point, Blacks harbour and Deadmans point. In part, these intrusives are basic, while other portions are acid rocks, largely red

felsites. The latter frequently occur at the base of the conglomerates, both at this place and about Passamaquoddy bay.

Beaver harbour to Lepreau.

From Beaver harbour, east to Lepreau, the shore section shows a series of eruptive rocks, consisting largely of granites and felsites. The associated rocks are generally schistose, and the actual age of these was not determined, though they may represent portions of the slaty series of Letite, altered by intrusives and pressure, as further west.

Lepreau harbour.

At Lepreau harbour the lowest beds of the Perry conglomerate rest conformably upon the recognized Devonian of that area, which in character and from their contained plants are precisely similar to the St. John Devonian as represented by the "Fern ledges." These contain an irregular bed of graphitized coal, partly anthracitic, which has been described in earlier reports (1878) as occurring on the north side of Belas basin. A large amount of work was spent on this deposit about 25 years ago, but operations were suspended shortly afterwards.

In the northern portion of the county our field-work has not yet been finished. The plant-bearing formation, in so far as examined, is practically as outlined on the published map, being probably of Devonian age, but further work is necessary to complete details of distribution.

Copper ore of Letite, &c.

The copper deposits of Adams and Simpsons islands and of Letite were examined by Mr. Johnston. The conclusions arrived at seem to indicate that while small quantities of rich ore are found at several of these places, the quantity is not sufficient to warrant any great outlay on permanent works. The occurrences are usually small and irregular in their distribution. A large amount of exploratory work appears to have been done at different intervals, but apparently without profitable results. At Letite several shafts were sunk about 40 years ago on belts of gabbro and diabase which cut Silurian slates, and some chalcopyrite and copper-glance, mixed with pyrrhotite were found ; and recently another shaft has been sunk to a depth of about 140 feet, from which good specimens of chalcopyrite are also obtained. As the shaft was filled with water at the time of our visit, the actual condition below the surface could not be ascertained.

Granite quarries.

The granite quarries in the vicinity of St. George still continue to be worked at intervals. A very full description of these is given in the recent report of Dr. Bailey on the "Mineral Resources of New Brunswick," Vol. X, 1897, pp. 102-106.

Nickel bearing rocks of St. Stephen.

The nickel-bearing rocks of St. Stephen was specially examined and found to consist of newer intrusives, instead of the Laurentian granites,

as at one time supposed. The rocks are chiefly of the gabbro type which have penetrated and altered a series of black and grey slates, the age of which has also been a matter of much doubt. They were at one time supposed to be of Silurian age, but from the absence of fossils, this point has never been fully determined. As developed about the head of Oak bay, it was also supposed that here they might be the equivalents of some portion of the primordial of the St. John area, but this point also has never been determined by finding fossils. On the geological map of the district they are provisionally coloured Cambro-Silurian. They apparently underlie conformably the sandy slates which are regarded as Devonian and which occupy the north-west portion of the county, and on this basis, their age might well be Upper Silurian.

Altered slates.

They are extensively altered in many places, changing into mica and chiastolite schists, but these alterations are purely local and caused by intrusions of the gabbro masses. They resemble, in certain points, pre-Cambrian schists, but not as a series. Further detailed examinations for fossils will be required to finally settle the question of their true horizon.

Occurrence of nickel ore.

The nickel near St. Stephen occurs in pyrrhotite, as at Sudbury, but the associated rocks are of a very different geological horizon from those of the latter district. The pyrrhotite is found in gabbro masses which cut a series of slates and have altered these extensively along the contacts. The mineral occurs apparently in pockety masses which are probably quite local in character. The ore is found at a number of points, but attempts at mining for nickel have been made chiefly at two places, on what are known as the Rogers and Hall farms. The former is usually styled the Todd mine, the latter the Carroll mine.

The Todd mine.

On the Rogers farm, considerable work, mostly of an exploratory nature, has been done. A shaft 12 x 12 has been sunk for 24 feet, and three trenches have been cut, with depths ranging from three to eight feet, the principal one being rather more than two chains in length on a course of S. 54° W., magnetic. In this trench, the ore is exposed for a little more than 30 feet along the line of the excavation, the rest of the cut showing partly mixed ore and partly rock. The width of the ore-body was not ascertained, as sufficient development work has not been done to decide this point.

Carroll mine.

On Hall's lot (Carroll mine) several shafts have been sunk, one of 77 feet, one of 14 feet and one of 12 feet. In addition, a bore-hole with a diamond drill was carried down from the bottom of the deepest

shaft to a further depth of 163 feet. From information obtained from Mr. J. Carroll, the first 40 feet of the main shaft was in ore, but from that point to the bottom, the ore was mixed with rock. The log of the boring shows as under :—

Section of bore and shaft.

	Feet.
Hard rock, dark gray	17
Ore, white	1
Hard rock, black	19
Rock and ore, mixed	7
Sandstone and ore	2
Ore, white	16
Hard rock, dark gray	6
Ore, steel gray	7
Rock, soft	12
	163

The formations at this place are practically the same as on the Todd area. The openings are apparently near the eastern edge of the gabbro mass, since altered slates are seen in close proximity.

A number of assays have been made from time to time of the ore from this locality. As there is apparently but little difference in the character of the ore from the two locations, these may be here given as fairly representing the quality as regards nickel contents.

Assays of nickel ore.

From the Carroll mine, an assay by Ricketts and Banks of New York city, from a sample of the core at a depth of 128 feet gave :

Nickel, per cent	2·42

Another by Ledoux and Company of New York, sample of boring from a depth of 128 feet gave :

Nickel	2·18
Cobalt	·15

An assay by Mr. R. A. A. Johnston of the Geological Survey laboratory gave :

Nickel	1·72
Cobalt	·16
Copper	·31

An analysis by Mr. W. F. Best of St. John, N.B., from the Carroll mine gave :

Nickel	2·62
Copper	7·92

An assay of ore from the Todd mine by the school of Technology, Boston, gave (See Report, 1890-91) nickel 1·92, and another from the trench gave 1·97.

Assays of ore from the bank of the St. Croix near Milltown, by the State Assayer, Boston, gave nickel, 1.10, and by the Geological Survey, from the Thompson Farm, ·923, with cobalt ·394 (See Report 1880-81-82, p. 16H).

Assays by Mr. Connor of this Department from specimens selected by Mr. R. A. A. Johnston, during the present season, from both the Todd and Carroll properties, gave nickel, 1·38, cobalt, 0·21, for the Todd mine, and for the Carroll mine, nickel, 1·35, cobalt, 0·21.

It will be seen from all these assays that the percentage of nickel in the pyrrhotite is practically too low to permit the ore to be smelted after the manner of those of Sudbury. If a process of concentration could be installed on the spot at an expense not too heavy, it is possible that a paying industry could be thus established, the resulting concentrates being shipped to the larger works at Constable Hook in New Jersey, where the final separation and refining could be completed.

Character of rocks and ore bodies.

The rocks at all these places appear to be very similar in character, and consist, for the most part of a gabbro, varying from fine to somewhat coarse-grained. The presence of the pyrrhotite is indicated by masses of gossan at the surface, and in places, the ore is largely mixed with rock. There does not appear to be any well defined contact of the ore-body with the adjacent rock, and but little indication of a vein-structure is visible. Outside of the ground covered by the trenches and pits, the surface shows the gossan cap at a number of points with a thickness ranging from a few inches to several feet. From the fact that this capping shows at several places, east of the main trench on the Rogers farm, it is probable that masses of pyrrhotite will be found over a considerable area, but probably in many cases so mixed with rock that careful separation would be necessary after mining. The existence of these ore-bodies could be best proved by judicious boring with a diamond drill. The areas of gabbro are limited and appear to rise in dome-shaped masses through the slate formation at a number of places. In the present state of development of the district, but little information of a definite nature can be given as to future values.

Nickel at Moore mill.

At the location near Moore's mill, while the gabbro is seen at different points, pyrrhotite appears to be disseminated in a mass of altered schistose slates. The ore here is apparently also of low grade and the extent of the deposit not large.

Grand Manan.

Time did not permit of an examination of the island of Grand Manan, but from previous reports by Verrill, Bailey and others, it would appear that the rocks are, as a whole, somewhat similar to those seen on Deer and Campobello islands. There are large masses of the newer intrusives, which have altered the slates of the Letite and Fryes island type into schists. The rocks on the west side of the island are of a different class, resembling the diabases of the upper part of the Bay of Fundy. A more detailed examination of this interesting area will be necessary.

Northern Part of Nova Scotia.

Mr. Hugh Fletcher.

Winter office work.

Mr. Fletcher spent the winter of 1902–03 in compiling the surveys of previous years enumerated in the Summary Report for 1902, pp. 388 to 399, in giving advice personally and by letter to miners and explorers in certain districts of Nova Scotia, and in studying the new and important extension and correction of former explorations in the light of results obtained by the government drills and otherwise, in their bearing on obscure points in the geology. Records of the exact position of all these boreholes and of the strata cut by them should be carefully kept.

Assistants.

Mr. Fletcher was assisted during a portion of the winter by Mr. J. A. Robert, B. Ap. Sc. and Mr. M. H. McLeod, and during the whole season by Mr. A. T. McKinnon.

Field work in Cumberland, Hants, Kings and Annapolis.

Leaving Ottawa on June 16 for field-work in Nova Scotia, he was employed for the most part in Cumberland county until the end of the year. Mr. McLeod worked in conjunction with Mr. Faribault and his assistants in the district north and west of St. Margaret's bay and from the Ponhook lakes to New Ross, in the counties of Halifax, Hants and Lunenburg; while Mr. McKinnon was occupied with a survey of roads necessary for the construction of a map of that portion of Kings and Annapolis counties lying north and south of the Dominion Atlantic railway, between the Hants county line and Lawrencetown, most of the streams having been already surveyed. Mr. McKinnon also made supplementary surveys on the Blomidon peninsula for sheet 83, which is now ready for publication, and, at the close of the field-season, collected a quantity of various minerals for educational purposes in Hants and Pictou counties.

The borehole at Hantsport* was given up at a depth of about 1,500 feet, the rocks cut being still similar to those near the top, but gray sandstone predominating. Boreholes at Hantsport, New Glasgow and Cheverie.

That on the East river, Pictou* was lost and another begun with a cable-drill at the same place, which has reached a depth of 1,900 feet and is still in the New Glasgow conglomerate.

The borehole at Cheverie* was abandoned at 1,910 feet. It was ten inches in diameter at the top, eight inches at the bottom, cased to 1,836 feet and reamed to 1,910 feet. The following section is given by Mr. C. S. Gayton, who is in charge.

	Feet.
1. Surface and drift	20
2. Dark gray shales	30
3. Shale and gypsum mixed in streaks	150
4. White gypsum	370
5. Red shale	80
6. Light-gray shale	10
7. Red shale	240
8. Red and gray shale in alternate layers	100
9. Gray sandstone, with a flow of salt water	20
10. Light gray shale, with a little sandstone	200
11. Red and gray shales mixed	50
12. Shales with gypsum	130
13. Whitish quartzose sandstone, very gritty	350
14. Dark gray shale	60
15. Dark-gray sandstone. A flow of salt water not so strong as the last	30
16. Dark-gray shale	50
17. Whitish gray sandstone, with a great flow of salt water	20
Total	1,910

No sign of petroleum was found. It is to be regretted that the dip of the rocks at this borehole was not taken.

In Cumberland county the work of last season consisted only of a more precise definition of lines laid down by Professor H. Y. Hind, Messrs. Scott Barlow and Walter McOuat, Dr. Ells and others, reproduced in the maps and reports of the Geological Survey, references to which are given on the map of the Springhill coal-field (No. 812). A

*Sum. Rep. for 1902, p. 391.

problem of great commercial and industrial importance here involved is similar to that discussed by Dr. Poole and Dr. Ells in regard to the existence of beds of workable or accessible coal beneath overlying strata in Prince Edward Island and New Brunswick, and has already been referred to.* On the strength of evidence collected as to the possibility of its existence, a borehole has been begun at the head of tidewater in the large brook at Spicers cove and another on the west side of River Hebert, a mile below the outlet of Fullerton lake. The results of this experiment will be watched with interest for, apart from the distance of this field from the coal mines at present worked, the depth to which boring must in any case be carried, and the difficulty of cutting conglomerate, the basal rock of the upper series, there must be added the uncertainty in regard to the thinning out of the workable coals in some directions, their deterioration as on the north side of the basin, at the Joggins and elsewhere, and the chance that some or all the strata underlying, as at Pugwash and River Philip, may be lower than the coal measures. The great belt of gray sandstone and clay shale in which lie the coal seams is of variable composition in different parts of the field, particularly as to the size of the coal-seams.

At Spicers cove.

The hole at Spicers cove, bored by Messrs. J. A. Johnson, B. F. Pearson and others with one of the government calyx drills (No. 5) is now down about 650 feet.† It began near the horizon of the small seams of coal exposed on the shore, but soon passed into a conglomerate containing large pebbles of red granite and other igneous and metamorphic rocks in a fine or coarse matrix, resembling in colour certain Triassic beds of the Bay of Fundy and including small basins of clay-shale with pockets of coal.‡

Atkinson brook.

Current reports of discoveries of coal on Atkinson brook, a branch of River Hebert and other places in the neighbourhood of the second borehole were found to be entirely without foundation; and there is no evidence that workable coal comes to the surface at any point on the southern edge of this trough. The borehole at Fullerton lake is now about 1300 feet deep.§ These two boreholes are in a basin tilted gently westward from the coal measures, millstone grit and Carboniferous limestone of the Springhill coal-field. To the eastward of it the lower strata extend, as shown on the map of 1885, to the neigh-

* Vol. XV., 1902, Part A, pp. 367, 377 and 395. On page 395 for 1,500 read 15,000.

† April 11, 1904.

‡ Sum. Rep. for 1892, pp. 41 and 42; for 1897, p. 100; for 1902, p. 378. Nova Scotian, Oct. 1903. Dawson's Acadian Geology, 'General Section Minudie to Apple River,' page 150.

§ April 15, 1904.

hourhood of Thompson station, where another basin of Permian rocks overlies and extends to the Pictou coal-field. This structure again suggests the question * whether parts of this second basin also may not be underlaid by workable coals, more particularly since, at Polly's brook and Oxford Junction, certain small coal-seams of the lower part of the Springhill section reappear in the eastern basin, the common axis of the two basins tilted west and east respectively, following the valley of Pollys brook for some miles among conglomerates which underlie the coal measures in nearly horizontal attitude. The gypsum of Salt-springs, Clairmont, and the belt northeastward to River Philip above Oxford, thence eastward to Birchwood, Hansford and Victoria, is clearly Lower Carboniferous, and that of Hartford, East Wallace (Plaster Cove) and Malagash Point is on the same anticlinal line.† an extension of the Clairmont anticline, the position of which is well marked along the shore. The limestones, red and green marls and flags of Johnston brook and the north side of Clairmont are part of the same formation ; while to the northward they are in contact with Upper Carboniferous rocks from Glenville to Oxford, marking the line of the Black river fault which is well shown at the mouth of the little brook from McManaman's and also on the north side of Black river at the bridge near Richard Keiver's, the rocks at the latter point, on the south side of the fault, being, however, coal measures.

Lowest coals of the Spring hill section.

Lower Carboniferous rocks.

Gypsum.

At Goose Point on River Philip, a fault seems also to separate the Permian from the Lower Carboniferous, the latter then spreading out in Roslin on another anticline, probably that which brings up also the gypsum and limestone of Canfield creek. These rocks apparently occur as outliers surrounded by Permian red marls and sandstones with layers of gray and greenish-gray crumbly sandstone, blackened with carbonized plants, stained green, and carrying trunks of trees converted into a mixture of coal, chalcocite and pyrite. The broken land of Canfield creek affords a fine display of 'plaster pits.'

