SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY BRANCH

OF THE

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR

1911

PRINTED BY ORDER OF PARLIAMENT

OTTAWA
PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY
1912

[No. 26—1912]—A [No. 1218.]

To His Royal Highness the Duke of Connaught and Strathearn, K.G., &c., &c., &c., Governor General of Canada.

May it Please Your Royal Highness,—

The undersigned has the honour to lay before Your Royal Highness—in compliance with 6-7 Edward VII, chapter 29, section 18—the Summary Report of the operations of the Geological Survey during the calendar year 1911.

(Signed) ROBERT ROGERS,

Minister of Mines.

To the Hon. ROBERT ROGERS, M.P.,
Minister of Mines,
Ottawa.

SIR,—I have the honour to transmit, herewith, my summary report of the operations of the Geological Survey for the calendar year 1911: which includes the reports of the various officials on the work accomplished by them.

I have the honour to be, Sir,
Your obedient servant,

(Signed) R. W. BROCK,
Director Geological Survey.

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SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY BRANCH

OF THE

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR 1911.

To the Hon. Robert Rogers, M.P.,
Minister of Mines.

Sir,—I have the honour to submit herewith, a summary report on the operations of the Geological Survey for the calendar year 1911.

The present organization of the Survey is as under:—

Director.

Administrative and General:—

Correspondence—Secretary, 3 stenographers.

Distribution—Chief, publication clerk, correspondence clerk.

Stationery—1 clerk.

Instruments—1 custodian.

Cabinetmaker—1.

Messengers, etc.—1 mail clerk, 4 messengers.

Geological Division:—

Palæontology—1 vertebrate palæontologist, 1 invertebrate palæontologist.

Geology—11 geologists, 9 assistant geologists, 1 compiler.

Mineralogy—1 mineralogist and curator, 1 assistant curator, 1 collector and distributer, 1 stenographer.

Topographical Division:—

Chief topographer, 3 assistant topographers, 1 model-maker, 1 triangulator and computer.

Draughting Division:—

Geographer and chief draughtsman, 13 draughtsmen, 1 clerk.

Photographic Division:—

Photographer in charge, 1 assistant.

Natural History Division:—

1 botanist and naturalist, 1 assistant botanist and naturalist, 1 assistant naturalist and custodian, 1 preparator and taxidermist, 1 taxidermist, 1 stenographer.

Anthropological Division:—

1 ethnologist, 1 assistant ethnologist, 1 archæologist, 1 stenographer.

Library:—

1 librarian, 2 assistants.

In the geological and anthropological division, officers were commissioned in addition to those of the regular staff, to take charge of field parties. Such officers are usually obtained from the staffs of technical universities. Field and student assistants were temporarily engaged for field work in the divisions of geology, topography, and natural history.

During the year the Survey lost through death the services of Dr. R. W. Ells and Mr. R. L. Broadbent. Dr. H. M. Ami was granted superannuation on account of ill-health, and Messrs. J. A. Dresser, F. H. MacLaren, and Hugh Matheson resigned.

Appointments to the staff were made as under:—

Dr. Charles D. Walcott, Secretary of the Smithsonian Institution, and formerly Director of the United States Geological Survey, accepted the honorary position of Collaborator in Geology with special reference to the Cambrian.

Dr. H. I. Smith was appointed archæologist; C. M. Barbeau, assistant ethnologist; Robert Harvie, S. J. Schofield, and L. Reinecke, assistant geologists; W. E. Lawson, A. C. T. Sheppard, and K. G. Chipman, assistant topographers; S. C. McLean, triangulator and computer; S. N. Graham, assistant curator mineralogy and geology; P. A. Taverner, assistant naturalist and curator; G. D. Barrowman, custodian of instruments; Geo. P. Clarke, photographer; Alice B. Wilson, assistant in palæontology; A. F. Clarke, and Adam McGregor, draughtsmen; and Eilleen Bleakney, stenographer.

The death of Dr. R. W. Ells deprived the Survey of one of its oldest and most highly respected members. He entered the Survey in 1872 and was in active service up to the time of his death. The greater part of his work was in the Maritime Provinces, Quebec, and eastern Ontario, but he also carried on investigations in the northwest and in British Columbia. The results of his extended labours in these fields are to be found in the voluminous reports and maps that have appeared under his name.

To Mr. R. L. Broadbent were due more, perhaps, than to any one else, the fine mineralogical exhibits for the Museum. His untimely death, at the moment the collections were to be installed in the new Museum, has been a blow which will long affect the work of the Museum.

The resignation of Mr. Dresser emphasizes the urgeucy pointed out in recent summary reports, for securing more rapid promotion and higher salaries for the scientific staff, especially the field officials. The loss of an experienced officer is irreparable; for he has in his work, secured a mass of detailed information concerning the districts in which he has been engaged that can never be embodied in a report, but that is of constant value to the Department and the public in answering inquiries concerning particular areas or special problems. When such an official leaves the service this fund of information is lost to the Department and to the public.

As a partial offset to such losses the Survey now has a corps of well-trained young geologists and topographers to draw upon. Four years ago when the Survey was able to announce that it had been removed entirely from politics and outside influences, and that appointments and promotions would hereafter be based strictly on merit, the most promising students in the colleges began to train for positions on the staff. By restricting the appointments as student assistants on field parties to students of at least two years standing in approved universities or technical colleges, who were studying for the professions of geology, mining, or topography, the Survey has been enabled to try out each year about sixty prospective technical men especially selected by their respective professors. The more promising of these are encouraged to proceed with their training, the geologists to take doctorate degrees in geology in post graduate universities, the topographers to train in the Survey. During the past year a number of such men had finished these courses and received appointments to the staff. Next year a further number of such specially qualified men will be available.

Such additions to the field forces render it possible to make much needed staff appointments, for general supervision of and consultation regarding the work. Until now, no experienced official could be taken from regular field work, since the field force was not strong enough numerically to cope with even the most pressing demands for field work, and the routine and other duties of the Director left him without the requisite time to devote to this branch of the work. Consequently, the individual officer did not receive the assistance in the field or in the office, in the way of friendly criticisms and suggestions, that is necessary to bring about the best results. It is now proposed to place experienced geologists in charge of office work and field work.

COMMITTEES.

The Geological, Map, and Library Committees have continued to render valuable service. The work devolving upon these bodies is arduous and makes heavy inroads upon the time of the members of the respective committees. Since the results of their labours do not appear in a form which admits of individual credit being given, I take this opportunity of emphasizing the valuable results of their work.

As it becomes possible to allot staff duties to special officers, the demands upon these committees will be lessened, as only general questions need then be referred to them.

PUBLICATIONS.

The results of the investigations of the various divisions of the Survey are recorded in maps and reports. Since, however, the information acquired by the Survey is of value for very different purposes by various classes and individuals, it is impossible in a given report to record every fact that may have a value to somebody or to treat the matter in a manner that is suitable for all purposes. Information that is not of general value has, as a rule, to be omitted from a report. But much of such information is furnished interested individuals in the field, and this is perhaps the most valuable service that the Survey renders. A great deal is supplied by correspondence. Information that is of immediate value to the public is supplied by means of Press Bulletins, which are furnished to any newspaper desiring such information, and to all individuals who have asked to be placed on the 'Notice list' of the Survey.

Any one who applies will have his name placed on this list, and will receive the Press Bulletins and a notice of reports as issued. No general distribution list is maintained.

The number of letters received during the year asking for publications was 5,616. The number of publications sent out in response was 20,506, distributed as follows: 17,945 to Canada, 2,029 to the United States, 202 to Great Britain and Ireland, and 330 to foreign countries. The sale of publications amounted to $286.24.

A list of maps and reports published during the year will be found near the end of this volume.

Attention may be called to the fact that maps now published by the Survey may be obtained printed on linen for field use. An extra charge of ten cents is made for maps on linen.

FIELD WORK.

The geological and topographical work undertaken during the past season has, as usual, been almost exclusively economic and confined to districts in which such work gave promise of being of greatest or most immediate value.

Arrangements are made with the mining departments of the Provinces of Ontario and Quebec to avoid duplication of geological work. Consequently the districts in which these provinces have field parties are not examined and reported on by the Geological Survey. Such districts are usually those which, in any year, are receiving marked attention from prospectors and mining men.

The distribution of field parties was as follows:—

GEOLOGICAL.

Mr. D. D. Cairnes was engaged on the Yukon-Alaska boundary line between the Yukon and Porcupine rivers.

For the geological work in both the Yukon and Alaska, a geological section to the Arctic ocean is needed, and the geological surveys of the United States and Canada are co-operating in this work, Canada becoming responsible for the section along the boundary line from the Yukon to the Porcupine river, and the United States for the section from Porcupine river to the Arctic ocean. The total length of the combined section will be about 340 miles.

Returning from the field, Mr. Cairnes examined a number of quartz properties in the neighbourhood of Dawson.

Mr. R. G. McConnell spent the field season in the Portland Canal district examining the mineral deposits of Goose bay and Alice arm on Observatory inlet, as well as continuing his investigations on Bear and Salmon rivers. He also made a reconnaissance trip across to the Nass river. The most important event in mining in this region during the season has been the advent of the Granby Company, whose vigorous development of their newly acquired Hidden Creek mine at Goose bay has proven the existence of large bodies of copper ore.

Mr. G. S. Malloch examined a portion of the Groundhog coal basin at the head of the Skeena river, north of Hazelton, a district which has attracted a good deal of attention during the past season. The basin is a large one, containing several seams of coal, anthracitic in character. Most of the seams are high in ash, but samples taken from one workable seam by competent men have had a low ash content.

Mr. C. H. Clapp spent the summer in a detailed investigation of the Nanaimo coal field, Vancouver island.

Mr. Charles Camsell spent a short time testing the Tulameen River gravels for diamonds, on the chance of finding stones of commercial size. Only minute diamonds were found. Minute rubies were also obtained. He made a geological survey of the Steamboat Mountain district which had received considerable notice during the preceding winter. His investigations tended to show that with the exception of one or two localities the district is economically unimportant. Some time was also spent on the Fraser river about Yale and northward up the Fraser canyon, where no work has been done by the Survey since the reconnaissance in 1872.

Mr. L. Reinecke concluded his investigations in the Beaverdell Mining district, West Fork of the Kettle river, through which a branch of the Canadian Pacific railway is being built.

Mr. C. W. Drysdale made a detailed geological examination of Franklin Camp, North Fork of the Kettle river.

Mr. O. E. LeRoy devoted a considerable portion of his time to visiting various mining centres in southern British Columbia and in superintending the work of several of the field parties. Among other districts, he visited the Slocan where very encouraging and important results have attended the development work that has been carried on. He made a detailed survey of an area of about 100 square miles covering the mining district about Nelson, where general mining conditions are improving.

Mr. S. J. Schofield continued his geological mapping in the East Kootenay district, paying special attention to the mineral deposits of the area, of which silver-lead is the most important.

Mr. R. A. Daly commenced work on the geological section across the mountains along the line of the Canadian Pacific railway. Work was begun near Kamloops and carried eastward to beyond Albert Canyon. For the detailed investigation of the mining districts, it is necessary to know the structure and general geology of the Cordilleran belt. To supply this information a number of geological sections across this belt are required. Mr. Daly has completed such a section along the 49th parallel (the International Boundary). This year he has begun a similar section along the Canadian Pacific railway. As soon as practicable a third section along the Grand Trunk Pacific will be undertaken.

Mr. J. A. Allen continued his examination of the area adjacent to the Canadian Pacific railway in the Rockies west of Field.

Mr. C. D. Walcott devoted the summer to a study of the Cambrian of the Rockies in the vicinity of Field from which he has obtained remarkable fossils.

Mr. W. W. Leach began a detailed examination of the Blairmore-Frank coal-field. Not only is this a heavy producer (over 1,600,000 tons in 1910), but it is being further developed.

Messrs. W. G. Miller, R. A. Daly, and George S. Rice examined and reported on the condition of Turtle mountain.

Mr. D. B. Dowling continued his investigation of the coal basins in the vicinity of The Grand Trunk Pacific railway near Yellowhead pass. One colliery is already in operation and the opening of three others is in contemplation. The Canadian Northern railway will also pass close to these collieries. A month was spent in examining coal occurrences in other parts of Alberta and in Saskatchewan, several of which, it is now reported, are being developed into mines.

Mr. A. C. Lawson was engaged in the Lake of the Woods and Rainy Lake district, where in his reconnaissance work in the '80's he had obtained most important geological results. His more detailed work the past season has supplemented these with an equally valuable contribution to the knowledge of Pre-Cambrian geology. Amongst other things, he has found fossils in a Pre-Cambrian horizon believed to be far below any hitherto known to be fossiliferous.

Mr. W. H. Collins continued his geological mapping of the country north of the Sudbury district. Since 1908, occurrences of silver-cobalt minerals similar to those at Cobalt have been found at various points within this district, and last August gold-bearing quartz veins were discovered near West Shiningtree lake.

Mr. W. A. Johnston continued his topographical and geological mapping in the Lake Simcoe district, important from the information it affords regarding the Ordovician rocks, and the superficial geology of Ontario.

Mr. F. B. Taylor continued his work on the superficial geology of Ontario. In New York, Ohio, and Michigan this has been carefully worked out; Mr. Taylor is connecting and correlating this work through southwestern Ontario.

Mr. C. Stauffer continued his study of the Devonian rocks of southwestern Ontario. Every Devonian formation is here of some economic value; the most important, however, is as a reservoir of oil.

Mr. A. F. Foerst made a study of the lower Palæozoic rocks of Manitoulin island.

Mr. M. E. Wilson continued his explorations in northwestern Quebec from Lake Abitibi eastward. The mineral bearing formations of northern Ontario extend into this portion of Quebec, and with approaching railway facilities it affords an attractive field for prospectors. There are also large areas of agricultural land.

Mr. J. Stansfield made detailed plans of typical apatite, mica, and graphite mines north of Ottawa river.

Mr. R. Harvie was assigned to the work previously carried on by Mr. Dresser, on the economically important Serpentine belt of the Eastern Townships, Quebec. No important asbestos deposits were noted in the area examined this season, but copper has been a product and may be again.

Mr. J. J. O'Neill made an examination of Belœil and Rougemont mountains, to complete the study of the Monteregian hills, a group of interesting old volcanoes that extend from Montreal eastward.

Mr. J. W. Goldthwaite continued his investigations of the raised beaches of eastern Quebec, extending the work into the Maritime Provinces. The determination of the amount and character of the post-glacial changes of level of the coast may lead to important deductions. This work is being correlated with similar investigations in progress along the Atlantic coast of the United States.

Mr. P. E. Raymond carried on field work in eastern Ontario and western Quebec, and also in the neighbourhood of Quebec city. New and important facts of palæontological value were obtained.

Mr. G. A. Young made a geological examination of the oil, gas, and gypsum district near Moncton, N.B. The gas field promises to become an important factor in the commercial development of this region.

Mr. H. E. Kramm paid special attention to the extensive gypsum deposits of the district as well as to several related deposits of the same mineral in other parts of New Brunswick and Nova Scotia.

Mr. W. A. Bell made a preliminary examination of the very important Joggins carboniferous section of Nova Scotia.

Mr. E. R. Faribault continued his mapping of the gold-bearing series in Queens and Lunenburg counties, N.S. In the area examined are several gold-bearing districts, at one of which, Fifteenmile Brook, a discovery of the tungsten ore, scheelite, was made.

Mr. W. J. Wright began a study of special problems relating to the gold-bearing rocks in Lunenburg county, N.S.

Mr. H. Ries continued the examination of the clay resources of the western provinces. The valuable results obtained from these investigations in past seasons have aroused keen interest in this important branch of the mineral industry.

Mr. J. Keele also contributed to the examination of the clay resources of the western provinces, and began the study of the clays of Quebec. He also visited the placer gold field of Beauce county, Quebec, where placer mining is being resumed.

TOPOGRAPHICAL.

Mr. K. Chipman mapped the northern half of the Cowichan-Alberni map area, Vancouver island.

Mr. R. H. Chapman surveyed the southern half of the same area.