The gypsum of Plaster cove seems to be on the north side of a fault passing clear of Macfarlane point. That of Blue Sea corner is succeeded to the westward on the shore by gray and rusty sandstone, containing drifted trunks of trees, coal-pipes several inches in diameter, traces of pyrite, chalcocite and galena, of black crystalline ironstone, calcareous 'bull-eyes' and masses of gray concretionary limestone-conglomerate.

The banks of red clay-marl dug for the use of the brick-works at Pugwash, broken land and a long ledge of limestone indicate the

Brick-clay and limestone quarries of Pugwash.

* Professor Hind's paper in the Nova Scotian, Oct., 1903, page 30.
† Report for 1885, Part E, page 40.

Lower Carboniferous on the west side of Pugwash harbour. This limestone is whitish and gray, nodular and compact, dips N. 58° E. < 73°, but is slightly contorted, in massive beds of considerable thickness, of an aggregate section of 150 feet. It has been quarried for some distance along the strike for shipment to Prince Edward island. The gypsum of River Philip and Hansford contains fine plates of selenite.

Collingwood and Wettchester.

By reference to the Springhill map, it will be seen that the conglomerate of Pollys brook, which underlies the coal seams, extends through Windham to Davison brook, at the head of which it rests upon the pre-Carboniferous rocks of the Cobequid hills. In the east branch of Davison brook, however, there is interposed a narrow belt of light gray, greenish-gray and rusty, fine, sandy flags and coarse grits, full of carbonized plants and threads of coal, interstratified with layers of red shale and sandstone and patches of concretionary, vesicular limestone-conglomerate, which extends from Collingwood corner up along the east branch of River Philip, through Westchester station to Wentworth and East New Annan. This series resembles that of the Glenville and River Philip quarries and certain rocks in the neighbourhood of Streets ridge; it everywhere underlies a conglomerate, but whether the latter is all of the same period of formation may be doubted.

Basin of the lowest seams.

There is apparently an unbroken belt of conglomerate down River Philip from Collingwood and Windham to Pollys brook and also eastward to Millvale and Westchester valley, overlaid to the northward by gray sandstone and grit, as on the south branch of Black river, and at the mouth of Tillet creek by reddish marls, whitish nodular sandstone and grit and rusty pebbly grit and conglomerate with a low southerly dip. An opposite dip, also low, is found among these rocks in the brooks crossing the old Westchester road between River Philip and Millvale, while the northern edge of the basin is indicated by outcrops on the Jungle road and the Intercolonial railway from Oxford Junction to Thompson. Eastward from these points they run across the Colonel's brook and the Emery Meadow brook, but before reaching Atkinson siding appear to pass beneath conglomerate and reddish and blackish soft crumbly shales, like those which overlie the coal measures between Springhill and Athol.

At Thompson.

This gray sandstone series, as already stated, includes the coal seams exploited on Pollys brook and about a mile east of Oxford junction.* These latter extend to Thompson among the gray sandstones exposed

* Depart. of Mines for N. S., 1893, page 6.

in the railway cuttings and bored by Mr. Thomas Matheson. The coal seam of Pollys brook consists of three inches of coal in a band of clay shale and underclay about six feet thick, underlaid in the brook by rusty conglomerate and grit, exposed for a considerable distance with a very low dip in flat undulations down stream towards the head of the millpond.

Below the Emery meadow there are obscure outcrops of gray sandstone. About one-eighth of a mile above the confluence of Emery brook, an excavation made by a Halifax company in the Colonel's brook disclosed, according to Mr. George Purdy, six inches of black coaly shale, included among greenish and gray clay-shales underlaid by a quantity of red shale. Between this point and Mr. Purdy's house, many large blocks of gray sandstone are found, while north-west of the road at his house, similar sandstone, in part massive and of fine texture, has been somewhat largely quarried in the Mile brook. Below the confluence of the Emery brook, gray fine sandstone, of good quarry texture and grindstone grit, is also exposed with a low dip.

From Pollys brook, the axis of the basin of which these rocks form the south side, passing half a mile south of Thompson, through Lower Wentworth, Brulé harbour and John bay, enters the sea three miles east of Cape John, the highest rocks in the field being underlaid east of Brulé by strata having a low dip to the westward. On the north side of this basin, rocks of the gray sandstone series keep along Big lake, through Kerr's and Howard's mills and north of Dewar river to Malagash point, where they contain small coal seams and were recognized as "very like the lower part of the coal measures by Sir J. William Dawson* who also remarks that unless the more important parts are concealed by the imperfection of the sections, the whole Carboniferous series appears here to be less fully developed than on the western coast of the county." It is on the assumption that this imperfection may be due to unconformity and to the overlapping† of the coal measures by higher rocks that deep boring for the discovery of the coals is suggested in this basin also. If no such unconformity exist, the strata of the basin south of Big lake, Dewar lake and Tatamagouche bay must represent the coal measures of other districts barren of coal. As having a bearing on this question, a close examination should be made of the rocks west of River Philip between Kolbeck and the Stanley mines, beyond the limit of the present map sheets, where the coals of the Joggins section appear to thin out or disappear.

At Malagash.

Boring suggested.

* Acadian Geology, page 216.
† Report for 1885, Part E, page 42.

Big Lake coal mine.

From the Lower Carboniferous rocks of Hansford and Birchwood the outlet of Big lake affords a fine ascending section to those of South Victoria and Streets ridge. The Big Lake coal mine, so called, is of great scientific interest, if of little commercial value. Here, with a small engine for hoisting and pumping, two slopes, about 280 feet apart, have been sunk about 60 feet S. 21° E. <50° on the dip of two belts of dark-gray clay-shale, full of fossil plants, trunks of trees and *Stigmaria*, with pipes and thin layers of coal, the largest not exceeding eight inches. The band farthest south is associated with balls or masses of flinty grit; in the other, both roof and pavement are regular and the band of gray shale and sandy flags is twenty feet in thickness. Gray Carboniferous strata also prevail to the northward, while immediately south of the mine lie red sandstone, grit and conglomerate of the higher series, provisionally called Permian, the change being so abrupt that unconformity seems probable. A similar unconformity seems to separate the gray sandstones of Thompson from the red marly shales and flags, grit and conglomerate of the Intercolonial railway between Thompson and Atkinson. The latter extend northward through New Jersey and occupy the country from Greenville to Streets ridge, borings made at intervals across this tract having shown only these red strata and confirmed the evidence of the natural exposures.

Westchester valley.

Up the brook south of Atkinson siding, conglomerate is well exposed in cliffs, and a small quantity of barite in highly crystalline aggregations has been dug from irregular veins and masses in it. At Westchester valley, up the main river, a pit dug in gray and rusty sandstone of the lower series shows many carbonized plants and a streak of coal associated with sulphides, principally pyrite.

Conn's mills.

The conglomerate of Pugwash river above Conn's mills succeeds the black shales of Hansford siding and Roslin, but is perhaps Permian. As there are conglomerates at the base of the three series of Lower Carboniferous, Millstone Grit and Permian rocks, great care must be taken to distinguish between them, and it is possible that with every precaution, mistakes will be made in their identification. Much of the land of Pugwash harbour and Port Philip is low and shows few exposures, but those along the outer shore are good. Southeast of the brick-clay deposit is a small quantity of coaly shale and a *Stigmaria* underclay, underlaid by gray and rusty sandstone and flags with patches of greenish-gray limestone-conglomerate and grit, but no workable coal. A little farther south, on Chisholm creek, gray and blackish sandstones and flags yield a large quantity of excellent chalcocite, specimens of which were shown at a recent exhibition in

Halifax as a good type of this class of ores, fully described in previous reports. Copper ore of Pugwash.

Intermittent attempts are still made at Wentworth Centre* to mine and reduce these ores by a process similar to that in use at Dorchester, New Brunswick, but the prospects of success do not seem to have improved.† Northwest of the limestone quarry, several pits have been sunk to test the bog iron ore found near the surface in that vicinity.

Not far below Kerr's mills, nearly vertical beds of light-gray and rusty conglomerate containing coal-pipes, pyrite and chalcocite rest against red shales and interstratified thick beds of gray sandstone. The quarry sandstones of Wallace bridge seem also to underlie this conglomerate, and these in turn are the sandstones of Wallace harbour.‡ A section of the rocks from Kerr's mills up Wallace river to the head of Howard's millpond, has been prepared in more detail than that given in Dr. Ells' report, and certain bands have been traced across the country; but the results will not be here presented. Gray sandstones are well exposed also on the roads from Malagash station to Wallace ridge, thence to the Stake road and to a considerable distance east of it; they resemble those of the Wallace quarries, Howard's mills and Wallace bridge. Wallace quarries.

As already pointed out, the north side of this basin is characterized by steep dips and faults, and the bottom of the basin is seldom far from the northern boundary of what have been regarded as the overlying or Permian rocks. On the south side, from the axis to the foot of the Pre-carboniferous hills, the basin is broad and the dips low; this would therefore, probably, be the best side to bore for possible coal measures, if the latter are not too deeply buried beneath the Permian.

The rocks of the Wallace river section differ considerably from those of Maccan river between Athol and Southampton, the latter being for the most part finer in texture, like those along the Upper Maccan river and Rattling brook. Those of the East brook are similar and towards the old Mountain road they include beds of conglomerate. Wallace river section.

Explorations have been made to a small extent, partly in the Lower Carboniferous and partly in the adjoining gray sandstone, northwest of Stewart meadow, by Mr. Thomas Pigott and others, in search of an extension of the Springhill seams: but no discovery of coal has yet been made. A borehole, now about 500 feet deep, on the south side Explorations near Springhill Junction.

* Sum. Report for 1902, page 396.
† N.S. Depart. of Mines, 1897, p. 50; 1898, pp. 51-52; 1900, pp. 54-55.
‡ Rep. for 1885, Part E., page 40.

of the Intercolonial railway track, at the water-tank immediately east of Springhill Junction, has passed through red marls with a few thin beds of reddish and gray sandstone. The belt of gray sandstone along the railway from Springhill Junction to Saltsprings station, interrupted only by a short exposure of the Lower Carboniferous of Stewart meadow, has led naturally to the supposition that they are continuous as well as on the same horizon.

Upper Maccan river.

Passing now to the south side of the Springhill basin, it will be remarked that the rocks of the Wolf road strongly resemble those of Mapleton and Leamington, the Rattling and Harrison brooks, their general resemblance to those of the south branch of Black river, which underlie the coals, being equally striking. At the house of Mr. Albert Brown, immediately east of the crossing of the east branch of Lawrence (South) brook, a small seam of coal is said to have been cut in a well at a depth of 60 or 70 feet, and coal-wash found north of it on the bank of this brook at a little burying-ground. This would seem to be directly on the strike of the coal cut in the 715-feet borehole at Mapleton* and would suggest the probable extension of this seam to that point

Exploration for coal.

Although many of these details may seem unsuitable for a preliminary report or may have been given before, they are repeated as having a direct bearing on the development of this district and as suggesting certain lines that explorations may follow. Prospecting for coal, like mining, is not a game of chance, but a legitimate venture that should be conducted under honest, competent management, without over-capitalization or appeals to the cupidity of shareholders by fraudulent or ignorant misrepresentations.†

Boring at Leamington and Mapleton.

In the Springhill basin, further explorations were made last summer by two men who bored eighty-four holes, sixty-one feet deep and under, and dug several pits, to define more precisely the position of certain distinctive beds of coal and shale in the district between Mapleton and Rodney.‡ By this means the coal seam traced from the 714-feet borehole was found to turn from the point to which it is drawn on the map of Springhill (No. 812) northward 1,200 feet to a point a few feet past Rattling brook, where it was lost, probably against the fault already proved at Mr. C. E. Corbett's, west of J. W. Hunter's at the old Mountain road. The belt of red shale overlying that seam from Mapleton northeastward is shown on the map. North of this

*Sum. Rep. for 1902, page 394.
†The Nova Scotian, Oct. 1903, pages 33 and 63.
‡Sum. Rep. for 1902, page 394.

fault a similar belt of red shale overlies the seam bored 700 feet north of Mr. Hunter's and was traced, around the point of the anticline* shown on the map, northward to the fault at the old Mountain road. This coal also was now traced, by boreholes, parallel to the red shale for about 1,500 feet to the point of the anticline, but was not followed on its northwesterly dip nor to the fault, for want of time, Enough was, however, done to prove it the probable equivalent (on the north side of the Corbett fault) of the seam of the deep borehole at Mapleton* which it strongly resembles in composition and associated strata. The coal seam represented as probably lying west of this one should, therefore, be erased from the map, as also the suggested connection of the Dan McLeod seams with the coal at the Athol road.

A broad belt of red shale, overlaid by gray and greenish-gray argillaceous shale like the foregoing, was next found on the old Mountain road 800 feet north-west of and overlying the coal traced from Harrison brook† southwestward to that road; so that this seam also, in the absence of any evidence to the contrary, may be regarded as identical with that of the Mapleton deep borehole, as suggested on the engraved map (No. 812). A hole sixty feet deep was bored below the outcrop of the seam at Mr. Herbert Stonehouse's on the Athol road, cutting gray shale and sandstone, the red strata overlying which, begin a short distance west of the house, are well seen at the crossing of the railway and along the latter nearly to the bridge across Harrison brook.

A few feet on the dip of one of the Dan. McLeod pits, west of the Leamington road* a borehole was put down to the coal, which was afterwards traced more than 1,000 feet to the south-eastward of the road, but seems here to be cut off. Little is known of the extension of these coal-seams to the eastward, but they could probably be proved by boring. Much of the surface hereabout is encumbered with large blocks of gray sandstone. From Herritt's old dam (from which a pump now throws a large stream of water through a straight line of pipe to the ponds above the west slope, for the use of the mines) southward, this sandstone is more pebbly as a rule than that on the north side of the river, but not otherwise different, there being apparently in passing south only an increase of conglomerate, with which is associated red marl, and in a little brook, sandstone, grit and argillo-arenaceous rocks, precisely as in the banks of Tom Boss and Sugarwood

Obscurity between Leamington and Rodney.

* Sum. Rep. for 1900, page 163, line 25.
† Sum. Rep. for 1902, page 394.
*Sum. Rep. for 1900, page 163, line 23.
* Sum. Report for 1900, page 163, line 7.

brooks, that nearest Maccan river being dark greenish-gray argilite and fine grit. The cores as described from the 134-feet bore-hole near Tom Boss show apparently an extension of these rocks.

The basin near Rodney nowhere indicates the proximity of a great fault or points to a possible separation of these rocks from those to the northward along a well-defined line and yet along the line from Tom Boss brook to Mapleton the coal-seams are succeeded by conglomerate, sometimes apparently abruptly ; and several small obscure faults have been proved.

Mining at Springhill and other collieries

Mining at Springhill has carried the 2,300 feet level of the west seam northward, approximately parallel with the line of outcrop shown on the survey map (No. 812), across the railway and the East brook, nearly to the Junction road ; and a slope or balance is being driven to the surface a considerable distance north-west of the Aberdeen slope, to serve as a return air-course. From these workings, at a seven-feet fault, samples of crude petroleum have been obtained associated with calcspar veins, resembling its mode of occurrence in thePictou coal measures.*

In this work Mr. Fletcher has again had the kind assistance of Mr. J. R. Cowans and other gentlemen whose names have appeared in previous reports.

For a description of recent mining operations at Springhill and the smaller collieries of Joggins, Chignecto, Minudie, Strathlorne and Jubilee, on the north side of the Cumberland basin, the Canadian Mining Manual and the Nova Scotian, pages 17 to 20, may be consulted. Of these collieries, Springhill furnishes as its share of the Intercolonial railway contract for coal 80,000 tons, Joggins 15,000 tons, Minudie 15,000 tons, Strathcona 5,000 tons.† Coal is now taken from the 1,400 feet level at Chignecto mines.

Magnetic iron ore.

Systematic search was begun last summer by Mr. Lindsay on the deposits of magnetic iron ore found in irregular masses and veins among the traps of Gerrish mountain,‡ but up to the present time no mass of workable size has been found.

Copper of Cape d'Or.

At Cape d'Or, the Colonial Copper Company has, during the last three years, expended some hundreds of thousands of dollars in exploiting the deposit of native copper also found, like the magnatite, in

*Poole's Pictou Coal Field in the Trans. N.S. Inst. Sc., Ser. 2, vol. I, Part 3, page 339.

†Maritime Mining Record, Dec. 9, 1903, pp 14 and 16.

‡Sum. Rep. for 1891, page 36.

Triassic trap* in irregularly scattered grains, plates and lumps sometimes weighing fifty pounds, in veins and dykes carrying quartz and zeolites. Several shafts have been sunk, one to a depth of 371 feet, with drifts and tunnels at intervals; machinery capable of treating 400 tons a day has been erected, and a railway, one mile and a quarter long, built to convey the ore from the mines to the mill.

New Annan.

Near William Warwick's at West New Annan, one of the irregular deposits of sulphides of iron, copper and other metals, said to carry gold, exploited from time to time in the Cobequid hills† was developed to some extent last summer.

Coal of Kennetcook river.

During the autumn two visits were made to Stanley in Hants county where a government diamond drill was at work on the right bank of Kennetcook river, nearly opposite the gravel pit at the station on the Midland railway. The cores to a depth of 485 feet consist of red and gray sandstone and shale, red predominating, but no trace of coal was met, although in the neighbourhood are found the indications observed by Sir William Dawson, who writes of them as follows:—‡

'Indications of coal have also been observed in the coal measures band extending from Lower Stewiacke toward and along the Kennetcook river. These measures are not well exposed, and I believe that nothing definite is known as to their real value. The occurrence of coal in this central district would, however, be of so great importance to the province, and to the success of its main line of railway, that the subject well merits a thorough investigation'.

Boring at Port Hood.

Some attention was also paid to the borings with a calyx drill at Port Hood,§ which have enabled us to fill up the gaps in the coast section below the main seam, down to the strata so well exposed in the cliffs at and near Cape Linzee, Sheet No. 16. Borehole No. 3 on Smith island, after passing through about 300 feet of the gray sandstone of Susannah point, with bands of conglomerate, cut 300 feet of the red Lower Carboniferous strata which underlie these gray sandstones along the shores of the island.

Borehole No. 1 began immediately below the outcrop of the main coal-seam near the Tremaine or present working slope; No. 2 was bored on the west bank of the millbrook (Little river), a few yards above the

*Acadian Geology, page 107. N. S. Depart. of Mines, 1876, p. 63; 1901, page 71. Can. Mining 1903, p. 72. Geol. Survey Ann. Rep., 1889-90, Part P., page 186. Sum. Rep. for 1901, page 214.

†N. S. Depart. of Mines, 1880, page 13, *et al.*

‡Acad. Geol., pp. 268, 269 and 276. Sum. Rep. for 1889, p. 30; for 1893, p. 41.

§Report for 1882-84, Part H., pp. 47, 56,*57 and 88. Sum. Rep. for 1900, p. 164, for 1902, p. 390.

shore road ; and No. 4 on the Little Mabou road, 200 yards north-east of the fork of the shore road. The section of No. 2 seems to commence about 477 feet below the top of No. 1 and to contain all the strata of No. 4, which commences about 77 feet below its top. The thick sandstone cut in all three holes, with an underlying coal seam, is apparently that of the section at Isthmus point given in the Geological Survey Report for 1882–84, page 57 H (Nos. 8 and 10 of the section.)

Port Hood mines.

An output of 95,000 tons of coal has been obtained by the Port Hood Coal Company from their mines during the past year. The slope is now down 1,576 feet, with a sump seventy feet below the lowest level. This level is driven north 2,500 feet and south 900 feet, the seam being 6 feet 3 inches thick on the south side, and 7 feet 3 inches on the north. A subsidy of $20,000 has been voted by government this year to help to restore the bar and make shipping safe at the wharf which is 3,000 feet from the engine at the bankhead.

Mabou.

The slope at Mabou coal mines is 100 feet under the sea with 350 feet of cover at the water line,* and interesting developments have been made in the sinking, although little coal has been shipped. The slope is now being re-timbered, preparatory to testing the continuance of a flattening of the coal to 6 feet at the face.

Inverness.

Since the completion of the railway to Port Hastings and Point Tupper, the production of coal from Inverness (formerly Broad Cove) mines has also largely increased.† Here a government calyx drill (No. 7) was employed to determine the character and thickness of rock-cover over the present working seam at the shore.

The large drill used at Port Hood has been removed to Chimney Corner coal mines.

Explorations at Cheticamp.

Exploratory work is still being prosecuted at Cheticamp on the extensive deposits of mixed sulphides, sometimes rich in gold and silver, which are described in Report A for 1898, page 148. A 'grab sample' taken by Mr. F. H. Mason, of Halifax, 'assayed nearly three ounces of gold, besides silver and copper values.' The presence of metallic ores in this region, pointed out by Mr. John Campbell in 1862, Professor Hind in 1870, the Geological Survey in 1881, and many others‡ has led to costly explorations at various times.

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*Maritime Mining Record, Dec. 9, 1903, page 15. Rep. for 1882–84, Part H, pp. 61 to 71, 88 and Sheets 14 and 15. Brown's Coal Fields of Cape Breton. Gilpin's Mines of Nova Scotia. Reports of N.S. Depart. of Mines.

† Report for 1873-4, pages 182, 183 and 188 to 191; for 1882-4, pages 14, 71 to 74 and 88 H, with map sheet. Sum. Rep. for 1900, p. 164.

‡ Rep. for 1882-4, Part H, pages 22, 39, 95, 97, etc.

On the eastern side of this northern tableland, at Aspey bay, a deposit of galena in limestone, like that of Pleasant bay* rests directly upon granitic rock, the ore following here, as elsewhere, the contact of the Lower Carboniferous with pre-Carboniferous rocks.

Coal reported at St. Anne.

Towards the end of July, Mr. Fletcher visited the north shore of St. Anns, in Victoria county, where indications of workable coal were reported to have been discovered in rocks coloured Lower Carboniferous on the geological map of that district. These reports were found to rest entirely on the occurrence of certain black bituminous shales, containing carbonized plants and coaly matter, which have often been mistaken for coal.† Near the mouth of Little river, at the house of Mr. Angus Matheson, broken land indicates the probable existence of limestone, and this has actually been dug in a well and pit near the house. Along the shore, the strata of the reefs are nearly horizontal: the most prominent rock at low-water is a band of gray, jointed, fossiliferous limestone, underlaid by coaly shale and coal of no great thickness, succeeded beneath by a dark calcareous underclay, full of rootlets. Farther south, the cliffs expose conglomerate, grit and light-gray, micaceous, sandy flags and shales, with thin layers of black shale, apparently all Lower Carboniferous. Pits and boreholes put down along the shore show no indications to support the claim that workable coal had been found.

The land between the shore and the felsitic rocks of the mountain is nearly a plain, greatly broken by plaster-pits, as shown on the map. Good outcrops of marl and gypsum occur at many points, backed by the felsites which, towards St. Ann's harbour, are again being exploited for gold and metallic ores.‡

At Hunters mountain.

Application has, it is said, been made for the use of one of the government drills to bore the Lower Carboniferous, so called coal seams of Hunters mountain, about eight miles from Baddeck.¶

Near Boisdale several days were spent, about the middle of August, with Mr. S. Ward Loper who was again collecting, for the United States Geological Survey, fossils described by Dr. G. F. Matthew in his Report on the Cambrian Rocks of Cape Breton.

Mining Society of Nova Scotia.

Acting on instructions received from Dr. Bell, Mr. Fletcher on October 27 brought before a meeting of the Mining Society of Nova

* Rep. for 1882-4, Part H, p. 93.
† Rep. for 1882-4, Part H, pages 46, 52, 53 and 90, and map sheet.
‡ Rep. for 1882-4, Part H, page 94.
¶ Rep. for 1876-77, p. 454. Rep. for 1882-84, part H. page 41. N. S. Depart. of Mines, 1877, page 36. Brown's Coal Fields of Cape Breton, page 37.

Scotia some of the results of the work of the Geological Survey in Cumberland county, principally on the coal measures in their relation to the overlying rocks, illustrating his remarks by maps of the district; and when in Halifax at that meeting he assisted Dr. Poole in revising a new map of the Pictou coalfield.

Explorations in the Sydney coal field.

A considerable amount of money was spent last summer by the Cape Breton Coal, Iron and Railway Company in explorations along the outcrop of the Tracey seam, under the advice of Professor Ray and Dr. H. S. Poole, in continuation of those made by the late Mr. E. T. Moseley and Senator MacKeen.

Sum. Rep. for 1901, p. 208; for 1895, p. 107; for 1896, p. 95; for 1897, p. 102. Report for 1874-75, p. 189; for 1875-76, p. 414. Note on the Sydney Coal Field (No. 685) with maps, p. 7.

SPRINGHILL, N.S., Dec. 18, 1903.

GOLD FIELDS OF NOVA SCOTIA.

Mr. E. Rodolphe Faribault.

Office work by Mr. Faribault.

Mr. Faribault was engaged in office work from October 22, 1902, until June 9, 1903, and from July 13 until August 4, 1903. The greater part of this time was spent in plotting plans and sections from surveys made by himself and his assistants during the previous summer, as detailed in the Summary Report for 1902, pages 399 to 427.

Much time was also taken up in correspondence, especially answering letters from persons seeking information and advice on the gold fields of Nova Scotia, which are attracting more and more attention from scientists and capitalists at home and abroad.

Report on deep gold mining to government of Nova Scotia.

At the request of the government of Nova Scotia, Mr. Faribault has prepared a report with plans and sections, entitled 'Deep Gold Mining in Nova Scotia,' which has since been printed for distribution among those interested in gold mining. The legislature of Nova Scotia, at its session of 1903, passed an act authorizing the Governor in Council to appropriate a sum of money sufficient to assist in the sinking of deep shafts, in such places as may be determined, under the direction of the Inspector of Mines. The government is to bear half the expense of the actual sinking from the surface to a vertical depth not exceeding 2,000 feet.

Plans of gold districts published.

The plans and sections of the gold districts of Isaacs harbour, Cochran hill, Wine harbour and Harrigan cove surveyed the year previous, and that of Gold river, surveyed in 1901, were completed

for publication. The plans of Isaacs harbour, Cochran hill and Gold river are now being published, while those of Wine harbour and Harrigan cove only require to be traced for engraving. These mining plans are impatiently awaited by those interested, to guide them in their operations, and they will be published as soon as completed.

Publication of maps.

Mr. Owen O'Sullivan of this department was engaged some four months during the winter in compiling the topographical surveys of the region lying immediately west of the line of the Intercolonial railway between Halifax and Elmsdale, and extending northward to Rawdon and Newport and westward to the main road leading from the latter place to Sackville and St. Margaret's bay. The compilation of the instrumental surveys made for several years past in the counties of Halifax, Hants and Lunenburg is still in arrears, but it will be pushed vigorously and completed for publication.

Field work in the gold fields of Nova Scotia.

On the field work accomplished in the gold fields of Nova Scotia during the past summer, Mr. Faribault reports as follows :—

In accordance with your instructions, I left Ottawa on June 9, for Halifax, N.S., where I met my assistants Messrs. A. Cameron and J. McG. Cruickshank, as well as Mr. M. H. McLeod, transferred for this season from Mr. Fletcher's party, and from thence proceeded to the interior country lying to the north of St. Margarets bay to examine that region and define the surveys necessary to complete the mapping of the area lying between Mr. Fletcher's work on the north and my own on the south. I returned to Ottawa at the end of June, but left again for Nova Scotia on Aug. 14, where I remained until early in October, my assistants continuing field-work up to October 18.

New methods of deep mining.

Owing to important new mining developments made or contemplated in many gold districts by means of vertical shafts on anticlinal systems of saddle veins to establish a new method of deep mining and on account of numerous requests received for geological information of use in these operations, much of my time was spent, by Dr. Bell's instructions, in making examinations of several gold districts beyond my field of systematic work.

Gold districts examined.

The following gold mining districts were examined :—Isaac's Harbour, Country Harbour, Wine Harbour, Goldenville and Miller's Lake in Guysborough county ; Ecum Secum, Harrigan Cove, Fifteen-mile Stream, Caribou and Oldham in Halifax county ; Mount Uniacke in Hants county ; Gold River, Leipsigate, Indian Path, Voglers Cove and Pleasant River in Lunenburg county and North Brookfield, Molega, Whiteburn, Fifteen-mile Brook and Mill Village in Queens county. The eight last named districts were visited for the first time

to ascertain their geological structure, as compared with those of the eastern part of the province, in order to arrive at some general conclusion as to a classification of all the gold districts and their suitability for deep mining. Some data were also collected on the bog iron deposits, prospected in Halifax county at Newcomb Corner, along the south side of the Musquodoboit river and as far west as Fall river; on the limestone, gypsum, ochre and supposed coal deposits of Mahone bay Lunenburg county and the Dominion Antimony Company's mine at West Gore, Hants county. At the end of the season's work, several days were spent with my party at New Ross, Lunenburg county, to examine the mode of occurrence of minerals and intrusions met with in this granite region.

Iron, antimony, ochre, etc.