Mr. A. T. Sheppard completed the Slocan map area and assisted Mr. Boyd at Blairmore.

Mr. S. C. McLean was engaged in triangulation in the Windermere district, East Kootenay, B.C.

Mr. W. H. Boyd supervised the mapping of the Blairmore area, and made a detailed map of Turtle mountain, Alta.

Mr. W. Lawson had charge of the topographical work in the Moncton map area.

Field work in natural history and anthropology will be mentioned later under the headings of these divisions.

PROGRESS OF DIVISIONS.

TOPOGRAPHICAL DIVISION.

The topographical division under Mr. W. H. Boyd has been strengthened during the year by the appointment of three topographers, and a triangulator. A number of other men now in training will soon be ready to undertake independent work. It is the intention to strengthen this division until it is able to furnish the base maps required by the geological division, so that the geologist entering the field will be provided with an accurate topographic base map on which to lay down in the field the results of his geological observations. This will result in a saving of time and in marked increase in the accuracy and usefulness of the geological work.

Our standard topographical maps now being produced by this division are accurate to scale and are in themselves of great value to mining and other engineers, and for all purposes for which such scale maps are suitable. The scales vary from 400 feet to 1 inch, as in the engineering maps, to 4 miles to an inch in areal maps; the contour interval varies from 10 to 500 feet according to the scale of the map and the nature of the district represented.

On account of the various classes of maps produced by the Survey, ranging from absolutely accurate contoured topographical maps to rough illustrative diagrams, it has been decided to classify them so that they may show on their face, for the information of the user, the degree of accuracy that may be expected to be found in them. The following is the classification adopted:—

Grades.	A Topographical Maps.	B Geographical Maps.	C Route Maps.	D Plans.	E Diagrams.
1. Standard	Unless mentioned as of lower grade assume standard quality.				
2. Graded	Grade 2..... .. " 3..... .. " 4..... ..	Grade 2. . .. . " 3.. .... " 4.... ..			
3. Inferior........	Inferior....	Inferior....	Track Survey...	Inferior....	Inferior.

The topographical maps are contoured, and show the relief, water, and cultural features.

The geographical maps show the water, and locations of places, etc., but are not contoured.

The route maps show the lines of exploration but do not represent the geographical features of the district as a whole.

The Standard maps are accurate to scale. Maps are to be regarded as Standard maps unless otherwise stated under the title. The Graded maps are graded according to the degree of accuracy obtaining throughout. The grade will be given under the title. Inferior maps are rough sketchy maps with insufficient instrument control, that should not be relied on as accurate, since they are intended solely to furnish a general idea of the geography or geology of the country, or to illustrate certain features.

Any of these maps or diagrams may be used as bases for geology.

DRAUGHTING DIVISION.

This division has been strengthened during the year by the addition of several draughtsmen, rendered necessary by the increased mapping being carried on by the Survey.

PHOTOGRAPHIC DIVISION.

This division has also been strengthened during the past year, and its work extended to include wet-plate photography.

The work consists of the developing and printing of photographs taken by officers in the field, enlarging of photographs taken in photographic mapping, photographing specimens for reproduction and making prints to illustrate reports, enlarging and reducing for map-making, blue printing, and making lantern slides. During the year the work turned out in this division comprised 396 dry-plate negatives, 1,533 dry-plate exposures developed, 8,537 contact prints, 647 topographic enlargements, 272 lantern slides, and 25 wet-plate negatives.

The work has been considerably hampered on account of the new laboratories not yet being fitted up, necessitating shift arrangements. Considerable progress has been made in cataloguing the extensive and valuable collection of negatives.

NATURAL HISTORY DIVISION.

Only a limited amount of field work was undertaken by this division during the past season, confined principally to the Ottawa district, New Brunswick, and Vancouver island. The major portion of the time was devoted to the collections intended for public exhibition and for scientific reference. Mr. P. A. Taverner was appointed to this division as assistant naturalist and curator. Now that facilities are being provided for its work, the natural history staff requires to be augmented to properly cover the wide field allotted to it.

ANTHROPOLOGICAL DIVISION.

The anthropological division during the year has been organized and its work is now well under way. In addition to overhauling and preparing the collections for museum purposes, systematic field work has been undertaken. In the ethnological subdivision the field work carried on was as follows:—

Mr. E. Sapir made a reconnaissance of the Iroquois and Algonkin of Ontario and Quebec.

Mr. C. M. Barbeau conducted an ethnographical research among the Hurons of Lorette, Amherstburg, and Wyandotte.

Mr. A. A. Goldenweiser was engaged in a study of the social organization of the Iroquois of the Grand River reserve.

Mr. W. H. Mechling spent the summer in research among the Micmac and Malecite Indians of New Brunswick.

Mr. C. MacMillan spent the season among the Micmac of Nova Scotia and Prince Edward Island.

Mr. V. Stefansson is still working among the Eskimo of the Arctic east of the Mackenzie river, near Coronation gulf.

In the archæological subdivision, Mr. H. I. Smith, assisted by Mr. W. J. Wintemburg, studied a number of typical village sites in southern Ontario.

LIBRARY.

On moving into the new quarters, the library was rearranged and the work of cataloguing undertaken. In this work the assistance of Miss Houston of the McGill library was secured.

MUSEUM.

The Victoria Memorial Museum is a Natural History Museum, including biology, geology, and mineralogy, ethnology and archæology. As the National Museum of Canada it is hoped that it will become the repository of all objects of scientific value found within the Dominion. To fulfil its mission, it is necessary to secure the interest and co-operation of the Canadian scientists and of the public generally. An effort will be made to have the leading scientists of the country accept honorary positions on the staff of the Museum and to actively co-operate in the various branches of Museum activity. For the present, at least, the Museum is confined to Canadian material, the object being to specialize in this until it becomes in all branches thoroughly representative of the whole Dominion, a place where the entire natural history of Canada may be studied. Each division of the Survey is in charge of its section of the Museum. The task of moving into the new building was completed during the year. With the increased space considerable progress could be made in selecting and preparing material for public display and for the scientific collections. Little progress, however, could be made toward installing collections owing to lack of furnishings.

The scientific reference collections are to be housed in the halls on the top story, while the lower halls and rotunda will be used as exhibition halls.

The work of installation has been seriously hindered by the death of Mr. Ralph Broadbent, whose intimate knowledge of the collections, long experience in exhibiting, and artistic taste would have been of the greatest service.

The needs of the Museum in the matter of staff, facilities, cases, and specimens, are pressing. While the collections at present are very valuable, and thoroughly representative of portions of the country, from other parts only scattering material has been as yet secured.

Vermin-proof storage cases are required, especially for the biological and ethnological collections.

Help is required in all branches, but particularly necessary are preparators skilled in modern museum methods.

It is hoped that these pressing needs may be met in the near future so that the Museum may speedily become worthy of its national character.

INTERNATIONAL GEOLOGICAL CONGRESS.

Preparations are being made for the Twelfth International Geological Congress which, on the invitation of the Canadian Government. the Geological Survey, and the Canadian Mining Institute will meet in Canada during the summer of 1913. It is expected that over one thousand of the leading geologists and mining engineers of the world will attend. Dr. Frank D. Adams has been elected president. and R. W. Brock, secretary-treasurer. An Executive Committee—consisting of F. D. Adams, R. W. Brock, W. G. Miller, T. Denis, O. E. LeRoy, W. McInnes, A. P. Coleman, W. Parks, J. B. Tyrrell, G. G. S. Lindsay, and A. E. Barlow—has been formed to superintend the arrangements for the Congress. Excursions will be made to points of geological and mining interest in the Maritime Provinces, Quebec, and eastern Ontario before the meeting. During the meeting, which will be held in Toronto, short excursions will be made to points of local interest. and after the meeting, excursions will be made through the west as far as Vancouver island and the Klondike.

The main topic for discussion will be the coal resources of the world. As a basis for this discussion. a monograph on the subject is to be issued before the meeting. The proper authorities in each country have been asked to supply the information concerning coal in their respective countries. From these reports the monograph is being compiled and edited in the Geological Survey. Guide books and maps covering the excursions will be prepared. It is the intention to make the excursions the chief feature of the Congress, affording the visitors, from all parts of the world, an opportunity to become acquainted with the geology and natural resources of the whole of the accessible portions of the Dominion.

TURTLE MOUNTAIN COMMISSION.

In the Summary Report of last year attention was drawn to the instability of Turtle mountain, Alberta. On its publication a deputation, representing the coal company operating on the seam at the base of the mountain and the citizens of Frank, waited on the government urging the appointment of a commission to examine the mountain and to delimit the area likely to be affected in case of further rockslip. It was thereupon decided to appoint a commission for this purpose, and the following gentlemen, approved of by the Geological Survey, and by the representatives of the Alberta Government, the citizens of Frank. and the coal company, were named to act on this commission: W. G. Miller, Provincial Geologist of Ontario; R. A.

Daly, Research Professor of Geology, Massachusetts Institute of Technology; George S. Rice, Coal Mining Engineer, of the United States Bureau of Mines.

Mr. Rice at the time was absent in Europe studying the effect of mining upon the stability of the ground, but on his return, the commission proceeded with their examination of conditions at Frank.

Mr. W. H. Boyd, and staff, of the Geological Survey, had meanwhile prepared a detailed topographical map of Turtle mountain and Frank for the use of the commission. The report of the commission already published,[1] confirms the opinions expressed by the Geological Survey from time to time since the great rockslip of 1903.

MINING LAW.

The Canadian Mining Institute for some years has been urging a Federal mining law to govern the acquisition of mining rights on lands under the control of the Dominion Government, on the grounds that the industry has now attained an importance deserving this recognition, and that a law would greatly stimulate the development of the mineral resources on Crown lands. It is also believed that the provinces having control of mining lands will make their mining laws conform closely to the Federal law, and thus secure, throughout the Dominion, uniformity in the mode of dealing with mining rights. At the suggestion of the Government, the Institute formulated the principles upon which it desired the law to be based. Mr. J. M. Clarke was engaged to draft an Act based on these principles. Subsequently, Mr. F. T. Congdon and the Director of the Survey were requested by the Committee on Mining Law of the Institute to revise this draft. After spending several months on the work they submitted a new draft which, with a few minor changes, has been accepted and recommended to the Government by the Canadian Mining Institute.

WORK OF THE DIRECTOR.

In addition to attending to the routine work of the Survey, various scientific meetings were attended, including meetings of the Council of the Canadian Mining Institute and of the Executive of the Twelfth International Geological Congress.

Tin and Topaz in New Brunswick.

In July, a visit was paid to the molybdenite-wolframite locality near Burnthill brook, southwest branch of the Miramichi river, to ascertain the mode of occurrence

[1] Report of the Commission appointed to investigate the conditions of Turtle Mountain, Alta., Geological Survey, Memoir No. 27.

of topaz (recognized by Mr. R. A. A. Johnston in specimens of ore received from there during the winter), and in the hope that tinstone might be found to occur with such an association of minerals. Dykes of greisen, a rock which often carries tin, were found at a number of points, and a little cassiterite (tinstone) was discovered in some of it. In order to inform the public without delay, a description of the occurrence was published in the *Canadian Mining Journal*, No. 17, September 1, 1911.

" The rocks are argillites, considered by Bailey and Ells to be of Cambro-Silurian age, that have been invaded by a granite batholite. Along the contact of the granite the argillites are metamorphosed to spotted schists and hornfels.

" Granite porphyry and aplitic dykes from the granite cut the country rock. A few basic lamprophyres were also seen, but, at least, some of the latter are older than the granite, as the quartz veins run uninterruptedly through the basic dykes.

" Within the highly metamorphosed zone of the sedimentaries, which forms a border, roughly half a mile or so wide, along the granite contact, the mineral-bearing quartz veins are developed.

" About Burnthill brook the veins appear to be best developed and most highly mineralized on the side-hill facing and opposite the mouth of the brook. Near the granite contact, which crosses the brook about a fourth of a mile from its mouth, veins do not seem so numerous nor so well mineralized.

" The strike of the country rock varies somewhat, but is about N. 67° E.,[1] dip 55° N. Both the sedimentaries and the granite are heavily jointed, the joint planes having a direction of from N. 20° to N. 40° W.

" Quartz is developed parallel to the strike of the schistosity of the sedimentaries and parallel to the joint planes. Parallel to the strike, the quartz is irregular, forming lenses and sending irregular stringers into the country rock. Between such stringers the country rock is often silicified. Parallel to the joint planes the quartz occurs in well defined, regular veins which can be traced in some cases for several hundred feet but some can be seen to pinch out. Some inclusions of country rock occur in the veins and the wall rock is occasionally silicified, thus there has been replacement as well as vein filling. The majority of the veins are under a foot in width, but at the point where the specimens were obtained last winter (they were mostly float), I found the vein for about 50 feet to average at least 2 feet.

" On the east side of Burnthill brook, at its mouth, a mineral-bearing quartz vein is bordered by greisen, a rock consisting of silvery mica and quartz. The mica of the greisen, which is muscovite, is often segregated in bands. A little farther north is another vein in which greisen predominates. North of this, near the granite contact, is a 4 foot dyke of greisen, parallel to the joint planes and the quartz veins. In it were a few quartz stringers and druses of quartz. It was in this greisen that I found tinstone. There is, therefore, evidently a gradation from the greisen to the normal quartz veins, and the veins are clearly contact phenomena of the intruded granite. The following minerals were observed in these veins: quartz, muscovite, brown mica, feldspar, topaz, fluorite, wolframite, molybdenite, pyrrhotite, chalcopyrite, and cassiterite.

" The quartz, which is milky and vitreous, is the chief gangue mineral. It occurs massive and crystallized in vugs and druses. Muscovite is most plentiful in the greisen, but is also found in the typical quartz veins. The brown mica was seen in one of the quartz veins.

" Feldspar was found in one of the banded quartz-greisen veins.

[1] Directions are magnetic.

"The topaz occurs in a great many if not most of the quartz veins, and in considerable quantity. It is most frequently found as crystals lining vugs and druses, but it also occurs massive. The crystals are microscopic to thumb-large in size. Little unweathered material could be obtained, and the topaz seen was mostly cloudy, or stained with iron oxide. Some crystals were almost milk white, but some small clear yellow crystals of gem quality were found. In one small vein a druse with a surface area of about 8 square feet was completely coated with topaz crystals. The dark purple fluorite also occurs in druses, but sparingly.

"The brownish-black wolframite occurs in considerable amount, usually more or less segregated into bunches which are commonly near the centre or along the edges of a vein. Although bunchy, it is sufficiently plentiful to warrant some prospecting. The molybdenite is less abundant. Its occurrence is similar to that of the wolframite.

"Pyrrhotite and chalcopyrite are only sparingly present. The iron sulphide is later than and veins the wolframite. The brown cassiterite or tinstone was found in the greisen in small amount only, but it may occur also in the quartz veins.

"The granite in the neighbourhood of Burnthill brook is for the most part drift-covered, but some is exposed in the brook itself. Some small quartz veins and pegmatite dykes were observed in it. The quartz veins were similar to those in the sedimentaries, but only molybdenite was observed in them. There is no reason, however, why tin-bearing greisen, or wolframite-topaz veins should not be found in the granite, especially in fractures near its contact with the sedimentaries, where pneumatolitic action would be as apt to occur as in the sedimentaries near the contact.

"The district is one that is worth some prospecting. While one cannot yet state that it is present in commercial quantity, the wolframite is in sufficient amount to warrant prospecting, and there is a chance that prospecting might reveal larger and richer veins. There is also a possibility of finding more tin. Greisen is notably a tin-bearing rock, and the association of minerals is also suggestive of tin. Some topaz of gem quality is likely to occur. The stone in the rough is not worth much but it has some value.

"While there are no roads, if a workable deposit were found, transportation would not be difficult. In winter supplies might be brought on the ice or a road would not be difficult of construction; in summer they might be floated in scows down the river from the National Transcontinental railway and the products floated on down to Boiestown. The chief difficulty in prospecting is the paucity of rock exposures, the wooded nature of the country, and the depth of wash and drift over much of it.

"To prospect, the contact of the granite should be sought and followed, and prospecting carried on both in the granite and in the metamorphosed zone of the argillites. In the latter the strike of the rocks should be followed, as the promising mineral-bearing veins are parallel to the joint planes at right angles to the strike. Where float is found in quantity the source is usually close at hand."

The locality is reached from Boiestown, on the Fredericton branch of the International railway, by driving about 9 miles to Campbell Settlement, and a day's poling up the southwest Miramichi in a canoe.

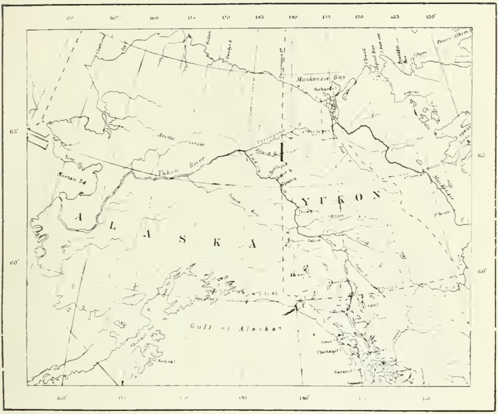
Western Canada.

On August 11, I left Ottawa for Edmonton to discuss with the Provincial government the arrangements for the Turtle Mountain Commission. From Edmonton I went to Prince Rupert, and up the Skeena river to Hazelton, visiting some of the prospects in the vicinity. These have already been described by Mr. W. W. Leach.[1]

[1] Summary Reports: 1909, pp. 65-66; 1910, pp. 97-98.

Returning to Prince Rupert, a few days were spent with Mr. McConnell on Bear river, Portland canal, visiting prospects in this district.

My main work in the west was to have been a reconnaissance survey of the Iskut river, a tributary of the Stikine, and all arrangements had been made for carrying out this project which, however, had to be abandoned on account of an attack of typhoid fever. I returned to Ottawa, November 10.



DIAG. 1. Yukon and Alaska, showing the area along the International Boundary that was geologically mapped by the Canadian Geological Survey during the season of 1911.

I

GEOLOGY OF A PORTION OF THE YUKON-ALASKA BOUNDARY BETWEEN PORCUPINE AND YUKON RIVERS.

(D. D. Cairnes.)

INTRODUCTION.

GENERAL STATEMENT.

With the exception of a few days in October, which were spent examining certain quartz claims in the vicinity of Dawson,[1] the field season of 1911 was devoted to studying and mapping the geology along a portion of the 141st meridian (the Yukon-Alaska boundary) between Yukon and Porcupine rivers (see Diag. 1). For a number of years the desirability of obtaining a geological section along the International Boundary between Alaska and Yukon has been recognized by both United States and Canadian workers in these territories; and accordingly the Geological Surveys of the United States and Canada decided to unite in performing this work. A commencement was made during the past summer, this time being considered particularly opportune as a number of International Boundary Survey parties were to be engaged in work along the portion of the 141st meridian under consideration, and it was possible to make arrangements for those engaged in the geological work to become attached to these parties from time to time, thus obviating the necessity of procuring separate outfits for the geological work—and effecting in this way a considerable economy.

The Geological Surveys undertook to perform the geological work along that portion of the boundary lying between Yukon river and the Arctic ocean, a distance of about 340 miles, the investigations to the south and north of Porcupine river to be conducted respectively by the Canadian and United States departments. Mr. A. G. Maddren commenced at the Porcupine and continued northward for the United States Geological Survey, and the writer, in accordance with instructions from the Director of the Canadian Geological Survey, undertook the geological work south of this river.

I desire to express my indebtedness to the various members of the International Boundary Survey parties with whom I came in contact, all of whom were most courteous and obliging. Particular thanks are due Messrs. J. D. Craig and Thos. Riggs, Jr., who had charge respectively of the Canadian and United States parties; these gentlemen rendered numerous favours, and facilitated the geological work in every possible way.

The topographic work was performed by the International Boundary Surveys, and either copies of the finished map or tracings of the plane-table sheets were supplied me, thus enabling the geology to be much more readily and accurately plotted than would otherwise have been possible. The topography was mapped for 2 to 2½ miles on each side of the boundary, giving a map 4 to 5 miles wide; the work was plotted in the field to the scale of 1: 45,000 and is to be published on a scale of 1:62,500 or about one mile to the inch, the contour interval being 100 feet.

Geological work was commenced during the past season, at the Orange fork of Black river, at latitude 66°09′, and continued northward to latitude 67°00′—a

[1] For descriptions of these properties, see pages 33 of this Summary Report.

distance of about 60 miles—the geological formations being investigated and mapped for 2 to 2½ miles on each side of the boundary line to cover the International Boundary Survey's topographic map. My assistant during the summer was Mr. M. Y. Williams.

ACCESSIBILITY.

To reach the district the usual route was followed as far as Whitehorse, *i.e.* the parties travelled to Skagway, Alaska, by steamer from either Seattle or Vancouver, distances respectively of 1,000 and 867 miles, and thence proceeded to Whitehorse, 101 miles distant, over the White Pass and Yukon railway. To get from Whitehorse to Dawson during the season of open navigation, it is customary to take passage on one of the steamers that ply regularly up and down Lewes and Yukon rivers between these points, a distance by river of about 460 miles; from the time of the 'freeze-up' in the autumn to the opening of navigation in spring, stages make regular trips over the Dawson-Whitehorse wagon road. Slack water stretches generally freeze over about the middle of October, but during some seasons the rivers remain open until well into November; the rivers generally open early in May, but the ice remains longer on the lakes. Lake Laberge, which is only a widened portion of Lewes river, having almost no perceptible current, generally blocks navigation until the first week in June.

During the past season the Boundary Survey parties arrived in Whitehorse early in May and were desirous of reaching Dawson with as little delay as possible. As the wagon-road at this time in the spring was in an almost impassable condition for stages, due to mud caused by rains and melting snow, the majority of the men walked to Carmacks, a point on Lewes river about midway between Whitehorse and Dawson, and at a distance of 131 miles measured along the wagon-road from Whitehorse; at Carmacks a steamer was waiting to convey them to Dawson. Others took small boats to the head of Lake Laberge, and then either walked or rode in sleds pulled by dogs, over the ice to the foot of the lake which is about 31 miles long; thence they went by boats to Carmacks and joined those who had come over the wagon-road.

From Dawson, the writer went by steamer down Yukon river to the mouth of Sheep creek and thence by trail to the point where the 141st meridian intersects the Orange fork of Black river, at which poiut the actual field work commenced. The horses to be used by the line-cutting party to which the writer and his assistant were attached were driven from the mouth of Sheep creek to the point where the International Boundary crosses Charlie creek, over a trail which for the greater part of the distance traverses muskeg and tundra with occasional snow-capped summits—the trip being made in 11 days. The provisions, outfit, etc., for the first half of the season, were poled up Charlie creek to the boundary, and thence were packed by the horses along the line as required. The intention was to send the supplies for the remainder of the season up Black river by means of a gasoline launch, but low water prevented this, with the result that the necessary provisions and horse feed had to be packed by horses south along the boundary from New Rampart House on Porcupine river. At the close of the season the writer accompanied the pack-team north to Porcupine river, and thence went down stream in small boats to Fort Yukon on Yukon river, where passage was taken on one of the lower Yukon River steamers to Dawson. Arriving at Dawson in September, the journey to Whitehorse was made all the way by steamer. The trip from Ottawa to the Orange fork of Black river, where the geological work was commenced, consumed 51 days—from May 1 to June 20 inclusive—but the journey from camp to Ottawa was made in 29 days, the return trip being much the quicker, as navigation was open on Lewes river, and the unavoidable delays contingent upon travelling with a large party, as in the spring, were obviated.

Summary and Conclusions.

Topographically the district under consideration is included in what is generally known as the Yukon plateau, and in certain localities where the prevailing bed-rock is limestone or dolomite, the plateau characteristics are still well preserved, and extensive upland tracts occur over 3,000 feet above sea-level that are strikingly even and plain-like in contour. Outside these areas and where the bed-rock consists dominantly of other sediments such as slates, phyllites, quartzites, and related rocks, the plateau surface has been almost or entirely destroyed, and the topography is characterized by generally well-rounded hills and ridges irregularly distributed and dependent for their form and position, largely or entirely, upon the geological formations composing them.

The geological formations outcropping throughout the district consist dominantly of Quaternary, Mesozoic, and Palæozoic sediments, but a few small exposures of intrusive igneous rocks also occur. The Palæozoic sediments belong to the Ordovician-Silurian, and the Carboniferous periods. The Ordovician-Silurian beds are chiefly limestones, dolomitic limestones, and dolomites, and the Carboniferous members consist mainly of limestones, cherts, and cherty conglomerates. The Mesozoic beds are thought to be chiefly Cretaceous, and consist largely of sandstones, shales, phyllites, quartzites, dolomites, and magnesites. The Quaternary formations embrace the superficial deposits, mainly gravels, sands, clays, muck, peat, soil, and ground-ice. The specimens of the intrusives that have been examined, prove to be syenites, diorites, diabases, and andesites.

Marble, lithographic limestones, and magnesite occur extensively in parts of the district, and would be of considerable value if found in more accessible localities. Situated as they are, however, they have no present economic importance.

General Character of the District.

TOPOGRAPHY.

The district under consideration lies within and toward the northern edge of what is generally known as the Yukon Plateau physiographic province. This terrane is a portion of the great Central Plateau region that trends northward through central British Columbia and continues northwesterly through Yukon, and northwesterly and westerly through Alaska to Bering sea, following in a general way, the direction of the Pacific coast. In Yukon and Alaska, this plateau province is bordered on one side by the Rocky Mountain system and on the other by the Pacific Mountain system, and throughout its length has its centre approximately marked by Yukon river.

Within the area mapped during the past summer (1911) two distinct types of topography are represented, one of which possesses marked plateau features, while the other is almost entirely lacking in these characteristics. From the Orange fork of Black river northward along the 141st meridian for over 40 miles, the exposed rock formations are composed largely of Mesozoic slates, phyllites, quartzites, and also to a less extent of Carboniferous cherts, cherty conglomerates, and limestones, and there the topography is characterized by irregularly distributed, generally well rounded hills and ridges, that are dependent largely or entirely for their form and position upon the rocks composing them. The higher summits invariably consist of some resistant, indurated material, generally quartzite, and the valleys are everywhere underlain by slates, phyllites, or related beds that are readily susceptible to weathering and eroding agencies.

To the north of this irregular topography the bed-rock is dominantly limestone and dolomite, and there an even, but gently undulating upland over 3,000 feet above sea-level, is presented which truncates the limestone and dolomite beds wherever these are unconformable with the almost horizontal plateau surface. The upland is dissected by gorge-like valleys having precipitous and, in places, nearly perpendicular walls, at the junction of which with the upland surface, decided shoulders marking topographic unconformities are always in evidence.

Standing on the upland, well back from the valley walls, a plain-like surface is presented with only occasional small rounded summits rising above the general level. Such a nearly base-levelled or peneplanated and typically old topography was apparently produced when the region stood much nearer sea-level than at present. In accordance with this assumption the planating process must have been interrupted by a regional uplift while occasional hills still remained to relieve the monotony of the landscape, and these now constitute monadnocks rising above the general plateau surface. The uplift rejuvenated the streams which quickly trenched their valleys in the upland. The Ordovician and Silurian limestones have proved to be much more resistant to ordinary sub-aerial erosive processes than the Mesozoic and Carboniferous rocks to the south, as there the old plateau surface has been almost entirely destroyed and is now only indicated by occasional straight-topped ridges, and by a certain rather indefinite general summit level which may be noted in some localities.

As to the date of the uplift, the evidence in the district only shows that it was subsequent to the deposition of the most recent of the exposed Mesozoic rocks.

In addition to the agencies at work tending to destroy the upland and reduce the region again to sea-level, other forces are engaged in grading the district within itself. The results of this process are most marked on the surfaces of the remaining plateau fragments, where the features of the already plain-like areas are being smoothed over or equalized, thus producing a topography more and more uniform in contour. The forces included in this process are mainly nivation, frost, and chemical action. These tend to remove the materials from the upper levels and deposit them in the adjoining lower places, thus filling the hollows with the material derived from the adjoining hills. Especially in the Ordovician-Silurian areas this equalizing process is facilitated by the massive character of the rocks themselves, and is aided by the existing condition of almost perpetual frost in the soil, which obstructs the drainage everywhere except along the main waterways. The products of decomposition of the exposed beds thus remain near their parent source, and constitute the soil or muck that goes to form the tundra which blankets the greater part of the even upland tracts, and fills many of the existing bed-rock depressions, resulting in a strikingly uniform surface being produced.

The area under consideration is drained largely or entirely by Black river and its numerous tributaries which flow into Porcupine river. The main streams all have a westerly trend and consequently are transverse to the area mapped. The valley of the main Black river is about 5 miles in width, but those of its tributaries rarely if ever exceed 2 miles. The depressions occupied by the smaller streams are generally typically V-shaped and range from gorge-shaped incisions in the northern part of the area to those having much less steeply inclined walls. The form of the valley of the main Black, as well as of some of its tributaries in places, depends on the structure of the underlying beds, the valley walls on one side of the stream being steep and on the other gently inclined. The Mesozoic beds to the south of Black river dip at low angles in a northerly direction, causing the land-surface to slope gradually down to the valley bottom throughout a distance of over 4 miles, while to the north the river is bounded by precipitous walls due to the easy and abrupt breaking of the brittle slaty beds across the bedding planes.

The valley bottoms of the larger streams contain considerable amounts of gravel, sand, etc., largely of local origin, that have been deposited during wet seasons; and the main streams all possess wide flood channels showing that they are subject to seasons of extremely high water.

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CLIMATE.

The climate of the district appears to vary greatly from year to year. 'Old-timers' in the country report that some summers are exceptionally wet and cold, and that rain or snow falls during more than half the days. Last season (1911) however, was quite the reverse of this, being warm, frequently uncomfortably so, from June 1, to September 15, during which time but few showers occurred and these were generally light and seldom of more than 3 or 4 hours duration. In fact the climate was almost ideal, although the mosquitoes were very troublesome, and were most active and persistent throughout the entire summer.

The rivers and creeks generally open about May 1, but on some of the lakes the ice remains until the first week in June. Slack water stretches freeze over any time after October 1, but occasionally the rivers remain open until near the end of November.

FLORA AND FAUNA.

The valleys are generally well timbered and about one-third of the entire country is forest clad, the northern and eastern slopes being considerably more open than the southern and western hillsides; timber line extends to about 2,900 feet above sea-level. Five principal forest members occur that attain the dimensions of trees and ten varieties of shrubs were noted. Specimens were collected during the season of all the plants, including trees and shrubs, that were noted in the district, and these were delivered to Mr. J. M. Macoun of this department, from whose report the names here used are taken. The five main varieties of trees are, white spruce, aspen poplar, balsam poplar, northern canoe birch, and tamarack or American larch, and the more important shrubs include juniper, five species of willow, two species of alder, dwarf birch, and 'soapollali.' The spruce is the most important of the trees and constitutes about one-half of the forest growth of the district, extending on timbered hillsides in most places to an elevation of 2,400 feet, and in occasional draws, 400 or even 500 feet higher; specimens having 21 inch stumps were noted in some of the valley-bottoms, but the larger individuals generally range from 12 to 16 inches, and a tree 18 inches in diameter 3 feet from the ground is somewhat exceptional. The two varieties of poplar are very plentiful both on the valley floors and on the hillsides; these have stumps, generally less, and rarely more than 10 inches in diameter. Northern canoe birch occurs in occasional small groves both in the valleys and on the mountain sides, but it rarely has stumps exceeding 10 inches in diameter. Larch was only found in one locality, and only a few small specimens of this tree were noted. Willows, alders, and dwarf birch are very plentiful, reaching to timber line, and in places constituting quite dense thickets; the dwarf birch extends probably the highest and grows prevailingly near timber line, forming in places a dense undergrowth on the upland surfaces; the soapollali and juniper are not nearly so plentiful.