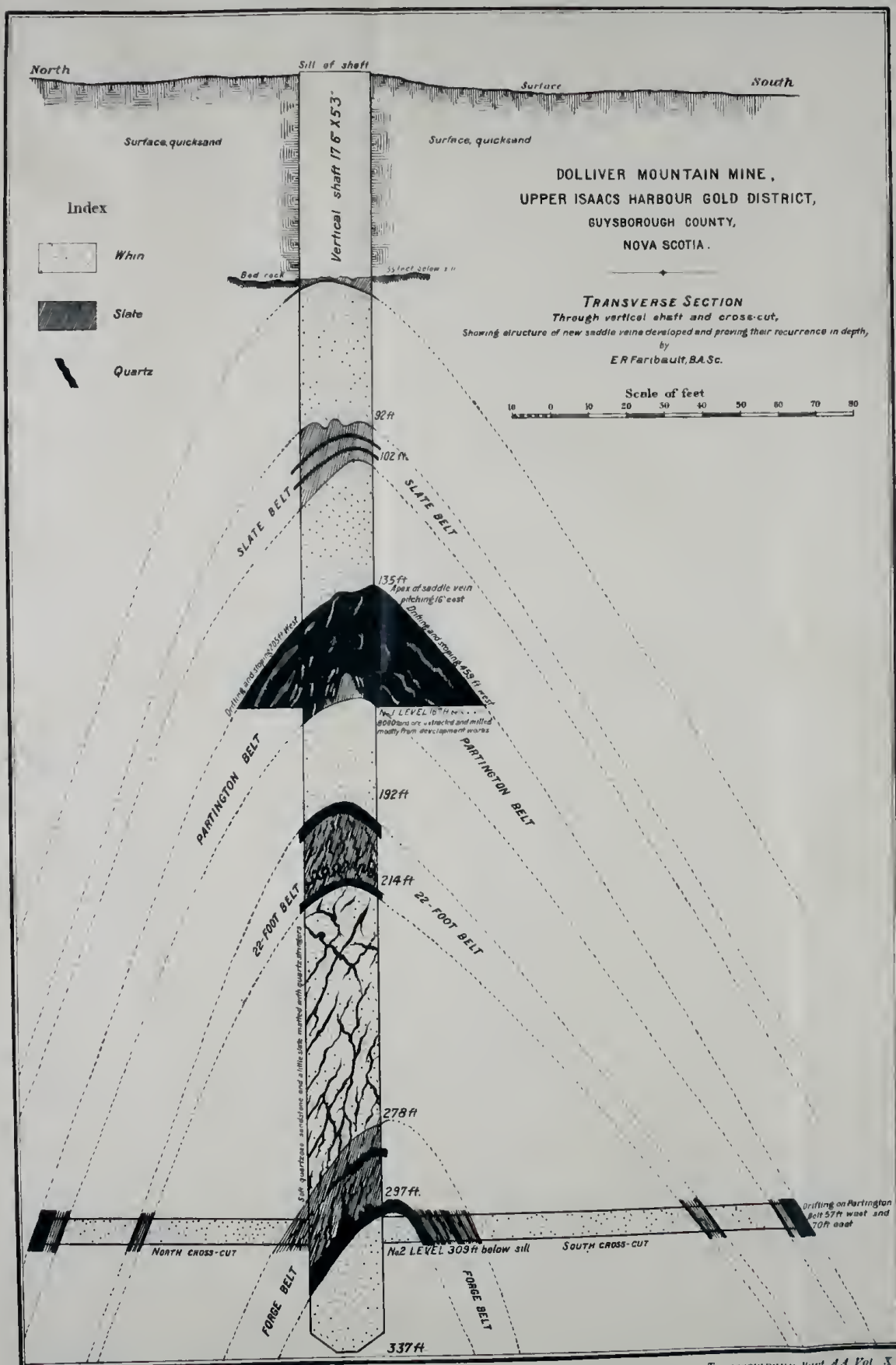
In the performance of my field-work I have received valuable information and assistance from miners and other in Nova Scotia and I wish to offer especially my acknowledgments to the following persons: Hon. A. Drysdale, Commissioner of Works and Mines, Dr. Edwin Gilpin, Inspector of Mines, Dr. M. Murphy, Provincial Engineer, Dr. H. S. Poole, Prof. J. Ed. Woodman, and Messrs. F. B. Wade, K.C., M.P., Harry Piers, Curator Provincial Museum, Alex. McNeil, K.C., F. H. Mason, D'Arcy Weatherbe, Fred. P. Ronnan, and F. J. Tremaine, K.C., of Halifax; James A. Fraser, New Glasgow; G. J. Partington of Isaacs Harbour East; W. F. Fancy, Isaacs Harbour; Ch. M. Donohoe, Goldboro; J. C. McDonald, Country Harbour mines; S. R. Heakes and Matthew McGrath, Wine Harbour; Arthur G. McNaughton and Wm. McIntosh, Goldenville; George W. Stuart, Truro; Monroe Archibald, Walter C. Boak and E. H. Oland of Harrigan Cove; L. W. Getchell, Caribou mines; Ed. Whidden, Oldham; Jas. A. Crease, Geo. E. Johnson, Mount Uniacke mines; C. Noble Crowe, West Gore; Prof. G. S. Kennedy, Dr. H. Y. Hind and Clarence H. Dimock, Windsor; Charles Keddy, Lake Ramsay; C. U. Mader and Dr. C. A. Hamilton, Mahone Bay; V. J. Paton, T. W. Moore, Dr. Henry W. Cain and H. S. Badger of Bridgewater; W. L. Libbey, North Brookfield; R. R. McLeod, Brookfield; Samuel Sutherland and D. McD. Fraser, Molega gold mines; W. H. Banks, Caledonia Corner; Gordon C. Smart, Whiteburn; and James Sheriff, Fifteen-mile Brook near Middlefield in Nova Scotia; also John E. Hardman of Montreal.

Acknowledgments.

Last season's surveys are not all plotted and the results have not yet been fully made out, but the following summary of information and conclusions are given subject to revision.

Geological Survey of Canada

ROBERT BELL D.Sc. [illegible] LLD MD FRS ACTING DIRECTOR



Drawn for photo-lithography by O E Prud'homme

To accompany Part A.A Vol XV

No 850.

Iron, anti
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Acknowl
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UPPER ISAACS HARBOUR GOLD DISTRICT.

An examination was made of the underground development works in progress at the Dolliver Mountain and Richardson mines.

Dolliver Mountain mine.

Dolliver Mountain Mine.—The vertical shaft on the anticlinal fold has attained a depth of 337 feet and has already intersected five saddle veins. From data kindly supplied by the resident manager, Mr. G. J. Partington, a transverse section made through the vertical shaft is here reproduced to show that the structure of the saddle veins is the same as it was at their cropping, further west and proves their recurrence in depth. The section need not be described as it is self-explanatory.

Section of saddle veins developed by vertical shaft.

Some 8,000 tons of ore have already been taken out, mostly from development tunnels and cross-cuts on the Partington belt; they were milled separately and the distribution of the gold plotted on large scale plans. These plans are most interesting and valuable. They show at a glance the distribution of the ore values, and prove that some portions of the saddle veins are not profitable, while others give pay-values which are now being traced by stoping to determing the pay-choots which will probably be found to pitch eastward 16°, like the apex of the saddle.* As far as the developments have gone it appears that the ore on the arch-core of the fold is probably of too low grade to be worked with profit, while at a certain distance below the apex the ore is richer. On account of the great size of the veins the preliminary developments were necessarily extensive and costly, but the knowledge gained on the Partington saddle will now be available and valuable in the development of underlying saddle veins, as it is probable that the pay-choots on the various veins occur in the same relative position on the anticline, and extend in depth in a direction nearly parallel with the apex of the fold. Should the Partington saddle prove unprofitable it does not follow that the underlying saddle veins will also be so, and I am pleased to learn from advice just received that the ore recently taken out from the apex of the Forge saddle, at the No. 2 level, 309 feet below the surface, shows good plate values in the mill and gives evidence of good battery values also, judging from the amount of mercury required. In Bendigo (Australia) profitable saddle reefs occur only every 300 or 400 feet in depth, on an average. The sinking of the vertical shaft has been discontinued, while developing the station at No. 2 level, but it will be resumed shortly.

* Summary Report Geol. Surv., Can., 1902, p. 424.

Richardson mine vertical shaft.

Richardson mine.—The Boston-Richardson Mining Co., which has recently acquired the property, has enlarged the vertical shaft, which was sunk by the old company on the anticlinal fold, into a three compartment shaft, 19 x 6 feet, in the clear, with a view to deep mining. The present depth of the shaft is 180 feet. Between the depths of 130 and 160 feet, five new veins were intersected, measuring respectively 8, 5, 7, 5 and 6 inches of quartz, and several other leg veins of greater size will undoubtedly be cut before intersecting the Richardson saddle vein at the estimated depth of about 375 feet.

Upper Isaacs Harbour anticline.

Mr. W. F. Fancy has recently located the anticline between Isaacs Harbour and Country Harbour, by surface prospecting, on area 576, Block 18. Assuming that there is no important fault between this point and Isaac's Harbour, it should cross the main road up the harbour at the south side of area 454, Block 6, or about 240 feet further south than indicated on the published plan of Upper Seal Harbour gold district.

COUNTRY HARBOUR GOLD DISTRICT.

Country Harbour gold district.

Assisted and profiting by Mr. J. C. McDonald's intimate knowledge of the district, I succeeded in making out its general structure in a more satisfactory manner than had hitherto been done. The district is situated on the east side of Country harbour river and forms part of a large block of country which has been swung to the south by a main cross-country fault following the river valley. All veins worked in the district have thus a general northand south direction; they follow the planes of stratification and occur on the western dip of the main anticlinal fold.

Structure of anticlinal fold.

The anticline was located with certainty at two points namely, at the north-west side of area 1064, where a ledge of whin crops out prominently on the northwest side of a small brook, and at the south corner of area 1340, about 200 feet directly east of the Morrison shaft. At both places the anticline shows a decided pitch to the south and on area 1340 a quartz vein curves on the apex of the fold with rolls pitching south at an angle of 15°. This would seem to prove that the pay-choots on the leads dip to the south at a low angle. Immediately east of the anticline the rocks are concealed, but further away dip east at a low angle, and on the west side they curve abruptly and assume rapidly a steep westerly dip.

Zone of pay-ore.

From knowledge gained in other districts it might be inferred that workable veins are confined to the western leg of the fold and that the zone of special enrichment should occur close to and parallel with the

anticline. As the anticline has a pitch to the south, the strata and the main leads do not run quite parallel with it at the surface but approach it towards the south until they eventually curve around it and assume an easterly dip. As a result the pay-choots will probably crop at the surface on the different leads along a line approximately parallel with the anticline and systematic prospecting along that line should develop pay-choots on other leads towards the north and south, probably as rich as those already worked so successfully on the Mason and Prince leads. In depth the axis-plane of the anticline dips eastward; consequently, to keep in the pay-zone and develop new pay-choots on underlying adjacent veins, cross-cutting to the east should be done as greater depth is attained

Granite intrusions.

Several dykes and spurs of granite from adjoining granitic masses intersect the auriferous strata and veins of the district, generally at a slight angle, and in the underground workings they occasionally interrupt the pay-choots. The veins intersected are not much displaced and appear to continue their original course beyond the granite intrusion, except further south in the vicinity of the main river-fault, where they are much disturbed. The rocks are much altered in places, but the richness of the vein and the pay-choots within them do not appear to be otherwise affected, which goes to prove that the granite intrusions are more recent than the impregnation of the auriferous veins.

GOLDENVILLE GOLD DISTRICT*.

Goldenville district. Bluenose mine. Development of new saddle-veins.

Bluenose mine.—Since last year's visit, the main shaft on the old Springfield belt has been sunk to a depth of 485 feet and at 460 feet, or 100 below the second cross-cut, a third cross-cut was driven north 90 feet, intersecting the McNaughton belt 74 feet from the shaft. On that level, drifting and stoping are being done west 200 and east 30 feet. The west face of the drift shows better ore than the east and the structure of the belt indicates that the pay-choot pitches westward and that developments should be pushed in that direction. The company will wisely continue the third cross-cut until it reaches the anticline, so as to intersect the Faribault belt and other large saddle veins cut in the second cross-cut, as well as others underlying, and test the north-dipping veins on the Cantley crumple. The McNaughton belt has now been worked for 900 feet in length and 265 feet in depth. The ore on the apex of the saddles does not appear to be as rich as lower down on the legs, as was also found to be the case on the Partington saddle vein at Dolliver mountain. Detailed plans and sections should

*Summary Report Geol. Surv. Can. 1902, p. 421.

be kept at this mine to record the values extracted as they would greatly assist in determining the pay-choots.

Nova Scotia and Mexican mine. Veins developed by vertical shaft and cross-cuts.

Nova Scotia and Mexican mine.—Mr. Stuart's new vertical shaft, on area 743 at Goldenville, has reached a depth of 160 feet, and at this depth cross-cuts have been driven north 180 feet and south 198 feet, intersecting some thirty-five quartz veins of different sizes, several of which are reported to show gold. In the south cross-cut, 74 feet from the shaft, a slate belt 10 feet wide includes seven well mineralized quartz veins, three of which show free gold, and a mill test of the whole belt is said to have given a satisfactory result. This new development shows that the pay-choots cropping out at the surface and for the most part worked out, are underlaid by others of equal richness on adjacent veins, and that the south zone of special enrichment may be proved to have great depth, as well as surface extent where it has been proved for an aggregate length of 4,400 feet across the south dipping leads, from the Bluenose to the Palmerston workings. But it must be remembered that the pay-zone dips north and receedes from the vertical shaft, as greater depth is attained, necessiting longer cross-cuts northward.

MILLERS LAKE GOLD DISTRICT.

Millers lake district preliminary survey.

A preliminary survey was made of this newly discovered district but a full description of its structure must be deferred. The district is situated at the western extremity of Guysborough county and is reached from the Ecum Secum bridge on the Atlantic coast by a rough road four miles and a half in length. Mining areas have already been taken up for a length of some two miles east and west between Millers lake on the East brook of Ecum Secum river, and the foot of the Big Stillwater on Liscomb river.

Structure of anticline.

All the veins discovered so far follow the planes of stratification, on both dips of the Gegogan Harbour anticline, close to the axis. This anticline crosses Millers lake at its outlet, and was traced thence some two miles to a short distance below the foot of Big Stillwater. The fold pitches eastward. On the north side the strata dip north at an angle increasing rapidly to 45° and 58° and on the south side, still more abruptly south to 50° and 75°. The leads vary from a few inches up to twelve inches, while a few rolls of quartz, generally auriferous, reach eighteen inches in thickness and pitch east like the anticline. A great number of leads have already been uncovered and some which are auriferous were prospected along their course for short distances by open cuts or shallow pits, but no important mining developments have

yet been undertaken. Rich float has been found at different points along the anticline and further prospecting will undoubtedly uncover veins of workable value. As far as present developments have gone, the zone of special enrichment appears to run parallel and close to the anticline, but it is hoped that fuller information on this point can be given when the surveys are plotted. Rich float.

HARRIGAN COVE GOLD DISTRICT.

On the Boak property a vertical shaft, started on the apex of the south anticline at the south end of area 384, had, on November 24, attained a depth of 68 feet and cut nine new saddle veins, ranging from one to six feet, all in whin, no slate having yet been cut. The quartz on the apex is coarse and contains sulphides but does not appear to hold free gold. The company operating intend to sink to greater depth before cross-cutting to intersect the south legs of the saddles cut in the shaft, where they will be found smaller but undoubtedly much richer than on the apex. Harrigan cove district. Boak property shaft on anticline.

OLDHAM GOLD DISTRICT.

Last summer the water was pumped out of the old workings on the Sterling barrel lead, situated on the east turn of the anticlinal fold, and the opportunity was taken to visit the developments made some twenty-five years ago. Two slopes or inclines starting from the same deck-head have been sunk on the eastern dip of the belt. The most southerly of these is 250 feet deep and at the bottom it is 120 feet from the northerly slope which is 430 feet deep. At 112 feet from the surface in the latter a tunnel is driven east along the anticlinal fault to a vertical shaft situated 264 feet from the mouth of the slope. This shaft is about 120-feet deep and is reported to intersect several saddle veins, which could not, however, be observed at the time of my visit, as the shaft had not yet been cleaned up. This may be considered one of the earliest attempts made in Nova Scotia to develop new underlying saddle-veins on the anticline. A mill test of 35 tons, recently taken, gave 85 ounces of gold, which is very encouraging. Oldham district. Sterling property saddle-veins developed.

It is of interest to note, from information only recently obtained that the vertical shaft sunk, some twelve years ago, on the anticline, at area 103 of the Napier property, attained the depth of 214 feet and intersected seven new underlying saddle-veins which do not crop at the surface, two of which are reported by the operator to have shown quartz of a sufficiently high grade to justify further development. Judging from the surface developments already accomplished in the Napier property. New saddle-veins developed by vertical shaft.

district it would appear that the dome of the anticlinal fold, to the west of the Black brook, in the vicinity of the schoolhouse, is the most advantageous location for a deep test shaft.

MOUNT UNIACKE GOLD DISTRICT.

Uniacke ditrict, West lake property. Recurrence of rich quartz crumples proved.

An examination and a survey were made of the old underground works and of recent operations on the West Lake property. Sections were prepared and two are here reproduced, No. 849*. The general section shows four crumples of rich quartz operated on a subordinate fold, 650 feet south of the main anticline, which have evidently originated during the folding of the strata and are probably underlaid by others as rich and as large. The structure of the fold would lead to the conclusion that the several unproductive veins and slate belts uncovered at the surface to the north of the Borden lead may also form large deposits of quartz and become rich in gold on underlying crumples. On my recommendation the company is now sinking the main shaft on the Borden lead below the crumple to intersect the underlying crumples.

At the Hurrane Point and North Star mines the same conditions exist and the rich quartz crumples already worked at both mines are undoubtedly underlaid by a succession of others which are likewise very promising for deep and permanent mining.

Promise for deep mining.

This succession of crumples offers a great field for future operations on a large scale and may be developed most advantageously by an inclined shaft along the axis of the fold or by a vertical shaft sunk at a certain distance north of the outcrop of the fold and by a succession of cross cuts at different depths to intersect the crumples.

Gold production.

The production of gold from the West lake and Nugetty crumples is—

1142 ozs. 14 dwt. 2 grs. extracted from 1472 tons crushed.

That from the Borden crumple is—

2991 ozs. 10 dwts. from 2121 tons crushed.

Origin of gold.

The two sections illustrate beautifully the intimate relation between the deposition of the ore bodies and the structure of the strata, and give more evidence on the origin of gold. The rich ore-bodies are confined to the slate belts at the crumples, pitching eastward under 18°. The auriferous quartz crumples are connected along the axis plane of the fold by quartz stringers, generally barren of gold and well

*The scale of the general section should read 50 ft. instead of 25 ft. to one inch.

called "feeders" by local miners. From a close study of these "feeders" in this and other gold districts we are lead to the conclusion that they are the channels through which came the *upward moving waters* which concentrated the gold and associated minerals, finally deposited at the most favourable places in certain slate belts along the apex of the folds, constituting a well defined zone of special enrichment.

CYANIDE PROCESS FOR EXTRACTION OF GOLD.

Practical cyanide process for gold extraction in N. S.

Mr. H. S. Badger has lately introduced in Nova Scotia a cyanide process for the extraction of gold from the tailings of the quartz mills which were formerly lost. Old tailings accumulated for years and new tailings straight from the mill have apparently been treated successfuly and profitably by this process at the Caribou, Richardson, Leipsigate and the North Brookfield mines.

The introduction into Nova Scotia of a practical process of extracting gold from the sulphides contained in the tailings means much for the successful future of gold mining in the province, especially in the case of large low-grade ore deposits, such as the Richardson, Dolliver, Bluenose &c., where there is only a small margin for profit.

Cyanide plant of Mic-Mac mine.

Cyanide Plant at the Mic-Mac Mine, Leipsigate—At this mine a cyanide plant has been in operation since last February, with apparent success. It includes four treatment vats 16 x 5 feet for sand tailings and two settling tanks for slimes. The slimes are not treated at present, but the intention is to elaborate the plant so that their values may be extracted later. The strong solution (·25 per cent) is allowed to cover the sands about three inches, and after leaching, is strengthened gradually, until it comes out at the stopcocks the same strength as going in. The sands are then washed and the total period of leaching, from the time the strong solution flows into the tank until the clean water comes out in the launders, is about 30 hours. These tanks hold nearly 50 tons and one is filled and one emptied each day. At present "stock" is being taken from the old tailings bed as well as from the plate discharge.

The following notes and figures will, no doubt, prove interesting, as the apparent success of the work at this mine may be repeated at many other localities.*

H. S. Badger's notes on cyanide process at Mic-Mac mine.

'The facts were kindly furnished by Mr. H. S. Badger, who is in charge of the milling plant at the Mic-Mac mine.

'The gangue of the ore is a calcareous quartz, containing slate and 'gouge.'

* Report Dept. of Mines, Nova Scotia, 1903, page 60.

'By assay, the ore gives per ton $10.58 worth of gold and the concentrates are sulphides of iron, copper, lead and zinc.

'By amalgamation it is found that the best recovery that can be got on the average was about $7.08 per ton.

Cyanide plant installed.

'It was therefore decided, after experiment, to put in a cyanide plant. This was completed in February, 1903, at a cost of $5,000. The plant has a capacity of about 50 tons per 24 hours, and operations were commenced on February 22.

'The idea is to eventually treat the tailings from the mill plates alone; but in the meantime the old beds are also being treated. Difficulties are met here as the 'sharps' and 'slimes' often lie in separate layers, and mixed in places with organic matter, &c., which retards lixiviation.

'Altogether 5,104 tons of stock valued at $3.78 per ton, or a total value of $18,295 were treated, and an extraction made of 74·9 per cent., equalling as shown by the mint returns $2.83 per ton.

'The total cost of producing this is $1.05 per ton, divided as follows:—

Labour for charging tanks	$ 0 26
" discharging tanks	0 09
Technical staff, including management	0 34
Cost of chemicals, per ton	0 33
Time for precipitation	0 03
Total cost per ton	$ 1 05

'It must be borne in mind, as stated above, that about half the stock treated was from the old beds, thus considerably raising the cost of treatment as well as lowering the percentage of extraction. Again, the mill tailings contain about 50 per cent of slime, worth about $2.25 per ton, or say $1.15 per ton of ore. At present the recovery from these is very limited, but as soon as possible, arrangements will be made to separate these properly and treat them to advantage.

Average value of bullion produced.

'The average value of the bullion produced by the cyanide process at this mine is $16.26 per ounce, composed of:—

Gold	792·90	parts.
Silver	126.00	"
Base metals: Zinc, Lead, Copper	81.10	"
	1000.00	

Geological Survey of Canada

ALFRED E. BELL D.S.O. (Canada) LLD MD F.R.S. ACTING DIRECTOR

1904

GENERAL SECTION

This section shows the structure of a subordinate fold occurring 650 ft. south of the main anticlinal fold, and demonstrates that the four crumples of rich quartz operated were formed by the folding of the strata and that they are most probably succeeded by others as rich and as large

TRANSVERSE SECTION

WEST LAKE MINE

MOUNT UNIACKE GOLD DISTRICT,

HANTS COUNTY, NOVA SCOTIA.

by

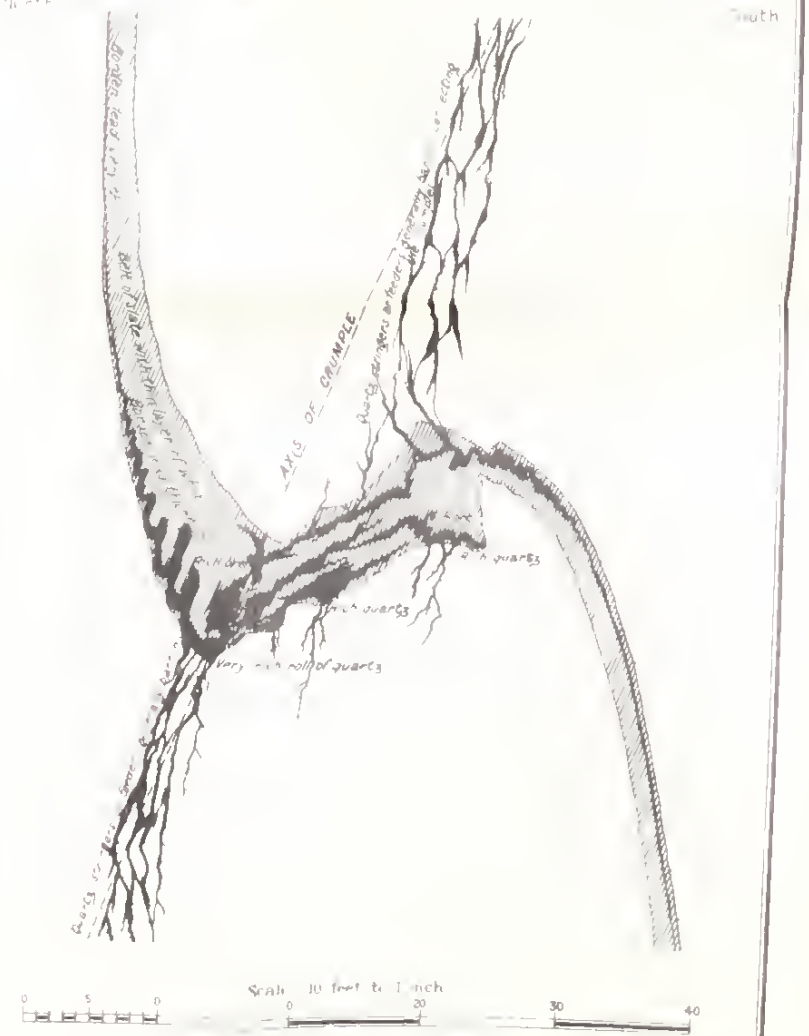
E.R. Faribault B.A.Sc.

Index

Slate

Quartz

DETAIL SECTION



Drawn for photolithographic by E. Haycock Jr.

To accompany Part A.A. Vol XI

No. 849

Bog Iron Ore.—Several deposits of bog iron ore have been observed to occur in low sampy places generally overlying belts of the Upper slate division of the gold-bearing rocks, from which they originated by the decomposition of the iron sulphides contained therein. Eleven specimens of bog iron ore received from Mr. F. J. Tremaine of Halifax, have been analysed by Dr. G. Christian Hoffmann, as follows :—Nos. 1, 2, 3 and 4, Guysborough Road, Knodell's Farm ; No. 5, Ship Harbour Road, east of Musquodoboit ; No. 6, three miles east of Black Brook, Musquodoboit ; No. 7, Hill Top, Musquodoboit ; No. 8, 'Bog,' Musquodoboit ; No. 9, Black Brook, Musquodoboit ; No. 10, Reddan's Farm, Newcomb Corner, Musquodoboit ; No. 11, Fall River, north of Waverly, Halifax Co. Equal weights of material were broken off each specimen, finely powdered, and most thoroughly mixed, thereby ensuring a fair average sample of the whole eleven specimens. An analysis of this gave :— Bog iron ore prospected in Halifax county.

Ferric oxide	64·04
Ferrous oxide	9·27
Manganous oxide	2·14
Alumina	0·68
Lime	1·55
Magnesia	0·68
Phosphoric anhydride	0·04
Sulphuric anhydride	0·30
Silica	5·65
Water, hygroscopic	3·37
Water, combined	10·53
Organic matter	3·22
	101·47
Metallic iron	52·04
Phosphorus	0·17
Sulphur	0·12

Analysis by Dr. Hoffmann.

The foregoing analysis shows it to be an excellent ore of its kind. Certain bog iron ores from the province of Quebec have been found to contain the following percentages of metallic iron :—Ore from Petite Côte, Vaudreuil, 52·15 ; ore from Côte St. Charles, Vaudreuil, 53·86 ; ore from St. Maurice Forges, 54·32, 52·01, 45·36 and 54·36 respectively ; ore from Upper Rocky Point, Eardley, 54·46. Area surveyed by assistants in Lunenburg and Hants.

In Hants and Lunenburg counties my assistants, Messrs. A. Cameron, J. McG. Cruickshank and M. H. McLeod, were engaged the whole summer surveying the head waters of the Indian, Ingram, Middle and Gold Rivers, flowing south into the Atlantic, and those of Granite.

the St. Croix and Avon rivers, running northward into the Bay of Fundy. The area surveyed covers 360 square miles and completes sheets 72, 86 and 87 which had been left unsurveyed between Mr. Fletcher's work to the north and my own to the south. This completes Halifax and Hants counties, while Lunenburg is also all surveyed with the exception of a small area at the west corner of the county. The country is underlaid with granite and is for the most part very rough with huge blocks and debris of this rock strewn all over the surface, making travelling very difficult. In Nova Scotia granite is not generally considered a favourable rock for the occurrence of minerals of economic importance, nevertheless several minerals have been observed in the vicinity of New Ross.

New Ross manganese mine.

Float of manganese ore has been discovered at several places to the north-east of New Ross which point to important deposits. One mile west of Wallaback lake a vein of this mineral was discovered a few years ago running in a northerly direction. It has been mined to the depth of 112 feet and some 50 feet in length. At the outcrop the vein is wholly composed of limonite, which passes at the depth of six feet into an association of specular iron ore and manganite and, a few feet deeper, into a mixture of pyrolusite and manganite. A similar vein has been slightly prospected about two miles further to the north-east.

Other minerals.

Molybdenite, zinc-blende, smoky and black quartz, fluor-spar, calcite, mica, tourmaline, garnet, scapolite, pyrite and chalcopyrite have also been observed in veins in the granite. Magnetite and argentiferous galena were found in the drift, and deposits of clay suitable for the manufacture of building brick occur at several places.

Patch of gold-bearing rocks in granite.

A patch of the Cambrian gold-bearing slate and whin from one to two miles in width and 15 miles in length occurs in the granite to the north of the road leading from Vaughan to New Ross and crosses about the middle of Wallaback lake where several quartz veins were observed, one of which is said to have shown gold. A dyke of fragmentary white quartzose rock, cemented with red jasper, susceptible of taking a good polish, occurs half a mile east of New Ross where it runs north-easterly and has been quarried to a small extent.

Timber and soil.

This granite region is generally well timbered with spruce, hemlock and some pine on the head waters of the Indian, Ingram, St. Croix and Avon rivers, where lumbering is prosecuted. Alluvial soil suitable for farming is not found over any large areas, except on hills of boulder clay and along narrow intervales, but a great number of large hay-marshes are found on several streams.

CHEMISTRY AND MINERALOGY.

Dr. G. C. Hoffmann.

Reporting on the work done in these branches of the survey's operations, Dr. Hoffmann says :— Work of chemical laboratory.

'The work carried out in the chemical laboratory during the past year has, conformably with the practice of preceeding years, been almost exclusively confined to the examination and analysis of such minerals, &c., &c., as were likely to prove of more or less economic value and importance. Briefly summarized it embraced :

'Analyses of several varieties of fossil fuel from various parts of the Dominion, that is to say—Of lignite, from near Halbrite, as likewise from La Roche Percée, Souris river, in the district of Assiniboia ; from Knee Hill creek, a tributary of Red Deer river, in the district of Alberta, in the North-west Territory ; and from near Enderby, Yale district, in the province of British Columbia. Of coal, from the Springhill district, Cumberland county, and from near McLellan's brook, Pictou county, in the province of Nova Scotia ; from the vicinity of Morley, and from the north fork of the Old Man river, section 35, township 10, range 3, west of the 5th initial meridian, in the district of Alberta, North-west Territory ; and of an anthracitic coal from the north-west quarter of section 29, township 24, range 10, west of the 5th initial meridian, also in the district of Alberta, North-west Territory. Analyses of fossil fuels.

'2. Analyses of the following iron-ores, namely—Of magnetite, from near Pincher creek, eastern slope of the Rocky Mountains, district of Alberta, North-west Territory ; and from near Enderby, Yale district, in the province of British Columbia. Of hematite, from the Rocky Mountains, south of Blairmore, district of Alberta, in the North-west Territory : and of clay iron-stone from Collins Gulch, Tulameen river, Yale district, in the province of British Columbia. Of iron-ores.

'3. Analyses, partial, of samples of copper-ore from—Westport, Digby county, in the province of Nova Scotia : York county, and from La Tête, Charlotte county, in the province of New Brunswick ; from the township of Orford, Sherbrooke county, in the province of Quebec ; and from mining location No. 2961, R. 455, north-east of Schreiber, district of Thunder Bay, in the province of Ontario. Of copper-ore.

'4. Analyses, in regard to nickel content, of many samples of pyrrhotite, among which was one from the west-half of the tenth lot

of the fourth concession of the township of Olden, Frontenac county, in the province of Ontario, which was found to contain 1·92 per cent of nickel.

Assays for gold and silver.

'5. Assays, for gold and silver, of samples of material from Mira Hill, near Jas. MacMillan's lake, south side of East Bay, Cape Breton county, in the province of Nova Scotia; and from Warren's Landing, Mossy Point, northern extremity of Lake Winnipeg, in the district of Saskatchewan, North-west Territory; as likewise from many other localities.

'6. Analyses of building stones, that is to say, of a limestone from the immediate vicinity of Phillipsburg, on the east side of Missisquoi lake, township of St. Armand, Missisquoi county, province of Quebec; and of a limestone from Carswell's quarry, Bryson, lot thirteen of the first range of the township of Litchfield, Pontiac county, also in the province of Quebec.

'7. Analyses, partial, of several graphitic schists from, among other places, the farms of Donald McInnis and McSween, Big brook, near West Bay road station, Inverness county; and from near Baddeck, Victoria county, in the province of Nova Scotia.

Analyses of natural waters.

'8. Analyses of natural waters (with the object of ascertaining their suitability for economic or technical purposes, or possible value from a medicinal point of view) from, among other localities:—A spring at Brook village, about seven miles east-south-east of the town of Mabou, Inverness county; and from a well near the post office at Granville Centre, Annapolis county, in the province of Nova Scotia; the How Spring, on the fifteenth lot of the third concession of the township of Fitzroy, Carleton county, in the province of Ontario; as likewise from a boaring in Courtright, on the eighth lot of Front street, or Front concession as it is sometimes called, in the township of Moore, Lambton county, also in the province of Ontario; and from a hot spring near the city of Vancouver, district of New Westminster, in the province of British Columbia.