Eleven principal varieties of wild fruits were noted, some of which grow in great abundance; these are, bilberry, alpine bearberry, crowberry, bog apple or yellow berry, northern comandra, red currant, black currant, arctic raspberry, 'soapollali,' foxberry or northern cranberry, and high-bush cranberry. Of these the bilberry, bog apple, crowberry, northern cranberry, and bearberry are particularly abundant, and in places extend over entire hillsides and ridge tops. The high-bush cranberries, red and black currants, and raspberries occur only in occasional patches; the comandra and soapollali berries are fairly abundant but are not pleasant to taste.

The following is from Mr. Macoun's report on the plant specimens, including trees and shrubs, collected in this district:—

'Several species are quite unknown to either my father or myself, and these, with a few others about which we are uncertain, have been sent to specialists. Your collection is valuable in the first place as being the only one that has been brought from that region, and even did it contain nothing new either to Canada or science it would constitute a valuable addition to our knowledge of the flora of northern Canada. However, there are at least ten species that had not before been collected in Canada, and there are at least five new species of which one will, I believe, constitute a new genus. I am keeping a duplicate list on which I shall make corrections as I hear from specialists, and when this has been done the corrected list will be given you. As I have already told you, the specimens, though sometimes few in number, are all excellent in quality.

Polypodiaceae—

Aspidium fragrans, Sw.

Equisetaceae—

Equisetum sylvaticum, L.
" *pratense*, L.
" *fluviatile*, L.

Lycopodiaceae—

Lycopodium Selago, Desc.
" *annotinum*, L., *var. bungens*, Desv.
" *alpinum*, L.
" *clavatum*, L.

Pinaceae—

Juniperus nana, Willd.
Picea canadensis, (Mill.) BSP.
Larix laricina, (DuRoi) Koch.

Gramineae—

Hierachloa alpina, R. and S.
Arctogrostis latifolia, Griseb.
Galamagrostis Langsdorfii, Trin.

Cyperaceae—

Carex microchaeta, Holm.
" *rigida, Good?*
" *rariflora*, Smith.

Juncaceae—

Luzula glabrata, Hoppe.

Liliaceae—

Zygadenus elegans, Pursh.

Orchidaceae—

Cypripedium guttatum, Sw.

Salicaceae—

Populus tremuloides, Mx.
" *balsamifera*, L.
Salix anglorum, Cham.
" *orbicularis*, Andr.
" *phyllicifolia*, Andr.
" *Richardsoni*, Hook.
" *Seemanii*, Rydb.

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FLORA AND FAUNA.

The valleys are generally well timbered and about one-third of the entire country is forest clad, the northern and eastern slopes being considerably more open than the southern and western hillsides; timber line extends to about 2,900 feet above sea-level. Five principal forest members occur that attain the dimensions of trees and ten varieties of shrubs were noted. Specimens were collected during the season of all the plants, including trees and shrubs, that were noted in the district, and these were delivered to Mr. J. M. Macoun of this department, from whose report the names here used are taken. The five main varieties of trees are, white spruce, aspen poplar, balsam poplar, northern canoe birch, and tamarack or American larch, and the more important shrubs include juniper, five species of willow, two species of alder, dwarf birch, and 'soapollali.' The spruce is the most important of the trees and constitutes about one-half of the forest growth of the district, extending on timbered hillsides in most places to an elevation of 2,400 feet, and in occasional draws, 400 or even 500 feet higher; specimens having 21 inch stumps were noted in some of the valley-bottoms, but the larger individuals generally range from 12 to 16 inches, and a tree 18 inches in diameter 3 feet from the ground is somewhat exceptional. The two varieties of poplar are very plentiful both on the valley floors and on the hillsides; these have stumps, generally less, and rarely more than 10 inches in diameter. Northern canoe birch occurs in occasional small groves both in the valleys and on the mountain sides, but it rarely has stumps exceeding 10 inches in diameter. Larch was only found in one locality, and only a few small specimens of this tree were noted. Willows, alders, and dwarf birch are very plentiful, reaching to timber line, and in places constituting quite dense thickets; the dwarf birch extends probably the highest and grows prevailingly near timber line, forming in places a dense undergrowth on the upland surfaces; the soapollali and juniper are not nearly so plentiful.

Eleven principal varieties of wild fruits were noted, some of which grow in great abundance; these are, bilberry, alpine bearberry, crowberry, bog apple or yellow berry, northern comandra, red currant, black currant, arctic raspberry, 'soapollali,' foxberry or northern cranberry, and high-bush cranberry. Of these the bilberry, bog apple, crowberry, northern cranberry, and bearberry are particularly abundant, and in places extend over entire hillsides and ridge tops. The high-bush cranberries, red and black currants, and raspberries occur only in occasional patches; the comandra and soapollali berries are fairly abundant but are not pleasant to taste.

The following is from Mr. Macoun's report on the plant specimens, including trees and shrubs, collected in this district:—

'Several species are quite unknown to either my father or myself, and these, with a few others about which we are uncertain, have been sent to specialists. Your collection is valuable in the first place as being the only one that has been brought from that region, and even did it contain nothing new either to Canada or science it would constitute a valuable addition to our knowledge of the flora of northern Canada. However, there are at least ten species that had not before been collected in Canada, and there are at least five new species of which one will, I believe, constitute a new genus. I am keeping a duplicate list on which I shall make corrections as I hear from specialists, and when this has been done the corrected list will be given you. As I have already told you, the specimens, though sometimes few in number, are all excellent in quality.

Polypodiaceae—

Aspidium fragrans, Sw.

Equisetaceae—

Equisetum sylvaticum, L.
" *pratense*, L.
" *fluviatile*, L.

Lycopodiaceae—

Lycopodium Selago, Desc.
" *annotinum*, L., *var. bungens*, Desv.
" *alpinum*, L.
" *clavatum*, L.

Pinaceae—

Juniperus nana, Willd.
Picea canadensis, (Mill.) BSP.
Larix laricina, (DuRoi) Koch.

Gramineae—

Hierachloa alpina, R. and S.
Arctogrostis latifolia, Griseb.
Galamagrostis Langsdorfii, Trin.

Cyperaceae—

Carex microchaeta, Holm.
" *rigida, Good?*
" *rariflora*, Smith.

Juncaceae—

Luzula glabrata, Hoppe.

Liliaceae—

Zygadenus elegans, Pursh.

Orchidaceae—

Cypripedium guttatum, Sw.

Salicaceae—

Populus tremuloides, Mx.
" *balsamifera*, L.
Salix anglorum, Cham.
" *orbicularis*, Andr.
" *phyllicifolia*. Andr.
" *Richardsoni*, Hook.
" *Seemanii*, Rydb.

Betulaceae—

Betula glandulosa, Mx.
" *resinifera*, (Regel.) Britton.
Alnus tenuifolia, Nutt.
" *sinuata*, (Regel.) Rydb.

Polygonaceae—

Polygonum alpinum var. alaskanum, Small.

Santalaceae—

Comandra livida, Rich.

Caryophyllaceae—

Silene acaulis, L.
" *repens*, Patrin.
Stellaria longipes, Goldie var. *læta*, T. and G.
Arenaria lateriflora, L.
Merckia physodes, Fisch.

Ranunculaceae—

Anemone Richardsoni, Hook.
Anemone (?).
Anemone narcissiflora, L.
Pulsatilla (?).
Ranunculus Lapponicus, L.
" *Eschscholtzii*, Schlecht.
" *affinis*, R. Br.
Delphinium glaucun, S. Wats.
Aconitum delphinifolium, DC.

Papaveraceae—

Papaver radicatum, Rottb.

Cruciferae—

Cardamine purpurea, Cham. and Schl.
Parrya macrocarpa, R. Br.
Lesquerella arctica, (Rich) Watson.
——————— (?). Undescribed genus.

Crassulaceae—

Sedum Rhodiola, DC.

Saxifragaceae—

Saxifraga tricuspidata, Retz.
Therophron Richardsoni, (Hook.) Wheelock.
Parnassea palustris, L.
Ribes rubrum, L.
" *Hudsonianum*, Rich.

Rosaceae—

Spiræa betulifolia. Pallas.
Potentilla nivea, L.
" *fruticosa*, L.
Rubus Chamaemorus, L.
" *arcticus*, L.
" *stellatus*, Smith.
Dryas integrifolia, Ch. and Sch.
Rosa acicularis, Lindl.

Leguminoseæ—
Lupinus arcticus, Wats.
Oxytropis podocarpa, Gray.
Hedysarum boreale, Nutt.

Empetraceæ—
Empetrun nigrum, L.

Violaceæ—
Viola palustris, L.

Elæagnaceæ—
Shepherdia canadensis, Nutt.

Onagraceæ—
Epilobium angustifolium, (L.) Scop.
" *latifolium*, L.

Cornaceae—
Cornus canadensis, L.

Ericaceae—
Ledum palustre, L.
Rhododendron Lapponicum, Wahl.
Loiseleuria procumbens, Desv.
Andromeda Polifolia, L.
Gassiope Mertensiana, (Bong.) Don.
Arctostaphylos alpina, Spreng.
Vaccinium uliginosum, L.
" *Vitis-Idaea*, L.

Diapensaceæ—
Diapensia Lapponica, L.

Gentianaceae—
Gentiana glauca, Pall.

Polemoniaceae—
Phlox Sibirica, L.

Borraginaceae—
Mertensia alaskana, Britton.
Myosotis sylvatica, Hoffm. var. alpestris, Koch.
Eritrichium nanum, Schrad. var.

Selaginaceae—
Gynandra stelleri, Cham. and Schlecht.

Scrophulariaceae—
Castilleja pallida, Kunth. var. septentrionalis, Gray.
Pedicularis flammea, L.
" *Langsdorfii, Fisch, var. lanata*, Gray.

Lentibulariaceae—
Pinguicula villosa, L.

Orabanchaceae—
Boschniakia glabrata, C. E. Meger.

Betulaceae—

Betula glandulosa, Mx.
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Orabanchaceae—
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Rubiaceae—

Galium boreale, L.

Caprifoliaceae—

Viburnum pauciflorum, Pylaie.
Linnaea borealis, Gronov. var americana (Forbes) Rehder.

Valerianaceae—

Valeriana bracteosa, Britton.

Campanulaceae—

Campanula lasiocarpa, Cham.

Compositae—

Crepis elegans, Hook.
Solidago multeradiata, Ait.
Aster sibiricus, L.
Antennaria.
Chrysanthemum integrifolium, Rich.
Artemisia.
Petasites frigida (L.) Fries
Arnica angustifolia, Vahl.
" *alpina*, Olin.
Arnica.
Saussurea remotiflora (Hook.) Rydb.

'The characteristic mosses are: Sphagnum acutifolium, Sphagnum acutifolium var. rubrum, Sphagnum acutifolium var. versicolor, Sphagnum compactum, Dicranum fuscescens, Dicranum Bergeri, Polystichum strictum, Splachnum luteum.

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A few plants from this collection were sent to Dr. Edward L. Greene, Associate in Botany, United States National Museum, Washington, D.C. Among these specimens is a plant considered by Dr. Greene to belong to a new genus which he has named *Melanidion.* This was collected north of Runt creek, at long. 141°, lat. 66° 18′, and at an elevation of 2,300 feet above sea-level, and is described by Dr. Greene as follows:—

'Low perennial herb, with stout suberect branches racemosely floriferous throughout and subsecund. Sepals equal, narrowly oval, persistent even under the mature fruit. Stamens, six; subequal; filaments slightly flattened; anthers oval. Petals equal, the limb cuneate-obovate, obtuse, tapering to a short claw, the colour, purple. Style manifest and stout; stigma capitate. Silicle firmly ceriaceous, subcompressed, suborbicular, the body strongly double-convex, but the valves meeting by flattened margins forming a thick wing-like elevation all around, and dehiscent through this wing or ridge; the whole one-celled, the partition obsolete. Seeds, 1 to 4, oval or round-obovate, not much flattened; cotyledons accumbent.

'*Melanidion boreale.*—Leaves unknown, as also the root and the absolutely basal part of the plant. The branches, the rather long pedicels of the fruits, and the middle of each sepal are all whitened by a villous pubescence. The calyx is wholly of a very dark purple, yet quite herbaceous as to texture. The specimen is very mature, only a few of the corollas remaining at the summits of two of the racemose branches. Most of the silicles had shed their seeds. The valves are straw-coloured, also reticulate-veiny both without and within. The type is of so strange appearance and character that I am unable to name any genus to which I should say that it is nearly allied.'

Dr. Greene has also described a new species of *Anemone* from among the specimens sent him, as follows:—

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'This very beautiful new anemone Dr. Cairnes obtained from two localities in the region; the first specimens are from somewhere north of the Orange fork of the Black river, long. 141°, lat. 66° 10′, the land having an altitude of some 2,000 feet. These were taken on June 21, 1911. Other specimens, and these the best, are from between Teecat and Runt creeks, the altitude 3,000 feet, and were gathered June 26. This is, perhaps, the most beautiful of American species of the genus, and the blue colour of the flowers is remarkable. I gladly dedicate the species to Dr. Cairnes. Viewed as a whole the plant bears some suggestion of *Pulsatilla*; but the perianth is rotate, and from what I see in the pistils as they exist in the flower, I am confident the fruit when known will be shown to be that of genuine *Anemone*.'

Moose, caribou, and sheep are somewhat plentiful in many localities. The moose are the large giant moose, *Alces gigas*; the caribou are also the giant variety, Osborn's caribou, *Rangifer osborni*; and the sheep are Dall's mountain sheep, *Ovis dalli*. Black, brown, and grizzly bears are also plentiful, and with wolves, wolverine, martin, lynx, ermine, and fox constitute the chief fur-bearing animals of the district. Rabbits are also quite plentiful.

The chief game birds noted are: rock ptarmigan, *Lagopus rupestris rupestrus*, (Gmelin); willow ptarmigan, *Lagopus lagopus*; Alaska spruce partridge, *Canachites canadensis osgoodi* (Bishop); Hutchin geese, *Branta canadensis hutchinsi* (Rich), and several varieties of ducks. The ptarmigan are very plentiful and are to be found on nearly every hill. The partridge are also quite abundant, as also are the ducks and geese in certain seasons. A considerable variety of other birds was noted in the district, but only a few specimens were obtained; these have been examined by Mr. P. A. Taverner of this department, who has supplied the above identification as well as the following list: the Alaska jay, *Periospeus canadensis fumifrons* (Ridg.); Swainson hawk, *Butec swainsoni* (Bonaparte); hawk owl, *Surnia ulula caparoch* (Muller); northern varied thrush, *Ixoreus naevius meruloides* (Swain); townsend solitaire, *Myadestes townsendi* (Aud.); grey-checked thrush, *Hylocicicla alicie aticiae*. (Baird)?; fox sparrow, *Passerella iliaca iliaca* (Merriam), Vole (Sp.?).

The streams are generally well supplied with fish, mainly a variety of grayling.

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The geological formations of the area under consideration are mainly of sedimentary origin, but a few small exposures of intrusives were also noted. The sedimentary beds consist of Quaternary gravels, sands, clays, muck, peat, soil, and ground-ice, and Mesozoic, Carboniferous, and Ordovician-Silurian, sandstones, shales, slates, phyllites, quartzites, cherts, cherty conglomerates, limestones, dolomitic limestones,

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TABLE OF FORMATIONS.[1]

Sedimentary.

Quaternary	Superficial deposits	Chiefly gravel, sand, clay, muck, peat, soil, and ground-ice.
Mesozoic (Probably largely Cretaceous)	Orange group	Chiefly sandstone, shale, slate, phyllites, quartzite, dolomite, and magnesite.
Carboniferous	Racquet series	Chiefly limestone, chert, and cherty conglomerate.
Ordovician-Silurian	Porcupine group	Limestone, dolomitic limestone, and dolomite.

Igneous.

Mesozoic or Post Mesozoic	Small isolated exposures of syenite, diabase, diorite, and andesite.	

DESCRIPTIONS OF FORMATIONS.

Porcupine Group.[2]

The rocks belonging to the Porcupine group constitute the bed-rock of the northern 20 miles, approximately, of the area mapped. These beds have an aggregate thickness of at least 5,000 feet and consist of limestones, dolomitic limestones, and dolomites, that range from white through various shades of grey to almost black, and are even occasionally decidedly reddish or pink in colour. Structurally, these rocks are characteristically massive and crystalline, but, especially in some of the darker members, the bedding planes in places are still well preserved. Some heavy beds of beautifully white marble were noted, and in places extensive deposits of lithographic limestone also occur. The members of this group underlie the area in which they occur in gently undulating fashion, the folding being only of local significance.

A number of fossils were collected from different beds of the Porcupine group and all are either of Ordovician or Silurian age. Of these, Dr. E. M. Kindle, of the United States Geological Survey, says:—

'Lot VII j 5.[3]—This lot contains in addition to an undetermined sponge and a poorly preserved *Cladopora*-like coral two well marked species which strongly suggest the Silurian age of the faunule. One of these is a *Meristella* sp. undet. which, so far as can be judged by external characters, is identical with a species in the Wright collection from Glacier bay, Alaska, which has been referred to a late Silurian horizon.

The other is a large ostracode valve belonging to an undetermined species of *Leperditia*. This ostracode represents a form distinct from any of the very large

[1] The formational names used in this report are all of only local significance, and have been only provisionally adopted for convenience of description in this report.

[2] The name Porcupine group is here used for the first time, and has been chosen as the beds to which it refers correspond with the Ordovician-Silurian rocks on Porcupine river, which have already been described. See—
Kindle, E. M., 'Geologic reconnaissance of the Porcupine valley, Alaska'; Bull., Geol. Soc. of Amer., Vol. 19, pp. 322-327.

[3] The Lot numbers refer to localities on the map used in the performance of the field work.

species of this group in the Glacier Bay fauna. The evidence afforded by these two species is not, of course, entirely conclusive, but it is sufficient to suggest provisional reference of this fauna to a late Silurian horizon.

'Lot VI l 48.—The collection from this locality includes a small number of species, which are listed as follows:—

Favosites cf. *niagarensis.*
Camarotoechia cf. *neglecta.*
Conchidium cf. *greenei.*
Conchidium sp. undet.

In addition to the species listed above, two or three species of undetermined bryozoa are present. The *Conchidium*, which is comparable with *C. greenei*, outranks all of the others combined as regards number of individuals represented. This dominant species of the fauna has, however, more numerous and finer striæ as well as other features which distinguish it from *C. greenei*, and doubtless characterize a new species. Although none of the species have been definitely identified with described species, the assemblage is of such a character as to leave no doubt as to its Silurian age. It probably represents a Middle Silurian horizon and may belong to the Silurian fauna which the writer listed from the Porcupine River valley.[1] A larger collection of fossils would be required to determine the latter point.

'Lot VI c 22.—The following species in addition to some undetermined corals represent this lot:—

Streptelasma sp.
Cladopora sp.
Halysites catenulatus.
Trematospira cf. *cornura.*
Bronteus sp.

With the exception of *H. catenulatus* none of the species has thus far been recognized in the Alaskan faunas. I consider the fauna to be probably of early Silurian age. It appears to be somewhat older than the fauna which has been listed from the Porcupine River locality.[2]

'Lot VI n 48.—The oldest fauna in the collection is represented by this lot which includes the following species together with some undetermined forms:—

Favosites sp.
Calapoecia canadensis.
Halysites catenulatus var.
Dipyphyllum sp.
Columnaria alveolata (?)
Labechia sp.
Striatopora sp.
Dinorthis proavita.
Murchisonia sp.
Maclurina manitobensis.
Leperditella (?) sp.

'There appears to be no species common to the above fauna and the previously listed Silurian faunas. The *Halysites catenulatus var.* of Lot VI n 48 is characterized by much smaller corallites than *H. catenulatus* of Lot VI c 22. The Favosite coral also has much smaller corallites than the *Favosites* cf. *niagarensis*, which has been listed in one of the Silurian faunas of this collection. The poor state of preservation

[1] Kindle, E. M.: Bull. Geol. Soc. America, Vol. 19, 1908, p. 325.
[2] Kindle, E. M.: Bull. Geol. Soc. America, Vol. 19, 1908, p. 325.

and dolomites, of which the Mesozoic members extend over about two-thirds of the entire area mapped.

TABLE OF FORMATIONS.[1]

Sedimentary.

Quaternary	Superficial deposits	Chiefly gravel, sand, clay, muck, peat, soil, and ground-ice.
Mesozoic (Probably largely Cretaceous)	Orange group	Chiefly sandstone, shale, slate, phyllites, quartzite, dolomite, and magnesite.
Carboniferous	Racquet series	Chiefly limestone, chert, and cherty conglomerate.
Ordovician-Silurian	Porcupine group	Limestone, dolomitic limestone, and dolomite.

Igneous.

Mesozoic or Post Mesozoic	Small isolated exposures of syenite, diabase, diorite, and andesite.	

DESCRIPTIONS OF FORMATIONS.

Porcupine Group.[2]

The rocks belonging to the Porcupine group constitute the bed-rock of the northern 20 miles, approximately, of the area mapped. These beds have an aggregate thickness of at least 5,000 feet and consist of limestones, dolomitic limestones, and dolomites, that range from white through various shades of grey to almost black, and are even occasionally decidedly reddish or pink in colour. Structurally, these rocks are characteristically massive and crystalline, but, especially in some of the darker members, the bedding planes in places are still well preserved. Some heavy beds of beautifully white marble were noted, and in places extensive deposits of lithographic limestone also occur. The members of this group underlie the area in which they occur in gently undulating fashion, the folding being only of local significance.

A number of fossils were collected from different beds of the Porcupine group and all are either of Ordovician or Silurian age. Of these, Dr. E. M. Kindle, of the Uuited States Geological Survey, says:—

'Lot VII j 5.[3]—This lot contains in addition to an undetermined sponge and a poorly preserved *Cladopora*-like coral two well marked species which strongly suggest the Silurian age of the faunule. One of these is a *Meristella* sp. undet. which, so far as can be judged by external characters, is identical with a species in the Wright collection from Glacier bay, Alaska, which has been referred to a late Silurian horizon.

The other is a large ostracode valve belonging to an undetermined species of *Leperditia*. This ostracode represents a form distinct from any of the very large

[1] The formational names used in this report are all of only local significance, and have been only provisionally adopted for convenience of description in this report.

[2] The name Porcupine group is here used for the first time, and has been chosen as the beds to which it refers correspond with the Ordovician-Silurian rocks on Porcupine river, which have already been described. See—
Kindle, E. M., 'Geologic reconnaissance of the Porcupine valley, Alaska'; Bull., Geol. Soc. of Amer., Vol. 19, pp. 322-327.

[3] The Lot numbers refer to localities on the map used in the performance of the field work.

species of this group in the Glacier Bay fauna. The evidence afforded by these two species is not, of course, entirely conclusive, but it is sufficient to suggest provisional reference of this fauna to a late Silurian horizon.

'Lot VI l 48.—The collection from this locality includes a small number of species, which are listed as follows:—

Favosites cf. *niagarensis.*
Camarotoechia cf. *neglecta.*
Conchidium cf. *greenei.*
Conchidium sp. undet.

In addition to the species listed above, two or three species of undetermined bryozoa are present. The *Conchidium*, which is comparable with *C. greenei*, outranks all of the others combined as regards number of individuals represented. This dominant species of the fauna has, however, more numerous and finer striæ as well as other features which distinguish it from *C. greenei*, and doubtless characterize a new species. Although none of the species have been definitely identified with described species, the assemblage is of such a character as to leave no doubt as to its Silurian age. It probably represents a Middle Silurian horizon and may belong to the Silurian fauna which the writer listed from the Porcupine River valley.[1] A larger collection of fossils would be required to determine the latter point.

'Lot VI c 22.—The following species in addition to some undetermined corals represent this lot:—

Streptelasma sp.
Cladopora sp.
Halysites catenulatus.
Trematospira cf. *cornura.*
Bronteus sp.

With the exception of *H. catenulatus* none of the species has thus far been recognized in the Alaskan faunas. I consider the fauna to be probably of early Silurian age. It appears to be somewhat older than the fauna which has been listed from the Porcupine River locality.[2]

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Favosites sp.
Calapoecia canadensis.
Halysites catenulatus var.
Dipyphyllum sp.
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of the material representing this coral does not indicate whether or not it can be discriminated from the Silurian species of *Favosites*. The genera *Favosites*, *Striataporo*, and *Diphphyllum* have not previously been found associated together in a pre-Silurian fauna so far as the writer is aware. The presence in the fauna, however, of such characteristic Ordovician fossils as *Calapoecia canadensis*, *Maclurina manitobensis*, and *Dinorthis proavita* seems clearly to place the fauna in the Ordovician. The last named species resembles somewhat the Silurian shell *Orthis flabellites*, but Mr. E. O. Ulrich who has examined the specimens considers them identical with the Minnesota representatives of *D. proavita*. *M. manitobensis* is a characteristic and widely distributed species in the Ordovician of Alaska, occurring in both the extreme eastern and western parts of the territory. *Calapoecia canadensis* is another Ordovician species which has a wide distributiou in the northern part of the continent. It is one of the abundant corals in the Ordovician of the Seward peninsula.'[1]

In addition, Mr. Lawrence Lambe, of this department, states:—

'Three limestone fragments of fossil coralla, from Dr. Cairnes' Yukon-Alaska boundary collection of 1911, are determined by me as follows:—

From locality VI, C. 22:—

1 specimen of *Favosites gothlandica*, Lamarck.

The corallites in this specimen average about 3 mm. in diameter, there are numerous flat tabulae, and pores can be obscurely seen in sides of the walls, but neither in transverse nor in longitudinal sections of the coral can spiniform septa be detected. The species represented is with little doubt *F. gothlandica*.

1 specimen which probably is referable to Favosites but in which the absence of clearly defined structure renders a definite determination impossible.

From locality VI, U. 11:—

1 specimen which apparently belongs to the geuus Boreaster, Lambe.

'This genus has hitherto been known only from the Silurian of Beechey island, Lancaster sound, where it occurs with *Favosites gothlandica* (vide "Notes on the fossil corals collected by Mr. A. P. Low at Beechey island, Southampton island, and Cape Chidley, in 1904," by Lawrence M. Lambe, appendix IV, The Cruise of the Neptune, by A. P. Low).

'Dr. Cairnes' specimen reveals the presence of septa apparently of the nature of those found in Boreaster, and of mural pores arranged in vertical series. Flat tabulae are numerous and the walls of the corallites are thick, with their line of junction in contiguous corallites distinctly shown in longitudinal sections. In consequence of a decided thickening of the walls the connecting pores are conspicuously lengthened and they appear in longitudinal sections as mural passages whose length is four or five times their diameter. The corallites are generally five or six sided, and their calicular edges are ornamented with a single series of tubercles in which each tubercle represents the union of the upper ends of two septa of contiguous corallites.

'This specimen differs from *Boreaster lowi*, Lambe, the type species of the genus from Beechey island, in the following particulars—the corallites have twice the diameter, the walls of the corallites are much thicker, the tabulae appear to be more numerous as do also the mural pores which are, however, relatively smaller. Dr. Cairnes' specimen may represent a species distinct from *B. lowi* and should be further studied with this possibility in view.

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As already mentioned *Favosites gothlandica* and *Boreaster lowi* form part of the Silurian fauna of Beechey island. The discovery of *B. lowi* (or a nearly allied species of the genus) in northern Yukon is of interest as it implies that similar conditions affecting marine life prevailed in the north over a very extensive area during Silurian times.'

Racquet Series.[1]

The rocks belonging to the Racquet series extend over an area 6 miles long measured in a northerly direction, by 1 to 3 miles wide, the southern boundary of which is about 11 miles north of the Orange fork of Black river. The beds have an aggregate thickness of at least 1,500 feet and consist mainly of limestones, cherts, and cherty conglomerates, all three of which occur in places intimately associated.

The limestones are generally quite crystalline and range from nearly white through various shades of grey to almost black in colour, occasional reddish members being also noted; on fresh fractures, however, these beds are typically dark grey to nearly black. The upper limestone beds nearly everywhere contain chert pebbles which in places constitute the cherty conglomerates of this series, and all gradations occur from a limestone including only occasional chert pebbles to a cherty conglomerate with a siliceous matrix and containing no perceptible lime. The chert pebbles are well rounded and usually about the size of marbles, but some were noted as large as 1½ to 2 inches in diameter. In colour, most of the pebbles are some shade of grey, but occasional quite black individuals were noticed. Beds of pure massive chert similar in appearance to that cômposing the conglomerate pebbles occur in places, but are not nearly so extensive as the limestone or conglomerate members.

A number of fossils were found in the limestone beds of this series concerning which Dr. Raymond, after a preliminary examination, reports:—

'Specimens obtained from lower beds—

Productus, sp. ind.
Aviculopecten cf. A. affinis. Walcott.
A. cf. A. hagnei, Walcott.
Aviculopecten, 2 species.

'These Aviculopectens suggest the fauna of the White Pine shale of the Mississippian of Nevada.

'Specimens obtained from upper beds—

Productus, sp. ind.
Spirifer cf. S. alatus, Schlotheim.
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Canarophoria margaritovi, Tschernyscheu (?)
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Productus aff. P. gruenewaldti, Stuck.
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Dielasma bovidens, Morton.
Eumetria, sp. ind.

'Nearly all the above specimens from the upper beds were sent to Dr. George H. Girty of the United States Geological Survey, who very kindly determined them.

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He states that the fauna is that which occurs in the highest Carboniferous limestone in the Calico Bluff section of the Yukon.'

This series corresponds lithologically with the lower Cache Creek group[1] of British Columbia and Yukon, which, however, has not been very definitely defined. palæontologically, but from the fossils that have been reported it would appear that probably the lower Cache Creek group includes the Racquet series. Chert, cherty conglomerates and breccias, and limestones that lithologically also closely resemble the members of the Racquet series occur extensively on Macmillan river.[2]

The Orange Group.[3]

The Orange group is the most extensive geological terrane encountered, and extends over about two-thirds of the area mapped during the past season. These rocks outcrop south of the Orange fork of Black river and continue northward for a distance of over 40 miles, and with the exception of the 10 or 12 square miles throughout which the Carboniferous beds outcrop, and less than one square mile of igneous rocks, the Orange beds constitute the bed-rock throughout this 200 square miles of territory.

The group consists chiefly of slates, phyllites, quartzites, sandstones, shales, and occasional dolomite and magnesite beds. The quartzites range from nearly white to dark grey in colour, and are typically massive with a sugar-grained texture. Occasional beds, however, contain a certain amount of mica and chlorite, which in places are arranged in definite streaks between layers of purer quartzite, giving to the rocks a distinctly gneissoid habit.

The slates vary greatly in colour, being generally, however, black or various shades of grey, green, red, or brown. They have everywhere a decided secondarily induced cleavage and generally break readily into plates from one to several feet in diameter and as thin as $\frac{1}{16}$ of an inch or even less. Probably the most noticeable and persistent beds in the Orange group are certain beautifully banded red and green slates, the alternate bands of which are in places extremely thin and delicate and not more than $\frac{1}{4}$ to 2 inches in thickness, and frequently much less, presenting thus a decidedly ribbon-like appearance. The colours are apparently due to the various stages in the oxidation of the sediment before it settled from suspension, which is thought to be the result of changing climate. Writing on 'the colours of variegated shales.' Professor John Barrell, of Yale University, states[4]: 'This is mainly dependent upon the oxidation of the iron and the presence or absence of carbon; and in marine sediments I think it is generally due to the nature of the sediment before it comes to rest. I think it is typical of intermediate climatic states. Arid climates tend to give red shades, both marine and continental; semi-arid or seasonably arid tend to give uniform red or brown shades, more especially to continental river deposits; humid climates favour deoxidation and give uniform grey to black shades; climates oscillating about the mean will give variegated shades. Of course with any climate the physiographic factors are also fundamental.'