Miscellaneous examinations.

'9. Miscellaneous examinations, embracing the examination, accompanied, in many instances, by a partial analysis, of such material as—Bog manganese (from Prince Edward Island), bog iron ore (from the province of Quebec), coals (from about four miles south of the town of Windsor, Hants county, and from Debert river, Colchester county, in the province of Nova Scotia; and from two miles north-west of Flowers Cove, Grand lake, Queens county, in the province of New Brunswick), limestone (from near Windsor, Hants county, Nova Scotia),

shales (from Peterborough, county of Peterborough, and from the tenth lot of the fourth concession of the township of Cartier, district of Algoma, in the province of Ontario), etc., etc. Also the examination and testing of numerous samples of clay in regard to their suitability for the manufacture of bricks—ordinary building brick, or fire brick, for pottery or other ware, from, among other, the following localities :—Near Baddeck, Victoria county ; Irish Cove, Richmond county, and some localities in Hants county, in the province of Nova Scotia ; from Dutch Valley road, Sussex, Kings county, in the province of New Brunswick ; from near 'The Brook' village, in the township of Clarence, Russell county, province of Ontario ; and from the north bank of the Red Deer, south-east quarter of section 20, township 38, range 27, west of the 4th initial meridian, in the district of Alberta, North-west Territory.

'In addition to the foregoing work, five hundred and thirty-six mineral specimens have been examined and reported upon more or less exhaustively. Although this is numerically less than in the preceding year, the actual amount of work involved was very much greater. Very many of the specimens in question were brought by visitors ; the greater number, however, were received by mail or express from residents in more or less distant parts of the Dominion.

'The number of letters personally written—chiefly of the nature of reports, and embodying the results of examinations, analyses or assays, as the case might be, of mineral specimens—amounted to three hundred and six ; and of those received, to one hundred and fifty-eight. Correspondence.

'I have been most ably assisted by Mr. F. G. Wait in the general work of the laboratory. To this he has applied himself with considerable assiduity, and, as a result, accomplished much in the way of analyses, partial and complete, of minerals and natural waters, in addition to having carried out a great variety of miscellaneous examinations. Mr. R. A. A. Johnston also rendered valuable aid in the carrying out of analyses during the early part of the year.

'In the work connected with the mineralogical section of the museum I have, for the first eight months and a half of the year, that is to say, up to the 11th day of September, been assisted by Mr. R. L. Broadbent, during which time he was engaged in the labelling and cataloguing of newly received specimens and in the maintaining of the collection generally in an orderly condition.

Additions to museum.

'The additions to the mineralogical and lithological section of the museum during the past year embraced :—

A.

A sectional model of the gold district of Goldenville, Nova Scotia ; made by E. R. Fairbault, B. A., &c., of the Geological Survey.

Chalcopyrite, from the twenty-sixth lot of the first range of the township of Hatley, Stanstead county, Quebec.

Clay iron-stone, from the so-called twenty-feet seam of coal on Collins Gulch, Tulameen river, Yale district, B.C.

Coal, from the Debert river, Colchester county, N.S.

Coal, from the Bailey and C. W. Wetmore lot, two miles north-westerly of Flowers Cove, Grand lake, Queens county, N.B.

Coal, from near Morley, district of Alberta, N.W.T.

Coal, from the north half of section 9, township 31, range 22, west of the 4th initial meridian, district of Alberta, N.W.T.

Magnetite, from the eastern slope of the Rocky Mountains, near Pincher creek, district of Alberta, N.W.T.

Pyrrhotite, from the west-half of the tenth loth of the fourth concession of the township of Olden, Frontenac county, Ont.

B.

(Collected by members of the staff engaged in field-work in connection with the Survey).

Ami, Dr. H. M. :—

Sand, from the sand hills near Wellington, Prince Edward county, Ont.

Broadbent, R. L. :—

a. Magnesite, a series of specimens of, from various lots and ranges of the township of Grenville, Argenteuil county, Que.

b. Edenite, from the fifteenth lot of the ninth range of the township of Grenville, Argenteuil county, Que.

c. Antimony, native, from the Dufferin mine, on the eighteenth lot of the first concession of the township of Madoc, Hastings, county, Ont.

d. Limestone, from the thirteenth lot of the first range of the township of Litchfield, Pontiac county, Que.

e. Lime, prepared from the same.

Dowling, D. B., B.Ap.Sc. :—

Semi-anthracite, from a seam on the South Branch of Sheep creek, section 11, township 19, range 7, west of the 5th initial meridian, district of Alberta, N.W.T.

Fletcher, Hugh, B. A. :—

Core of sandstone conglomerate from a boring at Bear Brook, one mile and a half below the bridge over the East river at New Glasgow, Pictou county, N.S. Additions to museum.

McConnell, R. G., B.A. :—

Clay, under, from a seam of lignite on Rock creek, Klondike river, Yukon district, N.W.T.

McKinnon, Allan T. :—

a. Gypsum, several blocks of, from the Wentworth quarry, Hants county, N.S.

b. Manganite, several specimens of, from Bridgeville, East river, Pictou county, N.S.

c. Limestone, several specimens of, from same locality as the last mentioned.

d. Gypsum, several groups of crystals of, also from Bridgeville, East river, Pictou county, N.S.

C.

(Received as presentations).

Blue, John, Eustis, Que. :—

Vivianite, from the twenty-fifth lot of the second range of the township of Hatley, Stanstead county, Que.

Haycock, E. B., Ottawa, Ont. :—

Corundum, from the fourteenth lot of the ninth concession of the township of Methuen, Peterborough county, Ont.

Soues, F., Clinton, B.C. :—

Lignitified wood, from the Horsefly Gold Mining Company's property, Horsefly river, Cariboo district, B.C.

In addition to which, Mr. Willimott has received, for the purpose of making up collections, from :—

Mr. D. Farry, of Perth, Ont.—
Shell marl ..... 25 pounds.

Mr. A. McNeil, Halifax, N.S.—
Stibnite ..... 100 "

Mr. Allan T. McKinnon, (Survey)—
Specular iron ore ..... 700 "
Manganite ..... 700 "

'In the early party of August, Mr. C. W. Willimott was engaged in preparing a collection of minerals for the Dominion Exhibition, then about to be held in Toronto. This he very successfully accomplished by about the middle of the month. As a result of his efforts he Work by Mr. Willimott.

succeeded in bringing together a fine series of specimens illustrative of the mineral resources of the country. This, which weighed in the aggregate some thirty-eight thousand pounds, was forwarded by him to Toronto, and he himself followed shortly after to superintend the installation, which was accomplished in a very satisfactory manner. He remained in charge of the collection until the close of the Exhibition—September the 12th, when, having attended to the packing and reforwarding of the same to Ottawa, he returned to his customary duties at the Survey.

School collections of minerals.

'Previous to entering upon the foregoing work he was, and since his return from Toronto has been, engaged in making up collections of minerals and rocks for various Canadian educational institutions. The following is a list of those to which such collections have been sent :—

	Number of Specimens.
Public school, Newtown, Kings Co., N.B.	75
McKeough school, Chatham, Ont.	100
Public school, Rossland, B.C.	100
Literary Institute and School of Arts, St. Hyacinthe, Que.	100
High School, Barnston, Que.	100
Dundurn Castle Museum, Hamilton, Ont	100
High School, Tilsonburg, Ont	100
Creighton St. School, Ottawa, Ont.	100
High School, Uxbridge, Ont.	100
Richmond County Academy, St. Peters, Cape Breton Co., N.S.	100
High School, North Bay, Ont.	100
Ursuline Convent, The Pines, Chatham, Ont	75
High School, Vienna, Ont.	100
Stanford High School, Niagara Falls, Ont.	100
High School, Nelson, B. C.	100
Mutchmore Street School, Ottawa, Ont.	100
High School, Quebec City, Que.	100
Model School, Gananoque, Ont.	75
High School, Sydney Mines, Cape Breton County, N.S.	100
St. Louis Academy, Quebec City, Que	100
High School, Rat Portage, Ont.	100
Collegiate Institute, Sarnia, Ont.	100
Archibald Street School, Ottawa, Ont.	100
Public School, Searletown, P.E.I	75
Collegiate Institute, Cobourg, Ont.	100
St. Ninian's Street School, Antigonish, N.S.	75
College de Valleyfield, Salaberry de Valleyfield, Que	100
St. J. B. DeSalle Academy, Ottawa, Ont.	100
The Ladies College of the Congregation, Victoriaville, Que.	75
Couvent de la Congregation, Arthabaskaville, Que.	75
District No. 2, Parish of St. James, Charlotte County, N.B.	75
Public School, Fergus, Ont.	100
St. Malachie School, St. John, N.B.	100
Fern Avenue School, Toronto, Ont.	100
North Sydney Academy, N. Sydney, C.B., N.S.	100
Public School, Smiths Falls, Ont.	100
Westside School, New Westminster, B.C.	100
Gault Institute, Valleyfield, Que.	100
High School, Montague, P.E.I.	100
Lawrencetown School, Lawrencetown, N.S.	100
Dufferin School, St. John, N.B.	100
The Institute, West Bromwich.	75
Acadiaville School, West Arichat, C.B., N.S.	75
Total number of specimens	4050

Work of the Mines Section.

Mr. E. D. Ingall.

On the work of the Mines Section, Mr. Ingall reports as follows :— Scope of work.

'The work of the Mines Section has been continued along the lines followed in past years and the staff has been occupied with the usual collection of data, statistical and technical, relating to the mineral industries and resources of the country and with the work of preparing and putting through press the annual report on these subjects. As usual, a statement giving a close approximation to the mineral production for the previous year was prepared in advance of the detailed general report and issued on the 27th of February. The full report for 1902 was completed and published early in December and contained besides the usual statistical data and explanatory material, special articles on coal, infusorial earth, salt, zinc, etc., similar to those embodied in former reports.

Taking Canada as a whole, the mining industry has been fairly active during the year just closed. Compared with 1902, in some departments there has been an increase in quantities produced, but a decrease in the prices obtained, while in others the opposite conditions have prevailed. After balancing these results against one another and taking into consideration improved, stationary and retrograde conditions in other branches, the nett showing appears to be a slight falling off in the total value. As a class, the totals of the metallic products decreased both in quantity and value, although copper and nickel were notable exceptions in both respects. The total of the non-metallic mineral products showed an increase, but not quite sufficient to offset the decline in the metallic class, so that in the grand total there appears to have been a decrease of about one per cent in the value of the output, which amounted to about sixty three and a quarter million dollars. Mineral production.

The relative values of those individual products, each of which amounted to upwards of a million dollars, was in the following order : (1) gold, (2) coal and coke, (3) copper, (4) building material, (5) nickel, (6) silver, (7) cement. Gold and coal constituted far the largest items, amounting to about 30 and 26 per cent respectively of the total. The diminution in the production of placer gold in the Yukon territory amounted to about $2\frac{1}{4}$ millions of dollars on account of the progressive exhaustion of the richest deposits, but without a corresponding reduction in the industry itself. Relative values.

In connection with the discussions which have taken place at the sessions of the Canadian Mining Institute as to the correct way of Methods adopted.

illustrating the value of Canada's mineral products, it may be as well to mention the standpoint adopted by the Mines Section in its treatment of the subject. It was agreed that it is chiefly essential to correctly ascertain the quantities produced, eliminating all possible errors, and checking where possible by railway shipments, etc. As, however, quantities of such various substances cannot be added together it is manifestly necessary for the purpose of making up the grand total to adopt some basis of valuation which shall be comparable from year to year, so as to rightly illustrate growth. For the metallic ores, whose only uses are as sources of the metals and which are of such varying constitution, the final value of the amounts of the metals contained in the ores is manifestly the only common denominator or standard to which they can be brought. This is the method adopted by the United States Government and by that standard publication The Mineral Industry, issued annually by the Engineering and Mining Journal of New York.

Other methods.

Whilst other reliable authorities may properly adopt other methods equally correct and legitimate, with a view to illustrate the mineral industries from other standpoints, it is believed that the above method best meets the needs of this report. It must be borne in mind also, that this implies only to the general tabulation of the country's total mineral production of all sorts, and that in the Section's full annual report, the details relating to the different industries are given in the body of the publication.

For the non-metallic minerals it is manifest that only spot values can be adopted. They are practically all used as such and their value is a very variable quantity, often as far as the consumer is concerned, made up mostly of cost of carriage to the point of consumption. Thus the same material would have widely varying values at different points. The only other basis would be to value the material at its point of departure from the producer. This is found still to be only a rough approximation to uniformity, and each separate substance has to be considered by itself. Where there is some point of shipment or distribution common to a district, a more definite and uniform method can be arrived at, as with the phosphate of Quebec which was all handled at Montreal and the price was always quoted f.o.b. at that port.

It must also be borne in mind that no presentment of data, statistical or otherwise, will meet the varying needs of the people likely to be interested in the subject. The consumer is interested chiefly in the price he has to pay for the article; the producer in the value he can realize on his products. The main thing is to have the fundamental

data correct and to adopt a standard so definite and clear that any one can make the allowances necessary for the illustration of the industry from his particular standpoint.

Bruce Mines District.

Mr. E. D. Ingall.

In regard to the work under his charge in the Bruce Mines District, Ontario, Mr. Ingall reports as follows:—

Nature of work.

It had been arranged to proceed with the field-work begun in the summer of 1902 in the Bruce Mines region, and with that intention Mr. Denis left Ottawa on the 4th of July. Owing to pressure of work in the office, however, only three weeks could be spent in that field, during a part of which the weather was very unfavourable. In that time a beginning was made in the delimiting of the several greenstone belts which traverse the district. Two of these were traced out. One starting just west of the Stobie or Cameron copper mine at Portlock, was mapped from a micrometer traverse through a distance of some three and a half miles. It runs just south of Desbarats lake, has a direction of N. 50° to 60° W., which coincides with the general strike of the rocks. This development of greenstone has the appearance of an intrusive sheet of diabase between beds of quartzite.

The second greenstone area examined runs along the south side of the Canadian Pacific Railway from the Portlock road eastward. The direction of the ridge, which is nearly east and west was followed for one mile. This intrusion has the character of a boss more than of a sheet. The hand specimens of the rocks of both of the belts examined, seem to show the same constituents and to a great extent the same rock-structure.

Little mining being carried on.

There was very little mining activity in the district during the summer season. The Bruce mines had not resumed work, and the Rock Lake mine had greatly reduced its operations. The line of the Bruce Mines and Algoma Railway has been completed from Bruce Mines village to the Rock Lake concentrator. The Richardson and the Cameron mines were both idle.

During the latter part of the year, however, there have been reports of resumption of activity. Some iron ore locations north of Gordon lake have been tested by diamond drill holes, and the Bruce mines are said to have been purchased by the International Nickel Company, which will perhaps shortly reopen and work them. On his return

trip to Ottawa, Mr. Denis spent a few days in the salt region of western Ontario for the purpose of bringing the data of the Mines Sections up to date in regard to the production of salt. His observations are published in the Mines Section report for 1902, part S., Vol. XV.

Mapping and Engraving.

Mr. C. O. Senécal, Geographer and Chief Draughtsman.

Report of Grographer and Chief Draughtsman

I have the honour to submit the following statement of the work accomplished under my supervision during the past calendar year:—

Assignment of work.

Mr. L. N. Richard has drawn and lettered for engraving, and prepared the colour copies of the following maps, viz.:—the Perth sheet (No. 119, Ont.), the Sudbury map, the West Kootenay sheet and the map of Hudson Bay and James Bay (duplicate set of three sheets). He also attended to sundry work passing through the office. Mr. Richard is at present engaged in the preparation of the colour copies of the Haliburton sheet (No. 118, Ont.) and of the Pembroke sheet (No. 122, Ont.), for engraving.