The phyllites[5] also vary considerably in colour, but are generally some shade of grey, although occasional greenish, brownish, or black members were noted. These

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Gwillim, J. C. Ann. Rep., Geol. Surv., Can., Vol. XII, pp. 16 B-18 B.
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[2] McConnell, R. G. Ann. Rep. Geol. Surv., Can., 1902, Vol. XV, pp. 31 A-34 A.

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[4] Private communication.

[5] The term phyllite is here used in the sense in which it is intended by Rosenbusch, i.e., it includes all those rocks that resemble slates in structure, origin, and composition, but differ from these in containing noticeably more mica which gives a decidedly glistening appearance to the cleavage surfaces. A typical phyllite (Tonglimmerschiefer) is also somewhat coarser textured than an ordinary slate.

rocks are distinguished from the slates by containing more mica, and in general being somewhat coarser textured. In places, the phyllites are much crinkled, folded, and distorted—monoclinal and even closed folds being exhibited in hand specimens; these rocks, also, wherever found, break readily along the cleavage planes and frequently large thin slabs are procurable.

The sandstones and shales were only rarely noted and are the less metamorphosed phases of the slates, phyllites, and quartzites.

The dolomites and magnesites almost invariably weather to a rough surface and red colour due to the considerable amount of iron they contain. The dolomite beds are 100 to 200 feet or even more in thickness in places, but the magnesite beds rarely exceed 10 feet, and in places occur interbanded with the slates and dolomites, in layers less than 2 feet in thickness.

No accurate estimate could be formed as to the aggregate thickness of this group, as nowhere was a section found where the uppermost beds are preserved, and only small portions of it could be observed at a place. Also, on account of the metamorphosed condition of the rocks it was difficult, in most places, to determine the dip and strike of the beds. The group is, however, at least 6,000 feet in thickness and may be considerably more.

These beds overlie the Racquet Creek rocks, but nowhere could it be determined whether or not an unconformity exists between the two series.

The only fossils found in the Orange beds occur within 100 feet of the underlying Carboniferous rocks, and of these Dr. T. W. Stanton, of the United States Geological Survey, reports that owing to their poor and peculiar state of preservation, they cannot be definitely determined. He says: 'The specimens labelled F 18, 56, 59, 119, and some others appear to be casts of a simple species of *Ostrea*. The larger specimen labelled F 10 is probably a *Pecten*. The specimens labelled F 36, 64, and some others are referred to *Astarte* or a related genus. My judgment is that these fossils are not older than Mesozoic and they may be Cretaceous, though there is no definitely distinctive Cretaceous fossil among them, and they do not seem to fall into any fauna known to be from that region.'

On account of the distinctive lithological appearance of certain members of this group, especially the green and red banded slates, these are thought, in all probability, to be the same as certain beds occurring on the Macmillan and Upper Stewart rivers, which have been described both by Mr. R. G. McConnell[1] and Mr. Joseph Keele.[2] Mr. Keele found Triassic fossils in or immediately below rocks apparently corresponding to the members of the Orange group.

Igneous.

The igneous rocks occurring in the district are all intrusives and pierce the Mesozoic, Orange group; they were found only at five points and their outcrops are of relatively slight extent. The largest exposure occurs about 2 miles west of the boundary line and 5 miles south of the Stony fork of Black river, and appears to represent a small boss about one-fourth of a mile in diameter. This rock has a typical granitic habit, greyish colour, somewhat coarsely holocrystalline texture, and under the microscope is seen to consist mainly of microcline, microperthite, and biotite with a few small particles of accessory iron-ore, and their alteration products muscovite and calcite. It is thus a mica syenite.

The next largest exposure occurs about 2 miles west of the boundary line and three-fourths of a mile north of the Stony fork of Black river, and is at least 40

[1] McConnell, R. G. "The Macmillan river, Yukon district": Ann. Rep., Geol. Surv., Can., Vol. XV, pp. 31 A-34 A.

[2] Keele, J. "The Upper Stewart River region, Yukon": Ann. Rep., Geol. Surv., Can., Vol. XVI, pp. 13 C-18 C. "A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories": No. 1097, 1910, pp. 33-36, 39-40.

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Gwillim, J. C. Ann. Rep., Geol. Surv., Can., Vol. XII, pp. 16 B-18 B.
Cairnes, D. D. "A Portion of Conrad and Whitehorse mining districts, Yukon"; Geol. Surv., Dept. of Mines, 1908, pp. 25-29.

[2] McConnell, R. G. Ann. Rep. Geol. Surv., Can., 1902. Vol. XV, pp. 31 A-34 A.

[3] The name Orange group is here used for the first time, and is adopted, as the first of the rocks to which it is applied, that were enconntered during the past summer, occur on the Orange fork of Black river.

[4] Private communication.

[5] The term phyllite is here used in the sense in which it is intended by Rosenbusch, i.e., it includes all those rocks that resemble slates in structure, origin, and composition, but differ from these in containing noticeably more mica which gives a decidedly glistening appearance to the cleavage surfaces. A typical phyllite (Tonglimmerschiefer) is also somewhat coarser textured than an ordinary slate.

rocks are distinguished from the slates by containing more mica, and in general being somewhat coarser textured. In places, the phyllites are much crinkled, folded, and distorted—monoclinal and even closed folds being exhibited in hand specimens; these rocks, also, wherever found, break readily along the cleavage planes and frequently large thin slabs are procurable.

The sandstones and shales were only rarely noted and are the less metamorphosed phases of the slates, phyllites, and quartzites.

The dolomites and magnesites almost invariably weather to a rough surface and red colour due to the considerable amount of iron they contain. The dolomite beds are 100 to 200 feet or even more in thickness in places, but the magnesite beds rarely exceed 10 feet, and in places occur interbanded with the slates and dolomites, in layers less than 2 feet in thickness.

No accurate estimate could be formed as to the aggregate thickness of this group, as nowhere was a section found where the uppermost beds are preserved, and only small portions of it could be observed at a place. Also, on account of the metamorphosed condition of the rocks it was difficult, in most places, to determine the dip and strike of the beds. The group is, however, at least 6,000 feet in thickness and may be considerably more.

These beds overlie the Racquet Creek rocks, but nowhere could it be determined whether or not an unconformity exists between the two series.

The only fossils found in the Orange beds occur within 100 feet of the underlying Carboniferous rocks, and of these Dr. T. W. Stanton, of the United States Geological Survey, reports that owing to their poor and peculiar state of preservation, they cannot be definitely determined. He says: 'The specimens labelled F 18, 56, 59, 119, and some others appear to be casts of a simple species of *Ostrea*. The larger specimen labelled F 10 is probably a *Pecten*. The specimens labelled F 36, 64, and some others are referred to *Astarte* or a related genus. My judgment is that these fossils are not older than Mesozoic and they may be Cretaceous, though there is no definitely distinctive Cretaceous fossil among them, and they do not seem to fall into any fauna known to be from that region.'

On account of the distinctive lithological appearance of certain members of this group, especially the green and red banded slates, these are thought, in all probability, to be the same as certain beds occurring on the Macmillan and Upper Stewart rivers, which have been described both by Mr. R. G. McConnell[1] and Mr. Joseph Keele.[2] Mr. Keele found Triassic fossils in or immediately below rocks apparently corresponding to the members of the Orange group.

Igneous.

The igneous rocks occurring in the district are all intrusives and pierce the Mesozoic, Orange group; they were found only at five points and their outcrops are of relatively slight extent. The largest exposure occurs about 2 miles west of the boundary line and 5 miles south of the Stony fork of Black river, and appears to represent a small boss about one-fourth of a mile in diameter. This rock has a typical granitic habit, greyish colour, somewhat coarsely holocrystalline texture, and under the microscope is seen to consist mainly of microcline, microperthite, and biotite with a few small particles of accessory iron-ore, and their alteration products muscovite and calcite. It is thus a mica syenite.

The next largest exposure occurs about 2 miles west of the boundary line and three-fourths of a mile north of the Stony fork of Black river, and is at least 40

[1] McConnell, R. G. "The Macmillan river, Yukon district": Ann. Rep., Geol. Surv., Can., Vol. XV, pp. 31 A-34 A.

[2] Keele, J. "The Upper Stewart River region, Yukon": Ann. Rep., Geol. Surv., Can., Vol. XVI, pp. 13 C-18 C. "A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories": No. 1097, 1910, pp. 33-36, 39-40.

yards in width, but as bed-rock exposures are scarce at this point on account of the heavy covering of superficial material, the nature and extent of this outcrop was not determined. Megascopically the rock is finely-textured, holocrystalline, and dark-greenish in colour; a typical specimen examined under the microscope proved to be a quartz mica diorite, consisting chiefly of plagioclase, orthoclase, quartz, biotite, green hornblende, and accessory sphene and iron-ore.

The other three exposures of igneous rocks represented dykes less than 100 feet in width and traceable on the surface for less than 200 feet. These rocks are all finely textured, greenish materials. A typical sample from each locality was examined microscopically; of these, two specimens proved to be andesite and the other diabase.

Economic Geology.

The only deposits that have been found in this district that are of interest from the standpoint of economic geology are marble, lithographic limestone, and magnesite. Numerous beds of magnesite up to 10 or even more feet in thickness occur intercalated in the dolomites and slates of the Orange group in various places. Beds of beautiful pure, white marble up to 15 feet in thickness, and other beds up to 50 feet in thickness of what appeared to be a fair grade of lithographic limestone were noted in places and are included in the Porcupine series.

However important these might be if found in other places, situated as they are, so far from transportation, they possess no present economic value.

II

QUARTZ MINING IN THE KLONDIKE DISTRICT.[1]

Introduction.

After completing the regular season's work along the 141st meridian[2] (the Yukon-Alaska boundary) a few days in September were spent in the examination of a number of the more promising quartz properties in the Klondike district, mainly in that portion of Dawson Mining district which is situated along and between Indian and Klondike rivers and their tributaries.

Considerable interest has of late been displayed concerning the quartz veins of the Klondike, and special efforts are being made to develop the lode mining of this district, in the hope that a revenue may eventually be derived from this source that will continue to foster the mining industry of this portion of Yukon when the placer deposits have become exhausted, which it is thought, however, will not be for many years to come.

Summary and Conclusions.

Quartz veins are very plentiful in the schistose rocks of the Klondike district, and although the greater number of these deposits are small and non-persistent, still the aggregate amount of quartz is very great. Occasional very encouraging assays have been obtained, but with rare exceptions it is not even approximately known what average amounts of gold the deposits in the different localities contain. The quartz is practically all free-milling and is but slightly mineralized, the only metallic constituents apparent being pyrite, and rarely magnetite, chalcopyrite, galena, and native gold.

[1] Brock, R. W. Sum. Rep. Geol. Surv., Dept. of Mines, 1909, pp. 16-22.
[2] For the results of this work see pp. 17-33 of this Summary Report.

More systematic sampling and assaying should be conducted to obtain a fair general idea of the gold content of the quartz, and the various deposits should be more thoroughly prospected to ascertain their probably lateral and vertical extent. In case the results of these tests prove sufficiently encouraging, it would be particularly advantageous to have a stamp mill built at some convenient point capable of handling readily and quickly 5 or 10 tons samples from the various deposits of the district; in this manner claim owners could obtain sure and ready information concerning their properties. This is virtually the only way that reliable results can be obtained from these low-grade, free-milling deposits, as it is almost impossible to obtain perfectly satisfactory results from ordinary assay samples, and the expense of shipping small samples to outside points is practically prohibitive.

The Quartz Deposits.

A great amount of quartz occurs in the old schistose rocks that are so extensively developed in the Klondike district, and in some localities it is in sufficient quantity to even constitute a considerable portion of the whole rock mass. The quartz occurs prevailingly in veins which exhibit considerable variety of form, and are as a rule small and non-persistent, but range in size from mere threads to masses several hundred feet in length but in most places less than 10 feet in thickness; one vein, however, on Yukon river below the mouth of Caribou creek, exceeds 30 feet in thickness.

The most common type of vein is lenticular in form, the individual lenticles measuring but a few inches in thickness and less than 50 feet in length; in places, however, individuals as much as 10 feet in thickness occur, but even these are rarely traceable for any considerable distances. The lenses in most places follow, in a general way at least, the strike of the schistosity of the containing rocks, but along their dips they frequently cut the wall rocks at various angles.

Typical bedded or sheeted veins are also characteristic of some localities; in this type of deposit the quartz occurs interleaved with the folia of the schists, the individual quartz bands being generally but a few inches in thickness; in places such deposits occur in zones up to 10 feet or more in width that consist entirely of alternate quartz and schist lamellæ exhibiting a wide range of relative proportions.

Typical fissure veins were also noted, but on account of the decidedly schistose and fractured character of the enclosing rocks, these veins readily pass into the lenticular or sheeted types, due to the fact that the solutions from which the quartz was deposited, were naturally frequently diverted in whole or in part from the particular channels along which they might at any time be travelling, on account of the multitude of cleavage and fracture cracks which intersect these rocks, affording thus numerous routes for percolating waters. All types of veins are thus liable to bifurcate or branch out, and smaller veins frequently unite to form larger deposits. In places along lines of previous excessive fracturing, mineralized zones occur in which several of the vein types are represented; lenses, sheets, pockets, and various irregular deposits of quartz may be separated by and include varying amounts of wall rock, and the whole be intersected by, or associated with numerous stringers and fissure veins of quartz.

A notable feature of some of the veins is the presence in them of occasional feldspar crystals indicating their relation to certain pegmatites in the vicinity. In this connexion Mr. McConnell says[1]: 'A few examples of typical pegmatite veins or dykes occur in the district, and in one case, a coarse-grained pegmatite vein was observed to pass along its strike into a purely siliceous rock. The aqueo-igneous origin of the pegmatites, and their close genetic connexion with certain classes of

[1] McConnell, R. G. "Report on the Klondike gold fields": Ann. Rep., Geol. Surv., Can., Vol. XIV, p. 63 B.

quartz veins, maintained by various writers, is supported by the facts observed in the Klondike district.'

The quartz veins are in most places but slightly mineralized; pyrite and more rarely magnetite occur in places in sufficient quantity to produce a reddish coloration on the exposed and oxidized portions of the veins, and in a few places the quartz contains particles of galena, chalcopyrite, and native gold.

The Economic Importance of Quartz.

Often fair and occasionally even high assays are obtained, and in places the quartz shows native gold, but, except in possibly a very few instances, it is not known even approximately what average amounts of gold the quartz contains. From the various properties that have been examined, however, the gold that does occur is always either associated with metallic sulphides or is at or near the contact between the quartz and schists; in the latter case the gold is generally found in both vein material and wall rock.

It would thus seem possible that some of the fractured zones that have become irregularly impregnated with quartz, may prove of greater value than the more clearly defined massive veins, since the former contain a greater area of contact-surfaces in the same volume or weight of material. However, the majority at least of the mineralized zones that have been examined, do not appear to be sufficiently persistent to allow of their containing sufficient quantities of pay-ore to make a mine; it is possible, nevertheless, that larger and more richly mineralized zones may yet be found. In a number of places several veins or mineralized zones which were noted in close proximity to each other could be worked conjointly. These would yield a considerable tonnage, and would become important producers if the bulk of the quartz will pay for milling. It is thought that, since the majority of the veins are non-persistent, the successful exploitation of the quartz of this district will largely depend on finding groups of veins or mineralized zones sufficiently close to allow of their being worked conjointly.

The deposits that have already been discovered in Klondike, in all probability represent but a small portion of the quartz that actually exists in the district, as bedrock is covered by superficial deposits in most places, except along the summits of the hills and ridges, and along the sides of the secondary valleys, where the bulk of the quartz occurs that has so far been found; other discoveries have been largely accidental and due frequently to placer operations. It is, therefore, probable, that future prospecting and development will disclose numerous deposits that are at present unknown.

More development should be performed, however, in connexion with the quartz deposits of the district that have been already discovered, with a view to ascertaining their extent, and more systematic sampling and assaying should be performed in order to determine within reasonable limits, at least, the average values of the materials they contain. It seems probable that at least the upper weathered and decomposed portions of a number of the deposits could be profitably milled, due to the fact that the district has not been glaciated, and a certain surface concentration of gold is to be expected, and in places is known to occur.