Mr. O. E. Prud'homme traced and lettered the Apple River sheet (No. 100 and 101) and partly sheets Nos. 64, 75, 76, 82 and 83 of the Nova Scotia series of map-sheets; also the plans of Isaacs Harbour, Gold River, and Cochran Hill gold districts of Nova Scotia. He has drawn for photo-lithographing a sheet of sections of the Souris coal-field, the map of ancient shore-lines of Ontario, and a small map for the Summary Report. He also prepared the colour copy of the Bancroft map, attended to miscellaneous work and to the distribution of maps held for sale. Mr. Prud'homme was granted leave of absence from September 1 to November 1.

Mr. P. Frèreault compiled new surveys on the Nottaway River map and prepared the colour copy for the same. He traced and lettered for engraving and made the colour copy of a two-sheet map of the vicinity of Copper Cliff, Sudbury Mining District, Ont.; he traced the map of the Boundary Creek Mining district, B.C., the map of Blairmore-Frank coal-field, Alberta, and map-sheet No. 63, Nova Scotia. He has also lettered sheets Nos. 64, 75, 76, 82 and 83 N.S., for engraving and has drawn for reproduction by photo-lithography, the map of Northern Ontario and Eastern Keewatin and a small map, showing the recent land-slide near Buckingham, Que.

Mr. V. Perrin at intervals, attended to the cataloguing of maps and plans, prepared lists of instruments requiring repairs and attended to general work. He traced the map of Pictou coal-field, N.S.,

for photo-lithographic reproduction and made sundry tracings of plans for office use. He is, at present, assisting Mr. Wm. McInnes in the compilation of the Ignace sheet (No. 5, Western Ontario), and in the preparation of a map of Winisk river, Keewatin, for the Summary Report.

Mr. J. A. Robert spent most of his time on the compilation of the series of one mile-to-the-inch sheets, covering part of Hants county, N.S. He revised the compilation of the map of Pictou coal-field, prepared the colour copies of several Nova Scotia sheets and traced the map of Springhill coal-field, N.S., for the lithographer. He has now in hand, the compilation of Mr. H. Fletcher's more recent surveys on the above-mentioned series of sheets, extending into Kings county.

Mr. O. O'Sullivan again accompanied Mr. W. J. Wilson in the field last summer. He spent some time in the preparation of his returns, plotting, etc., and continued the mapping of Mr. E. R. Faribault's surveys on the map-sheets covering Halifax county, Nova Scotia.

Mr. W. J. Wilson compiled a map of northern Ontario and Eastern Keewatin, showing his surveys of 1902, as well as those of Mr. D. B. Dowling of 1901, to accompany the report of last year. He left for the field on May 26 and returned on September 30. He is now preparing a map of last season's surveys for the present Summary Report. Having received a valuable set of plans of surveys which were required for the mapping of the Michipicoten mining region, Mr. Wilson will be able to resume the compilation of Dr. R. Bell's and his own surveys on sheet No. 143, Ontario, and carry it to completion without delay.

Mr. J. Keele completed his map of the MacMillan river exploration and resumed work on the Eastern Ontario map-sheets, laying down on the Ottawa and Cornwall sheet (No. 120) the surveys of Dr. R. W. Ells and of the late Mr. N. J. Giroux. Mr. Keele has been on leave of absence from June 6 to November 1. Since his return he compiled a map of the Lake Temagami iron ore belts for Dr. A. E. Barlow.

Mr. W. H. Boyd completed the map of the Boundary Creek mining district, B.C., and left for the Lardeau mining camps, B.C. as topographer to Prof. R. W. Brock, on June 18. Since his return, October 5, he spent his time in plotting his field notes, &c.

Mr. J. F. E. Johnston returned from sick-leave at the end of November and resumed the plotting of his surveys of 1902.

Routine work.

The routine work has, as usual, been distributed among the staff and attended to, but, as I mentioned in my last year's report, the assistance of an employée to have the care of the manuscript maps and other documents, surveying instruments, &c., to do typewriting and general work, is urgently needed. The draughtsmen have to spend much time on work which could be more profitably done by a general office assistant. The stock of many maps is being rapidly exhausted, particularly of those which cover the regions of northern and northwestern Ontario, and in the near future, new editions, brought up to date, will be required. Such editions, which often entail as much labour as new maps, would lead to the delay of other necessary work, unless provision is made with this in view. One or two more good draughtsmen are therefore required in this office to attend to map-compiling the year round, especially as Messrs. Wilson, Keele and O'Sullivan who will hereafter have charge of field parties, can devote only a small part of their time to mapping.

Geographic Board.

The meetings of the government Geographic Board have been regularly attended and, as usual, lists of place-names covering our maps now in progress have been submitted.

Accompanying maps.

The following ten maps, plans and sections, illustrating part of the progress made in the field during the past season, accompany the present Summary Report and Part AA, Annual Report, Volume XV. :—

No. 842.—Map of part of the country between Peace and Athabaska rivers. Scale, 32 miles to 1 inch.

No. 845.—Sketch-map of the Cretaceous coal-bearing rocks at the headwaters of Sheep creek and Elbow river, Alberta. Scale, 2 miles to 1 inch.

*No. 846.—Exploration of the Winisk river and canoe-route from Fort Hope to Weibikwei or Winisk lake, Southern Keewatin. Scale, 16 miles to 1 inch.

*No. 847.—Explorations of the canoe-route from Montizambert station on the Canadian Pacific railway to English River Post on Kenogami river, and of the Little Current, Kebinakagami and Drowning rivers, Northern Ontario. Scale, 16 miles to 1 inch.

No. 848.—Plan of the recent land-slide on the Lièvre river, near Buckingham, Que. Scale, 12 chains to 1 inch.

No. 849.—Transverse section of West Lake mine, Mount Uniacke gold district, Hants county, N.S.

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*Maps Nos. 846 and 847 accompany Part AA, Vol. XV only.

No. 850.—Transverse section, Dolliver mine, Isaacs Harbour gold district, Guysborough county, N.S.

No. 852.—Map of the Northeast Arm and Vermilion iron ranges, Lake Temagami, Ont. Scale, 40 chains to 1 inch.

No. 853.—Index map, showing new exploration in the vicinity of Lardeau, B.C. Scale, 8 miles to 1 inch.

No. 862.—Map showing the older copper-bearing rocks of Southern Quebec. Scale, 10 miles to 1 inch.

Maps in progress.

There are, at present, twenty-three maps in the King's Printer's hands at various stages, including the geological West Kootenay sheet, the Apple River sheet, N.S., the Sudbury and Bancroft maps, Ont., and the Perth sheet, Ontario, of which the colour proofs have been revised and the edition is expected to be printed soon. In this number, are also included sheets Nos. 53, 59, 60, 61 and 62 of the Nova Scotia series and the map of the Klondike district which have been engraved, but the colour work is held over until the geological investigation in the fields covered by these sheets shall have been completed.

There are about thirty other maps under compilation in the office.

Field instruments.

The testing and repairing of field-instruments has been attended to, and the following new instruments have been purchased, viz.:—

One Hadley sextant, No. 8, from Cary, London, Eng.

One Folding Artificial Horizon, No. 13, from Cary, London.

Six Prismatic compasses and tripods, Nos. 71 to 76, from Cary, London.

One Zeiss monocular field-glass, No. 22, from Baush and Lomb, Rochester, N.Y.

Four surveying aneroid barometers Nos. 69 to 72, from Harrison & Co., Montreal.

One 66-feet steel tape, No. 15, from Keuffel & Esser, New York.

Two clinometer-compasses, Nos. 7 and 8, from Keuffel & Esser, New York.

One clinometer, No. 33, from Alex. Ross, Ponsonby, Que.

Two 66-feet Chesterman metallic tapes, Nos. 9 and 12, from Department of Stationery, Ottawa.

One Pocket Folding Kodak, No. 24, from W. J. Topley, Ottawa.

Two Premo cameras, Nos. 25 and 26, from W. J. Topley, Ottawa.

One Stück magnetometer, No. 1, from McGill University, Montreal.

Correspondence.

The number of letters, memoranda, specification sheets, etc., relating to map-work, was 240 sent, and 125 received.

Maps published.

An enumeration of the maps, plans, diagrams, &c., which were received from the printer during the calendar year, is appended herewith :—

Catalogue Number.	Description.	Area in Square Miles.
810	The Dominion of Canada, showing the progress of investigation by the Geological Survey of Canada, 1843-1903. Scale, 250 miles to 1 inch.	
805	Yukon—Explorations on MacMillan, Pelly and Stewart rivers. Scale, 8 miles to 1 inch.	
791	British Columbia—West Kootenay sheet (economical minerals and glacial striæ.) Scale, 4 miles to 1 inch	6,400
808	Alberta—The Blairmore-Frank coal-fields. Scale, 180 chains to an inch.	576
823	Assiniboia—Sections of Souris coal-field.	
804	Manitaba—Orographic map of the lower contour of Turtle mountain. Scale, 1½ miles to an inch.	
720	Western Ontario—Geological sheet No. 4 (Manitou Lake sheet.) Scale, 4 miles to an inch.	3,456
814	Ontario and Keewatin—Explorations south-west of James Bay. Scale, 16 miles to 1 inch.	
775	Ontario—The Sudbury mining region (Victoria Mines map.) Scale, 1 mile to 1 inch	230
809	Ontario—Shore-lines of ancient great lakes. Scale, 24 miles to 1 inch	
750	Quebec and Ontario—Geological sheet No. 121 (Grenville sheet.) Scale, 4 miles to 1 inch.	4,051
702	Quebec—Geological map of the Basin of Nottaway river. Scale, 10 miles to 1 inch.	
802	Quebec—Gaspé oil-fields. Scale, 2 miles to 1 inch.	
779, 780 & 781	Ungava and Quebec—Geological map of the east coasts of Hudson Bay and James Bay, sheets I., II. and III. Scale, 8 miles to 1 inch.	
801	Prince Edward Island—Geological outline map of P. E. Island and portions of adjacent provinces, showing anticlines. Scale, 16 miles to 1 inch.	
609	Nova Scotia—Geological sheet No. 46 (Pictou sheet.) Scale, 1 mile to 1 inch.	216
610	,, Geological sheet No. 47 (Westville sheet). Scale, 1 mile to 1 inch.	216
633	,, Geological sheet No. 47 (Eastville sheet). Scale, 1 mile to 1 inch.	216
635	,, Geological sheet No. 56 (Shubenacadie sheet). Scale, 1 mile to 1 inch.	216
636	,, Geological sheet No. 57 (Truro sheet). Scale, 1 mile to 1 inch.	216
637	,, Geological sheet No. 58 (Earltown sheet). Scale, 1 mile to 1 inch.	216
812	,, Preliminary geological map of Springhill coal fields. Scale, 50 chains to 1 inch.	113
806	,, Sections of Bluenose gold mine.	
773	,, Plan and section of Tangier gold district. Scale, 250 feet to 1 inch.	
	Also 8 diagrams showing the mineral production of Canada, 1902.	

Palæontology and Zoology.

Dr. J. F. Whiteaves.

Dr. Whiteaves reports that for rather more than three months (102 days, exclusive of Sundays) he has performed the duties of Acting Deputy Head and Director, during Dr. Bell's two visits to Europe and subsequent short absence from Ottawa.

In addition to this, a preliminary report of a sub-committee of the "Committee on the Nomenclature of Geological formations in Canada," appointed especially to "consider the names of the various divisions of the whole sedimentary series in Canada, from the Archæan up to the Pleistocene," has been prepared and read before the fourth section of the Royal Society of Canada at one of its meetings in May last.

Collections of fossils studied.

A study of the rather large collections of fossils from the Silurian rocks of the Equan river and Sutton lake, Keewatin, made by Mr. D. B. Dowling in 1901, has been completed, and the manuscript of a detailed and descriptive list of the species represented in it has been furnished to Mr. Dowling for publication as an Appendix to his forthcoming report on the Geology of that part of Keewatin. Some sixty-one species of marine invertebrata are represented in these collections, and of these, forty two are identified or described, both specifically and generically, and nineteen only generically. A commencement has been made of a study of some collections of fossils from the Silurian rocks of the Winisk river, Keewatin, made by Mr. McInnes during the past summer.

Palæontological papers written.

Ten small consignments of fossils from the Corniferous limestone of Ontario have been received from the Rev. Thos. Nattress, of Amherstburg. These fossils have been determined as far as practicable and returned. A few pieces of rock from near Fernie, holding some rather obscure fossils, have been examined and the approximate horizon of this rock has been ascertained for the sender. The fossils are fragments of the guard of a belemnite, and the rock containing them is evidently either Jurassic or Cretaceous.

Six short papers, descriptive or illustrative of fossils of special interest in the Museum of the Survey, have been written and published during the year. The first of these is descriptive of a new species of *Cyrena* (*C. Albertensis*) from the Belly River series at Fossil Coulée, Milk River Ridge, Alberta. The second is a note on three recently received "Crania of Extinct Bisons from the Klondike Creek gravels." All three appear to be referable to the great Alaskan bison, *Bison*

crassicornis, Richardson, teste Lucas, (=*B. Alaskensis*, Rhoads) which seems to have been the progenitor of both the Wood and Prairie bison. The third is a description, with figures, of a new *Matheria* (*M. brevis*) from the Trenton limestone at Ottawa. Only two other species of this genus are known. The fourth records the recognition of a well marked specimen of the exclusively Jurassic ammonitoid genus *Cardioceras* in the Crows Nest coal fields, while the fifth and sixth are devoted to the elucidation of the Canadian fossils from the Black River limestone that have hitherto been referred to *Lituites undatus*.

Zoological work i

At the request of Section IV of the Royal Society of Canada, a Bibliography of Canadian Zoology for the year 1902, exclusive of Entomology, was compiled and presented at one of its meetings in May last for publication in its Transactions.

A memorandum as to the number of species in the zoological collection of the Survey, and of photographs illustrative thereof, was prepared for Professor Macoun in February last. At that date, the collection consisted of at least one set, and in some cases of three or four sets, of the eggs of 266, since increased to 271 species or subspecies of Canadian birds, and of 82 photographs of the nests, etc., of some of them, amid their natural surroundings.

Apart from the extra correspondence necessitated by Dr. Bell's absence, the number of official letters received and answered has been about as usual.

Additions to museum collections by members of staff.

The following specimens have been received from members of the staff, or employées of the department, during the year 1903.

Ells, Dr. R. W. :—

About 200 fossils from the palæozoic rocks of Charlotte Co., N.B.

Chalmers, Dr. Robert :—

Three species of fresh water clams (*Unio complanatus*, *U. ventricosus* and *U. luteolus*) brought up by the Dominion government dredge from depths of 20 to 30 feet below the river level near the south shore of the St. Lawrence river at Sorel.

McInnes, W. :—

About 100 specimens of Silurian fossils from the Winisk River. 12 species of marine and fresh water shells from the Pleistocene deposits of the Winisk River, and about 50 specimens of fresh water shells from that river. Two arrow-heads and some chipped flints from Attawapishkat (or Lansdowne) lake.

Dowling, D. B. :—

28 Devonian and Carboniferous and Cretaceous fossils from the Cascade trough of the Rocky mountains.

Wilson, W. J. :—

28 specimens of Silurian fossils from the Kebinakami River, Northern Ontario.

Wilson, W. J., and O'Sullivan, O.:—

120 specimens of Silurian fossils from Little Current River, including a few that may be Cambro-Silurian ; and 37 Silurian fossils from Nagagami River, Northern Ontario.

O'Sullivan, O.:—

29 specimens of Silurian fossils from Drowning River, Northern Ontario.

Spreadborough, W.:—

Two sets of eggs of the American Magpie ; and one set each of the eggs of the Pigmy Nuthatch, Californian Crow and Dusky Horned Owl, from Penticton, B.C.; and of the American Three-toed Woodpecker from the Athabasca River.

125 skins of Birds and Mammals from Lake Okanagan, B.C., and 132 similar skins from the Peace River district.

The additions to the palæontological, zoological and archæological collections in the Museum during 1902, and from other sources, are as follows :— By presentation.

By presentation :—

(A.—Palæontology.)

Colonel C. C. Grant, Hamilton, Ont.:—

Numerous fine specimens of fossil polyzoa (bryosoa) from the Clinton and Niagara formations at Hamilton, and from the Niagara shales at Grimsby.

Dr. C. F. Newcombe, Victoria, B.C.:—

Fossil leaves from the Cretaceous rocks of the Queen Charlotte Islands ; and a recent marine sponge from 300 fathoms off the West coast of those islands.

Walter Harvey, Crofton, B.C.:—

Two specimens of *Pholadomya subelongata*, Meek, from the Cretaceous rocks at Nanaimo, B.C. ; and four land shells from Crofton, B.C.

Rev. Thos. Nattress, Amherstburg, Ont.:—

Three fine specimens of a species of *Polypora* and seven fragments of a monticuliporoid, from the Corniferous limestone at Pelée island, Ont.

J. E. Narraway, Ottawa :—

Specimen of *Strophomena Billingsii*, Winchell and Schuchert, from the Trenton limestone at Hull.

T. C. Weston, Minneapolis, Min.:—

One fine specimen each of *Metoptoma Melissa* and *M. Hyrie*, from the Levis formation at Levis.

Dr. Cephas Guillet, Ottawa :—

Three specimens of *Cylichna alba* from the pleistocene clays at Odell's brickyard, Ottawa East.

(B. Zoology.)

Hon. William C. Edwards, Rockland, Ont.

Section of trunk of a large oak tree with the femur of a ruminant embedded in its heart.

C. H. Young, Hurdman's Bridge :—

Mounted specimen of the Screech Owl (*Megascops asio*).

Dr. Roughsedge, Ottawa :—

Six gastroliths of crayfish from Billings Bridge.

H. Harley Selwyn, Ottawa :—

Nest and set of four eggs of the Chimney Swift (*Chætura pelagica*) from Kirks Ferry, P.Q.

Miss Kirby, Ottawa :—

Hoary bat (*Atalpha cinerea*) caught at Gilmour and Hughson's mill, Hull.

Dr. James Fletcher, Ottawa :—

Live specimen of a large land snail (*Epiphragmophora fidelis*, Gray) from Comox, V.I.

N. Harry Meeking, Port Hope, Ont.:—

Set of three eggs of the Western Red-tailed Hawk (*Buteo borealis calurus*) from near Calgary, Alberta.

P. J. Keeley, Ottawa :—

Albino variety of the White-throated Sparrow, shot near Rockcliffe.

C. O. Senécal, Ottawa :—

Specimen of the White Undereving (*Catocala relicta*).

Olof. C. Hylander, Caribou, Maine :—

Named collection of the Fresh-water shells of Maine.

By purchase :

Large and perfect burnt clay pot of Indian manufacture found by Mr. James Lusk in the township of Eardley, lot 20, range xi, Co. Wright, August, 1903.

Brewer's Duck, male, shot near Thurso. A hybrid between the Black Duck and Mallard.

Set of nine eggs of the American Merganser (*Merganser Americanus*).

Vertebrate Palæontology.

Mr. Lawrence M. Lambe.

Mr. Lawrence Lambe reports as follows :—

Work by Mr. Lambe.

In continuation of the work of reporting on the collections of vertebrate remains in the possession of this department, and in accordance with instructions received, my time, during a considerable portion of the past year, has been devoted to a study of the dinosaurian *Dryptosaurus incrassatus* (Cope), from the Edmonton series of the Cretaceous system of the North-west Territories. The result of this work is intended to take the form of an illustrated quarto monograph to constitute the third part of volume III of Contributions to Canadian Palæontology in succession to the second part, which appeared in September, 1902, descriptive of the vertebrate fauna of the Belly River series. The manuscript for this monograph is more than half completed and the drawings intended for its illustration, forming seven full sized plates, are now ready.

The importance of a more intimate knowledge of the fauna of the Edmonton series is apparent when it is borne in mind that the beds of this series in Alberta constitute the principal coal-bearing horizon of the district.

Importance of Edmonton series.

As the Edmonton series is regarded as the equivalent of the St. Mary River series of the country to the south, and of the Wapiti River group of the Peace River district to the north, too much stress cannot be laid on the value of a thorough acquaintance with these beds. From an economic standpoint, as a horizon marker over a vast stretch of country to the east of the Rocky mountains, it is of the greatest importance.

At the request of the director of this department, Professor E. D. Cope of Philadelphia, published in 1892, a preliminary description of

two excellently preserved skulls of *Dryptosaurus* collected by Mr. J. B. Tyrrell and Mr. T. C. Weston, in 1884 and 1889 respectively, in the Red Deer River district in Alberta. The memoir now in course of preparation is intended to take the place of a further description of these remains contemplated by Professor Cope but prevented by his death.

Resignation of Professor Henry Fairfield Osborn.

It is to be sincerely regretted that the recent resignation of Professor Henry Fairfield Osborn, curator of the department of Vertebrate Palæontology of the American Museum of National History, New York, as an honorary member of the staff of the geological survey has to be recorded. The value of the co-operation of so eminent a scientist in the palæontological work of this department cannot be overestimated and the loss sustained by his much regretted withdrawal from active participation in that work, as honorary vertebrate palæontologist, is manifest.

During the months of February, March and April, a general study of the *vertebrata*, both fossil and living, was undertaken by me in New York at the American Museum of Natural History and at Columbia University under Professor Osborn. Special post-graduate courses at the latter institution were taken advantage of and every facility was given me at the American Museum for the study of the magnificent collection of vertebrate remains in its possession. Before returning to Ottawa the following museums were visited, U. S. National Museum, Washington, the Museum of Yale University, New Haven, Conn., the Museum of Princeton University, Princeton, N.J., and the Carnegie Institute, Pittsburg, Penn., and a special and careful examination was made of the extensive collections of vertebrates in each of these institutions. Thanks are due to the scientific heads of these museums for facilities afforded in the study of material in their care.

Collections of fossils named.

Collections of fossils, chiefly corals, have been named during the year, for different officers of the department for use in the determination of geological horizons, and similar collections have been named for outside collectors who sought like information.

Attention is directed to the desirability of mounting in a permanent and attractive manner those specimens of the vertebrate collections that have been recently described and figured, and of providing space for their exhibition to the public. A permanent mount in the case of all heavy or fragile specimens is necessary in anticipation of any movement to which such specimens may be subjected, otherwise the risk of irreparable injury is great, even with the most careful handling.

Card catalogue.

A card catalogue of literature appertaining to vertebrate palæontology, with special reference to that of the Dominion, has been started and considerable progress made therewith.

Some time has been devoted to the study of vertebrates other than those of the Edmonton series, the results of which will be submitted for publication as occasion may permit.

The usual official correspondence in connection with the progress of the work on hand has been attended to as in the past.

During the year the following papers have been published :—

'On *Stegoceras* and *Stereocephalus*,' Science, new series, vol xviii., p. 60.

'The lower jaw of *Dryptosaurus incrassatus* (Cope),' Ottawa Naturalist, vol. xvii., p. 133, with plates I, II and III.

Botany and Ornithology.

Professor John Macoun.

After handing in my summary report last December, I continued working on Part II of my Catalogue of Canadian Birds and before spring this was completed, the proof read and by the beginning of May it was ready for the binder. While reading the proof of this part, the material for Part III, which completes the work, was being put in shape and it will go to the printer early in 1904.

As an example of the notices of this work showing how it is appreciated in the United States, I give below the review of Part II in 'The Auk,' which is the official organ of the American Ornithological Union. The reviewer is the editor of the journal.

'The first part of this important work appeared in 1900, and its general character and scope were so fully indicated in this journal (vol. xvii, Oct., 1900, pp. 394, 395), that it remains now only to chronicle the appearance and extent of Part II, which includes the Raptores, and the succeeding families of the A. O. U. Check List to and including the Icteridæ. As in Part I, we have a compendium of the previously published information regarding the range and breeding areas of the species known to occur in North America north of the United States, supplemented by a large amount of hitherto unpublished material gathered by the members of the Canadian Geological Survey, and contributions from a large number of trustworthy correspondents. The authority is given for each record, whether published or unpublished, thus explicitly designating the sources of the information here presented. In the case of published records, the place of publication is often, but not always, explicitly stated. The 'Catalogue' also includes a list of the specimens in the Government Museum at Ottawa, with full data as to their place and date of capture, &c.'

'It is announced that Part III, completing the work, is ready for the press, and that it will be published during the coming winter. It will include such information relating to species mentioned in Parts I and II as may have been received since their publication, as well as an index to the three parts, and a complete bibliography of the authorities consulted in the preparation of the work. The 'Catalogue' will thus be a work of great permanent value, and a most important contribution to our knowledge of the distribution of North American birds.—J.A.A.'

Early in May, Mr. J. M. Macoun, my assistant, was instructed to proceed to Peace river and make an extended exploration there. His absence threw all the office work upon me, and hence the only field-

work I did this year was in the vicinity of Ottawa. For years I have been collecting material for my various publications and, amongst others, I am preparing one on Canadian Fungi, which, when issued, will be Part VIII of my Catalogue of Canadian Plants. On this account my time was chiefly devoted to a study of the fungi in the vicinity of Ottawa. On account of our work having been always in the west, for the last 15 years, we have never had a complete series of the Ottawa plants in our herbarium; so this year I collected over 900 species and only about 300 others are necessary to complete our local collection.

For the last 15 years we have been gathering the material for a Catalogue of Canadian Mammals, and at present have over 1,000 skins of the smaller mammals from nearly every section of the country. Towards spring I purpose putting these in order and hope to publish a Catalogue of Canadian Mammals in the winter of 1904.

By an arrangement with you, Miss Stewart works half her time for me and the other half for the librarian, so that about 15 hours per week is the limit of her services for me. This, taken into consideration with the increasing work of the office, leaves very little time to either myself or my assistant for original work. Owing to our widening field of labour and the amount of material requiring distribution, it is absolutely necessary that I should have more clerical assistance if appreciable progress is to be made with our work. A great deal of the time of both my assistant and myself is taken up by work that could be done by an intelligent person whose services were entirely at our disposal.

My assistant Mr. James M. Macoun was occupied in field-work for more than five months. The remainder of the year was spent by him in the office, where his time was devoted to the study of material brought by him from British Columbia in 1901 and 1902. All the plants added to the herbarium were studied and named by him and the greater part of the botanical work of my branch is now under his charge.

About 3,000 specimens of plants for the herbarium were received from correspondents, the largest collection being a duplicate set of Engelmann's plants from the St. Louis Botanical Gardens. The number of flowering plants mounted and placed in the herbarium was 2,133 which brings the total up to 60,648. Only 1,427 sheets of specimens were sent out in exchange, as Miss Stewart had not the time to label more.

Eight hundred and ten official letters were written during the year and about the same number received.

The Library.

Dr. John Thorburn, Librarian.

During the past year, from January 2 to December 31, 1903, there have been distributed 15,693 publications of the Geological Survey, comprising reports, parts of reports, special reports and maps. Of these 12,397 were distributed in Canada; the remainder, 3,296, in foreign countries, as exchanges, to Universities, Scientific and Literary Institutions and to a number of individuals engaged in scientific pursuits.

The sales of publications, during the above period, including reports and maps, amounted to $727.22.

There were received as donations or exchanges to the library, 3,300 publications, including reports, transactions, proceedings, memoirs, periodicals, pamphlets and maps. Publications purchased, 136, scientific periodicals subscribed for, 42. The number of letters received in connection with the library was 2,260, besides 2,750 acknowledgments from exchanges and individuals for publications sent to them. The number of letters sent from the library was 1,739, besides 629 acknowledgements for publications received. There are now in the library about 13,700 volumes, besides a large number of pamphlets. The number of volumes bound was 219.

A large number of the earlier reports and maps are now out of print and can no longer be supplied.

As has been frequently stated, the space available for library purposes has hitherto been altogether insufficient, causing a large amount of unnecessary labour and time in finding information. During the past summer an additional room has been fitted up to relieve the pressure. This will be a great convenience for those having occasion to consult the books.

It may be stated that the library is open for consultation by persons wishing to obtain information in regard to scientific subjects.

Visitors to the Museum.

The number of visitors who signed the museum register during the year was 27,837.

Staff, Appropriation, Expenditure and Correspondence.

The staff at present employed numbers 57.

During the year the following changes took place in the permanent staff:—

Mr. Albert P. Low re-appointed a technical officer.

Mr. Thomas Burke, caretaker, died.

Mr. James A. McGee appointed a junior second class clerk.

Mr. John F. Lyons appointed caretaker.

The funds available for the work and the expenditure of the department during the fiscal year ending June 30, 1903, were:—

Details.	Grant.	Expenditure.
	$ cts.	$ cts.
Civil list appropriation	54,275 45	
General appropriations	78,866 73	
Civil list salaries		50,806 83
Explorations and surveys		23,815 10
Wages of temporary employees		24,570 30
Printing and lithographing		27,496 93
Purchase of books and instruments		1,569 40
" chemicals and apparatus		660 09
" specimens		93 18
Stationery, mapping material and King's Printer		1,417 91
Incidental and other expenses		3,361 34
Advances to explorers		10,545 00
		144,336 08
Deduct paid in 1901-02 on account of 1902-03		14,782 99
		129,553 09
Unexpended balance civil list appropriation		3,468 62
" general "		120 47
	133,142 18	133,142 18

The correspondence of the department shows a total of 7,970 letters sent, and 10,764 received.

I have the honour to be, Sir,

Your obedient servant,

ROBERT BELL,

Acting Deputy Head and Director.

January 1, 1904.

APPENDIX.

The following thirteen samples from the Klondike district were assayed for gold by Mr. M. F. Connor.

No. 1. Sample marked Skookum gulch: White subtranslucent quartz with vitreo-resinous lustre; weight of sample, 1 lb. 4 oz.

It contained no gold.

No. 2. From Lepine creek, marked 'Billy Button'; weight of sample, 1 lb. An association of non-stained quartz with a little feldspar.

It contained gold, a decided trace.

No. 3. Normans creek (Chisholm's claim); sample weighed 14 ozs., composed mainly of quartz with brown stains of iron oxide.

It contained gold, a trace.

No. 4. Lepine creek (claim of Cornelius Lowney); sample weighed $13\frac{1}{4}$ ounces. An association of quartz with sericite schist coloured deep brown by iron oxide.

It contained gold, a trace.

No. 5. Sample marked 'Violet Group,' and composed of quartz with slight iron stains; weight of sample, 1 lb.

It contained gold, a trace.

No. 6. McKinnon creek (Britannia mine); sample of quartz-conglomerate weighing 1 lb.

It contained no gold.

No. 7. Reuter creek (Great Eastern); weight of sample, 14 ozs. An altered sericite schist.

It contained gold, a decided trace.

No. 8. Sample marked 'Great Eastern Dyke'; weight of sample 1 lb. A highly altered feldspathic rock.

It contained gold, a decided trace.

No. 9. Marked 'Spotted Fawn' ore; a sample weighing 12 ozs. A dark grey quartzite.

It contained no gold.

No. 10. From head of Victoria gulch; a sample weighing 1 lb. 2 ozs. Mainly quartz (with cubes and grains of pyrites) associated with sericite schist.

It contained gold, a decided trace.

No. 11. Lepine creek (Tupper claim); sample weighing 1 lb. 5 ozs. Mainly quartz with a little sericite schist.

It contained no gold.

No. 12. From McKinnon creek, sample marked 'Blue Rock,' a blue quartz; weight of sample, 10 ounces.

It contained no gold.

No. 13. From Hunker creek, below Gold-bottom; weight of sample, $1\frac{1}{2}$ ounces. An association of quartz, feldspar and a little calcite; the mass stained with iron oxide.

It contained gold, a trace.

ABBREVIATIONS.

Alta.	District of Alberta.	N.W.T.	Northwest Territories.
B.C.	British Columbia.	O.	Province of Ontario.
N.B.	Province of New Brunswick.	Q.	Province of Quebec.
N.S.	Province of Nova Scotia.		

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