Prospectors and others interested in lode mining frequently do not sufficiently realize the importance of assays, and when these are made, in probably the majority of instances in Klondike district, they are from samples that are not representative of the deposits from which they are taken. Two reasons seem mainly to account for this condition: one is that it is not as convenient to have assays made in Yukon as in most mining districts, and moreover it is frequently realized how difficult it is to obtain really representative assay samples from free-milling deposits.

The most reliable and satisfactory results for such ores are obtained from mill tests of at least 5 or 10 ton lots. A sampling mill capable of making tests of 10 ton samples of the different quartz deposits of this district would greatly facilitate the development of the industry, and would stimulate prospecting throughout the district. With such a mill situated somewhere in the vicinity of Dawson, sufficient information could be obtained in a short time, possibly in one or two seasons, to demonstrate whether the Klondike has or has not a future in quartz. If these deposits are not profitably workable, the sooner this is known the better it will be for those owning, holding, and developing such properties; also if a number of deposits are sufficiently rich to become producers, the earlier this fact is established the greater will be the benefits that will accrue to the territory in general and to those most interested. In the meantime, however, it is important that more definite information be obtained concerning the extent and average value of the various deposits throughout the district.

Mining Properties.

GENERAL STATEMENT.

Among the more promising quartz properties in the Klondike district, and those on which the most energy has been expended in development, are: the Lone Star group, near the head of Victoria gulch, a tributary of Bonanza creek; the Violet group, situated along the divide between Eldorado and Ophir creeks; the Mitchell group, on the divide between the heads of Hunker and Goldbottom creeks; the Lloyd group and neighbouring claims, situated along the divide between the heads of Green gulch and Caribou gulch, tributaries respectively of Sulphur and Dominion creeks; and several groups of claims on Bear creek near where joined by Lindow creek. Of these, the Lone Star was the only property on which any work, other than the necessary assessment duties, was being performed during the summer of 1911.

In addition to the above-mentioned properties, considerable enthusiasm has been aroused during the past two seasons over a number of claims staked on Dublin gulch, a tributary of Haggart creek which drains into the south fork of McQuesten river. This locality is not in the Dawson mining district, but is in the Duncan Creek mining district; it is, nevertheless, frequently spoken of as being in the general Klondike district and will be here so considered.

The Lone Star Group.[1]

The Lone Star group is situated near the head of Victoria gulch, a tributary of Bonanza creek. This property is owned by a joint stock company with head office in Dawson and having a capitalization of $1,500,000; the president, Dr. Wm. Catto, as well as the secretary-treasurer, and the majority of the board of directors also reside in Dawson.

On these claims two main veins, or really one vein and a mineralized zone, have been discovered, which have been, by the owners, designated respectively the 'Corthay vein' and the 'Boulder lode'; these occur in much metamorphosed sericite and chloritic schists. The Boulder lode strikes N. 50° W.,[2] dips from 70° to 80° to the S.W., and is in most places at the surface from 3 to 10 feet in width, containing 1 to 7 feet of quartz. This 'lode' has been traced definitely along its outcrop for 400 feet, and quartz is exposed at various points in the same general line of strike for 600

[1] McConnell, R. G. "Report on the Klondike gold fields": Ann. Rep., Geol. Surv., Can., Vol. XIV, pp. 64 B-65 B.

[2] All bearings given in this report are astronomic or true. The magnetic declination in the Klondike district is in most places 35° east.

feet farther, indicating that this zone may persist for this distance. The quartz occurs prevailingly in lenses, sheets, and irregular bodies ranging in size from those that are only microscopically observable to others 3 or 4 feet in thickness; these are interbanded or interfoliated with the schists, and generally agree with them in strike, but along their dips cut the planes of schistosity of the enclosing rock at various angles up to 90°. In places masses of practically solid quartz as much as 4 or 5 feet thick occur, but such a condition is rather exceptional. Numerous fissure veins or stringers less than 6 inches in thickness, intersect the main zone in various directions.

The Corthay vein strikes N. 14° W., has an almost perpendicular attitude, and where it has been explored is much more regular than the Boulder lode; this deposit also resembles more an ordinary compound fissure vein, and consists mainly of quartz which is in most places from 3 to 6 feet in thickness.

The quartz of both the Corthay vein and the Boulder lode is but slightly mineralized, the only metallic constituents that were noted being pyrite and native gold. The pyrite occurs as scattered particles or in small bunches, and is in sufficient amount in places to give the quartz a rusty appearance where weathered. The native gold occurs mainly as occasional grains and nuggets both in the quartz and wall-rock, but prevailingly near their contact, and is in places quite well crystallized.

An open-cut about 70 feet long, 10 feet wide, and having an average depth of approximately 15 feet, as well as 8 or 10 smaller surface cuts or pits have been dug at intervals along the strike of the Boulder lode. A cross-cut tunnel 310 feet long has also been driven, from which, when examined in September, 1911, about 40 feet of drifting had been run on the Boulder lode which at this depth of approximately 60 feet was much narrower than at the surface and contained in most places less than 2½ feet of quartz. A vertical shaft has been sunk through the schists and tapped the Corthay vein at a depth of 60 feet where the quartz was about 4 feet thick. Another shaft 40 feet deep has been sunk on the Corthay vein and was connected with a drift from the tunnel by a 30 foot upraise; a drift 70 feet long was also run from the bottom of this shaft.

A four-stamp Joshua Hendry mill has been erected on this property, and a gravity tramway 3,500 feet long has been constructed to convey the ore from the workings to the mill on the creek about 900 feet below. A power line 4 miles long was about completed in September, which was to convey power to the mill from the power line of the Northern Light and Power Company on Bonanza creek, the cost of the power to be at the rate of three cents per horse-power.

Miners working on this property and in the vicinity receive $4 per day (10 hours) and board.

The manager of the Lone Star group claims to be able to mine and mill the ore from this property for $3.50 per ton. It is not known what average amounts of gold the quartz and adjoining rock there contain, but a number of promising assay returns have been received and the tests that have been made indicate that at least the somewhat decomposed superficial portion of the Boulder lode and possibly of the Corthay vein as well should pay to mill. No definite information was obtained concerning the remaining portions of the deposits.

The Violet Group.[1]

The Violet group is situated on the divide between Eldorado and Ophir creeks, about 5 miles from Grand Forks, and consists of four claims and a fraction, all of which are Crown granted. It is claimed that $60,000 have been spent in developing this property which, however, was sold by public auction in September, 1910, and acquired by the present owner, Mr. H. H. Honen.

[1] McConnell, R. G. "Report on the Klondike gold fields": Ann. Rep. Geol. Surv., Can., Vol. XIV, p. 65 B.

Three veins are reported to have been discovered on this property, but the bulk of the work has been done on one of these which strikes in a southeasterly direction with the enclosing schists, but dips across them. This vein is in most places from 3 to 6 feet in thickness, and the quartz composing it is crystalline and contains considerable reddish feldspar giving it a pegmatitic appearance. The quartz contains considerable iron which near the surface weathers and gives the vein a rusty appearance; particles of galena were also noted. It is not known what amounts of gold this vein contains but it is stated to average $10 to $11 per ton.

Three shafts, respectively 55 feet, 35 feet, and 150 feet in depth have been sunk on the property, and 300 feet of drifts have been driven; in addition, one open-cut 50 by 12 by 15 feet approximately, and a number of smaller cuts have been dug.

The Mitchell Group.

The Mitchell group is situated on the divide between the heads of Hunker and Goldbottom creeks, and consists of about 27 claims which are owned by Mrs. Margaret J. Mitchell.

A number of quartz veins occur on this property, but as the surface of the ridge on which these have mainly been discovered is in most places covered with superficial materials, it is not known either how many veins may be present, nor even how many veins the known occurrence of quartz represent, as considerable stretches of bed-rock are still covered between the different exposures. Quartz occurs in a number of small cuts or trenches more or less in alignment, that have been made on one part of the property at intervals throughout a distance of about 2,000 feet, yet this by no means proves that the quartz all belongs to the same vein; in places, trenches were sunk to bed-rock across the supposed line of strike of this vein, and no quartz was encountered: and further, the exposures themselves are, in places, decidedly lenticular in form. For 600 to 800 feet, however, quartz has been found along a N. 5° W. direction wherever bed-rock has been exposed to view, which is at frequent intervals; it would thus seem that for this distance either a fairly regular fissure vein or a nearly connected line of quartz lenses occurs. Other parallel lines of exposures were also noted, indicating that at least 3 or 4 veins and possibly many more than this number occur.

The quartz is all deposited in sericite schist, and whenever contacts between the quartz and wall-rock were noted the quartz cuts the schist folia along both dip and strike. The veins range from a few inches to 7 or 8 feet, but are in most places from 2 to 4 feet in thickness; the quartz generally contains almost no metallic constituents, but in places exhibits considerable disseminated pyrite which causes weathered surfaces to have a rusty appearance. A few particles of galena and native gold were also noted.

Only a few samples were taken from this property, but the results obtained from the analysis of these few, all indicate that the white unmineralized quartz rarely carries more than traces of gold, which mineral almost invariably occurs either associated with the metallic sulphides or near the contact of the quartz and schist, and in either material.

The development work performed on this property consists mainly of a number of open-cuts, shallow trenches, and pits, and also a shaft 80 feet deep, from which a 50-foot drift has been driven. The shaft was filled with water when visited, but a grab sample was taken from the dump, which assayed $5 in gold per ton[1]; this is the highest assay obtained from the various samples taken by the writer from the Mitchell group, although much higher returns are believed to have been received from other samples taken previously. It, therefore, appears that, although the aggregate amount

[1] All the samples that were taken by the writer from the various claims in the Klondike district during the past season, were assayed by the Mines Branch of the Department of Mines, Ottawa

of quartz on this group of claims is considerable, by no means all the material will pay for treatment. The various veins should thus all be systematically sampled, to obtain an estimate of their probable average values, and to determine approximately the veins and portions of these that will pay for mining and treatment.

The Lloyd Group.

The Lloyd group is situated at the head of Green and Caribou gulches, tributaries respectively of Sulphur and Dominion creeks, and consists of 17 Crown-granted claims owned by Messrs James Lloyd, J. A. Segbers, and Wm. Nolan.

A number of exposures of quartz 2 to 6 feet in width occur on this property, but in only a few places could the thicknesses of the veins, and their relations to the wall-rocks be determined; the other known occurrences of quartz were either still more or less covered with superficial materials, or the various shafts, cuts, etc., that had at one time exposed the veins, contained considerable water or other materials that had drained or fallen in since the work was performed. One vein, however, was well exposed in a 25 foot shaft near the cabin; this deposit has an average thickness of about 3 feet, strikes N. 58° W., dips at angles of 60° to 70° to the N.E., and cuts across the foliation planes of the schist wall-rock with every appearance, in the shaft at least, of being a typical regular fissure vein. The wall-rocks everywhere observed are sericitic or chloritic schists.

The quartz outcrops on this property are in most places from 2 to 3 feet in thickness, and represent at least 3 or 4 veins and possibly more. In different portions of the claims exposures of quartz, approximately in alignment, were noted at various intervals extending throughout distances of several hundred feet, but until more development has been performed, it will be impossible to decide whether these lines of exposures each represent one continuous vein or several more or less connected lense-shaped deposits such as characterize the schistose rocks of that district.

The quartz is characteristically white and generally but slightly mineralized; however, in some places, the veins carry considerable disseminated pyrite which where oxidized gives the quartz a reddish iron-stained appearance; occasional particles of galena were also noted.

Concerning the average gold content of the quartz, but little is known. The writer took only three samples from the different veins of the Lloyd group, and all yielded merely traces of gold. However, one of the owners of these claims had what he considered to be an average sample of one of the veins tested during the time I was in Dawson, and this gave $10.60 in gold to the ton; and other still higher assays are believed to have been obtained at different times. In this connexion, however, it is to be remembered, as previously mentioned, how extremely difficult it is to get satisfactory results from assay samples of low grade free-milling ores; the samples taken by the writer may not be at all representative of the veins from which they were taken. To obtain reliable information concerning such ores, either a great number of assays must be taken, or mill tests must be made.

Considerable prospecting work has been performed upon this group of claims, mainly as follows: about 10 shafts having an average depth of approximately 30 feet have been sunk, the deepest of these being down 56 feet when visited in September; in addition a number of open-cuts and trenches have been dug.

Bear Creek.

A number of quartz claims, probably 30 or 40 in all, owned by John Nicholas and others, have been located on the right limit of Bear creek near the junction of this stream with Lindow creek. The schistose bed-rock at different points on these claims, contains deposits of quartz impregnated with more or less pyrite, and in places showing particles of native gold that is occasionally quite crystalline. It is not known what average amounts of gold the veins in this vicinity contain, but it is claimed that a number of promising results have been received.

Dublin Gulch and Vicinity.

Dublin gulch is a tributary of Haggart creek which drains into the south fork of McQuesten river. A considerable number of claims have been located on Dublin gulch and in that vicinity, extending throughout a belt about 8 miles long. This locality has not been visited by the writer, but some quartz deposits near Dublin gulch were examined and reported upon by Mr. Joseph Keele[1] of this department in 1904.

During the past two seasons, especially, a number of discoveries that are reported to be very promising have been made in the Dublin Gulch locality, with the result that a considerable renewal of activities and enthusiasm has been evidenced; old claims have been relocated, new claims have been staked, and prospecting has received a decided stimulus. Some of the main claim holders in the district are Dr. Wm. Catte, Mr. Jack Stewart, and Messrs. Fisher and Sprague.

While in Dawson, the writer was shown a large number of specimens of the ores from Dublin gulch and the surrounding district; these all consisted mainly of quartz carrying varying quantities of mispickel (arsenopyrite or arsenical iron pyrite) and occasional particles of pyrite; the quartz in places was coated with a yellow ferric arsenate. A few typical samples were selected and an average assay has been made from these, which yields 3·98 ounces of gold, or $79.60 per ton.

[1] Keele, J. "The Duncan Creek mining district": Ann. Rep. Geol. Surv., Can., Vol. XVI, 1904, pp. 38 A-39 A.

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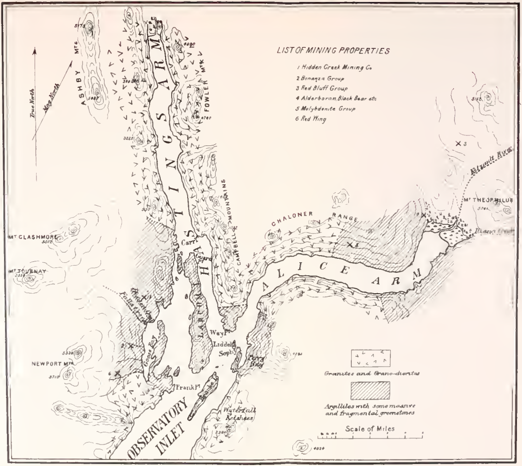

Diagram of portion of Observatory Inlet, B.C.; Geology by R. G. McConnell, 1911.

I

OBSERVATORY INLET, BRITISH COLUMBIA.

(R. G. McConnell.)

Introductory.

The work of the past season included a geological reconnaissance and an examination of the important mineral deposits around Goose bay and Alice arm, Observatory inlet; an examination of the Salmon River mineral district; the completion of a geological map of the Portland Canal mining area, and a reconnaissance trip across the Coast range to the Nass valley. I was assisted during the season by Mr. A. O. Hayes, and during August and September by Mr. G. G. Gibbins, both of whom efficiently performed all duties entrusted to them. The delineation of the geological boundaries in the Portland Canal district, as shown on the map, is largely the work of Mr. Hayes. A microscopical examination of a number of these sections was also made by him.

Observatory Inlet.

Observatory inlet parallels the lower portion of Portland canal on the east, and is connected with it by a passage north of Pearce island. Its shore lines are more irregular than those of Portland canal and towards its head it divides into two branches known as Hastings arm and Alice arm. Hastings arm continues in the general northerly direction of the main inlet, while Alice arm bends to the east and like Portland canal cuts through the granitic batholith of the Coast range and penetrates for some distance the argillites and associated rocks which border it on the east.

At the junction of the two arms, the inlet expands in width and contains a number of islands, some of larger size. Larcom island has a length of 7 miles and Brooke island of 3 miles. West of Larcom island is the entrance to Goose bay, an irregular sheet of water 3½ miles in length and from half a mile to a mile in width. The principal known mineral deposits of the inlet are situated in its vicinity.

The inlet is bordered on both sides by mountains in groups and short ranges except near the head of Alice arm. From this point, a high rough plateau broken by basaltic cliffs extends eastward to the Nass valley. The mountains present, as a rule, steep glacier-worn sides towards the inlet, and range in height from 3,500 to nearly 6,000 feet. Glaciers occur in some of the valleys but are not so large and conspicuous as along Bear river.

The streams entering the inlet are all of moderate size. They include Falls creek, a short stream with numerous falls emptying into Goose bay, the Kitzault and Ilianci at the head of Alice arm, and a branching sediment-laden stream at the head of Hastings arm. Falls creek is utilized to operate the plant at the Hidden Creek mine. It is a steep stream and flows a large volume of water during the greater part of the year, but like all of the streams of the district, the supply becomes greatly diminished during the midwinter months.

GEOLOGY.

Observatory inlet has its whole course in the Coast range and the rock section along it consists mostly of granite. A large included mass of argillites associated with greenstones, mostly pyroclastic in origin, occur at the junction of the two arms, and argillites also occur along the upper part of Alice arm.

Granites.

Granites occur along Observatory inlet from Pt. Ramsden, opposite Pearce island, northward to a point near the southern end of Goose bay where they are replaced by argillites and greenstones. The latter are exposed along the shores of the inlet for a distance of 9 miles and are then followed by granites and allied rocks which continue to the head of Hastings arm and for some distance beyond.

Alice arm extends eastward beyond the eastern edge of the Coast Range batholith. The mountains along the lower portion consist of granite, and those bordering the upper portion of argillites interbanded in places with greenish felospathic beds.

The granites along Alice arm and the lower part of Hastings arm are medium grained, occasionally porphyritic, greyish rocks made up mostly of quartz orthoclase and plagioclase with sparingly distributed biotite. In the upper part of Hastings arm, the grey granite is replaced by a dark coloured, more basic and apparently older variety, feebly schistose in places, and cut near the contact by acid granitic dykes. This rock is very coarse grained in places, has hornblende as the principal dark mineral, and represents a transition phase between the granites and diorites.

Argillites.

An area of dark argillaceous rocks with some greenstones enclosed on all sides by granite occurs at the junction of Alice and Hastings arms. The area has a width along the west shore of Observatory inlet of 9 miles, but narrows to the east. On the east shore, it is barely 2 miles wide and the area appears to wedge out in the bordering mountains. Larcom, Brooke, and other smaller islands near the junction of the two arms, consist of argillites cut by granitic dykes. The area, while not traced through, probably extends westward to Portland canal, as similar rocks somewhat more highly altered occur in the same strike in the vicinity of Maple bay.

The argillites and associated beds are very similar to the rocks of the Bitter Creek series of Bear river, but cannot be definitely correlated with them until the intervening region is more closely examined. The principal variety is a fine-grained sedimentary rock, made up largely of quartz grains with some feldspar, darkened with carbonaceous material. Mica, mostly secondary, is usually present, and in places the argillite passes into a quartz mica schist. Secondary quartz, pyrite, calcite, and hornblende are also common constituents.

In texture, the argillites vary from a hard, fine-grained, compact rock to a granular one in which the grains are distinctly visible. The colour varies with the texture, becoming lighter with increasing coarseness, and in places, the fine-grained, dark and coarse, greyish more feldspathic varieties alternate in thin bands.

The argillites are seldom, and only over limited areas, cleaved into slates. Usually they occur in rather heavy beds from 1 inch to 6 or more in thickness, and in weathering form a talus of angular fragments.

The associated rocks are greyish limestones and beds and wide bands of greenstone. The limestones are not prominent, and only occur in small beds and bands seldom traceable for any distance. The greenstones largely replace the argillites towards the southern edge of the area. They are granular, mostly fragmental rocks.

The beds of what may be called the Goose Bay argillite area are folded into a greenish micaceous schist.

The beds of what may be called the Goose Bay argillite area, are folded into a number of anticlines and synclines, striking approximately east and west, or parallel to the long axis of the area. The dips as a rule are regular and comparatively low, although, in places, the strata are steeply tilted and strongly distorted. No faulting on a large scale was observed.

The Goose Bay sedimentary beds occupy a depression in the granitic rocks of the Coast Range batholith, and are cut by numerous acidic dykes genetically connected with it. Various types are represented, including pegmatite, aplite, quartz porphyry and granitic dykes. A second system of lamprophyric and basaltic dykes, younger and more basic in character than those connected with the granitic intrusion, is also prominent. The dykes of this system are later than the mineralization of the region.

Dark, sedimentary rocks very similar to those in the Goose Bay area occur along the upper part of Alice arm, east of the main granite area. They consist mostly of fine-grained, dark, slaty rocks often in heavy beds, with coarser feldspathic bands some of which hold small angular fragments. Farther north along the Kitzault valley, in the vicinity of the Red Bluff group of claims, the dark sedimentary rocks are largely replaced by fine and medium grained greenish fragmental rocks tufaceous in character. These rocks include dark argillaceous bands and are much less altered than those in the vicinity of the granite. Their relation to the latter was not ascertained, as in the course travelled along the valley the connecting section is concealed.

No fossils were collected and no evidence in regard to the age of the sedimentary rocks was obtained, other than that they are cut by and are, therefore, older than the Coast Range granitic batholith usually referred to late Jurassic or early Cretaceous. The argillites are often highly altered locally, in places, passing into mica schists, but this is attributed to the effects of the great granitic invasion and affords no proof of extreme age. It is probable that none of the sediments are older than the Carboniferous.

MINERAL DEPOSITS.

The mineral deposits of Observatory inlet consist of quartz veins carrying values in silver and lead and in one case in molybdenum, and of what can only be described as mineralized areas carrying low values in copper. The latter will be described first.

Hidden Creek Copper Company.

The claims controlled by this Company were staked about ten years ago and a considerable amount of surface and underground work was done on them by the Hidden Creek Copper Company under the direction of Mr. M. K. Rogers. Recently the claims were bonded to the Granby Consolidated Mining, Smelting, and Power Company operating at Phoenix, B.C., and a diamond drill test of the property by this Company proved so satisfactory that the bond was taken up and preparations are now being made to work it on an extensive scale.

The thanks of the writer are due to Mr. O. B. Smith, General Mines Superintendent of the Granby Company, and Mr. MacDonald, local manager of the Hidden Creek mine, for permission to examine the workings for information, and for other courtesies.

Situation.—The claims are staked on the summit and sides of a hill 920 feet high, enclosed between two branches of Hidden creek, and situated 8,500 feet north of Goose bay, near its outlet into Observatory inlet. A good wagon road, planked where necessary, about 2 miles in length, has been built from the portal of the main tunnel to a wharf at Anyoux on Goose bay, the shipping port of the mine, and a tramway, partly gravity and partly traction, to the same point, was commenced some years ago but never completed.

Rocks.—The rocks in the vicinity of the mine consist of dark and dark grey argillites with occasional light coloured, coarse-grained feldspathic beds and rarely some limestone. Beds and bands of greenstones, probably largely of pyroclastic origin, occur with the argillites but are not prominent in the vicinity of the mine. Both argillites and greenstones are always more or less altered, and in places pass into mica, quartz mica, and chloritic schists. The bedding is coarse, and while a strong cleavage is developed in spots, the bedding planes over most of the area constitute the principal partings. The beds have been compressed into several folds, and, in places, dip steeply, but are seldom, in the section examined, overturned, and no large faults were observed. The strike, while generally east and west, shows considerable variation in places.

The argillites and associated rocks are exposed over an area about 9 miles wide, where cut by Observatory inlet. They are surrounded by the granite rocks of the Coast range, and are considered to be an undestroyed and deeply sunken portion of the old roof of the Coast Range batholith. The basin they occupy is of great depth, as the sedimentary rocks of the inclusion are exposed from base to summit of mountains over 5,000 feet in height, and they must extend for a considerable depth below the present surface.

The argillites are cut by numerous dykes, one set being older than the mineralization of the region and genetically connected with the enclosing granitic rocks. These vary widely in character and include granitic, dioritic, quartz porphyry, aplitic and pegmatitic types. In addition to these, a second widely distributed set occurs, the members of which were intruded after the mineralization of the region. These are fine to medium grained basic dykes often of a lamprophyric character. Thin sections from examples cutting Mammoth bluff showed laths and occasional phenocrysts of feldspar, mostly plagioclase, with abundant brown hornblende in long prisms and occasional plates of mica. Rounded irregularly bounded quartz grains, possibly of foreign origin, are also present, and large calcite areas probably representing original olivine are of frequent occurrence. A second type obtained from a dyke crossing the main tunnel of the Hidden Creek mine between the two ore bodies, contained large olivine and augite phenocrysts in a fine-grained hornblende-feldspar base and is classed as an olivine basalt. A third type, represented by a dyke crossing the Redwing, consists mainly of hornblende and plagioclase and possesses a well marked ophitic structure.

The later dykes may be connected with a basaltic flow which caps the hills south of Alice arm. They do not appear to affect in any way the ore bodies they cut.

Workings.—A large amount of surface and underground work has been done on the Hidden Creek mine. The mineralized area is very large and was first outlined roughly by long trenches running in various directions. Subsequently a working tunnel was started below what is known as Cabin bluff at an elevation of 530 feet, and has been driven straight into the hill in a northwesterly direction for 950 feet. A drift to the left from the main tunnel, starting 85 feet from the face, has been carried in for a distance of 300 feet, and several shorter drifts from points along the main tunnel serve to explore the ground bordering it.

Besides the main working tunnel and its branches, a number of shorter tunnels have been driven at various heights into the iron-stained slopes of Cabin and Mammoth bluffs. One of these, commencing in a depression at the foot of Cabin bluff, is connected by an upraise with the main tunnel.

In addition to the numerous trenches and tunnels, the mineralized area has been further extensively explored with the diamond drill by the Granby Company, the present owners of the property. A number of long bore-holes, starting from various points along the main tunnel and from the surface, have been drilled and have yielded valuable information in regard to the general character of the deposit.

Size and General Character of the Deposits.—The mineralized area, as shown by the various surface and underground workings, is of great extent although it has not as yet been fully defined, both ends being still unknown. In shape it forms a right angle. The smaller arm, known as the first ore body, has a northeasterly strike and dips to the northwest. It has been traced from the main tunnel in a southwesterly direction for over 600 feet, the width averaging about 160 feet or including a siliceous band which borders it on the northwest, of nearly 200 feet. The longer arm holding the second ore body has been traced in a northwesterly direction for a distance of 1,500 feet with an average width of about 400 feet. The deposit has been proved by a bore-hole to a depth of 514 feet below the main tunnel or approximately 900 feet below the surface outcrops on the hill.

While only a portion of the large area described contains valuable minerals in sufficient quantities to constitute commercial ores, the original rocks are everywhere either completely altered into greenish or less commonly brownish micaceous schists or replaced by quartz and iron and copper sulphides. The transition from the dark, slightly altered argillites which constitute the country rocks, to ore is usually fairly abrupt, often occurring in a few inches.

A conspicuous feature of the deposit is the presence of a zone of whitish quartz schists, practically strongly silicified argillites, traceable part way around it. This siliceous zone forms the northwestern boundary of the southwestern or smaller arm, crosses the deposit, then bending at right angles continues to the northwest as the northwestern boundary of the larger arm. It was not observed on the southwest border of the larger arm or the southeastern border of the smaller one.

The rocks in the siliceous zone vary in the amount of silicification undergone. In most places they are nearly pure quartz schists, but occasionally the zone consists of alternating dark and white bands. The width of the zone ranges from 30 to 60 feet and more. The dip where it skirts the smaller arm and crosses the deposit is to the northwest, but after bending to the northwest the dip, as shown by the bore-holes, changes to the northeast. It thus forms the hanging wall of both arms.

Mineralogy.—The metallic minerals present consist mainly of iron pyrite, some of it cupriferous, pyrrhotite, and subordinate quantities of chalcopyrite. A little bornite, evidently secondary, was found at one point. The principal non-metallic constituents are quartz, some calcite, a greenish micaceous schist, probably largely chloritic, some brownish micaceous schists, and occasionally some hornblende.

Pyrite is the most abundant metallic mineral present. It usually occurs in a granular condition, and in places near the surface breaks down into an iron sand. It is always associated with more or less quartz and large areas consist of pyrite grains separated by a thin siliceous matrix. It also occurs in grains and small bunches distributed through the secondary schists. Its distribution through the mineralized area is irregular, some portions containing only a small percentage, while others consist almost entirely of sulphides and quartz. The main tunnel, started some distance down the slope from the mineralized area to gain depth, passes through 380 feet of argillites, all somewhat altered and containing occasional grains and small bunches of pyrite, then through a pyritic zone 200 feet wide, becoming very siliceous towards the northwest border, then through a greenish schistose zone with some quartz and pyrite 240 feet wide, beyond which is a second pyritic area which continues to the end of the tunnel 120 feet. A drift to the left from a point near the end of the tunnel running about north for 300 feet, shows the continuation of the pyritic area for that distance, the breast being in granular sulphides mostly pyrite, embedded in a siliceous matrix. A drift to the left passes through sulphides and quartz for 100 feet, then through greenish chloritic schists only slightly mineralized for 120 feet.

The comparatively barren interval separating the two pyritic areas in the tunnel is not apparent on the surface, some of the ground overlying the lean portion being well mineralized with sulphides.

Pyrrhotite, while much less abundant than pyrite, is common throughout the greater part of the mineralized area. It occurs intermingled with the pyrite and also forming comparatively large masses usually specked with chalcopyrite.

Chalcopyrite in grains, small aggregates of grains, and in thin layers usually accompanies the iron sulphides where the replacement is complete or nearly so, and also occurs in small quantities scattered through portions of the schistose areas. The proportion present, while variable, is always small and in certain areas seems to be absent altogether. The chalcopyrite is associated so intimately with the iron sulphides that there is little doubt that both are the products of the same period of deposition.

Bornite was found at one point, but only as a surface alteration mineral, and it does not occur so far as known as a primary mineral of the deposit.

Among the non-metallic minerals, quartz is the most prominent. A wide siliceous zone crosses and bounds portions of the mineralized area, and the large sulphide areas are all more or less siliceous. Calcite occurs occasionally but is not prominent. Portions of the area included in the mineralized zone on the accompanying map consist of greenish micaceous schists often highly siliceous. These carry significant quantities of sulphides in some places and are nearly barren in others.

Ores.—The iron sulphides in the Hidden Creek mine carry very low values in the precious metals. Out of a number of samples assayed in the laboratory of the Mines Department one showed 0·02 ounce gold to the ton, one 1·65 ounce silver, and the rest only traces. The commercial value of the deposit must, therefore, depend mainly on the copper content. Chalcopyrite usually accompanies the iron sulphides, but in variable amounts. Some areas are nearly barren, while others contain sufficient quantities to constitute a low grade copper ore, that is ore carrying up to 3 per cent copper and over limited areas an even higher percentage.

The most important body of commercial ore so far outlined in the boring operations of the Company, occurs southeast of the siliceous zone previously described as bordering the shorter arm of the deposit on the northwest and continuing along the larger arm. The siliceous zone is fringed by a band of ore usually from 20 to 25 feet in width and already traced for a distance of nearly 1,400 feet. A vertical bore-hole from the main tunnel apparently proves it to a depth of 514 feet below that level and it extends to the surface above, a variable distance, depending on the contours of the country but probably averaging about 200 feet. The huge tonnage expected from this ore body will undoubtedly be greatly supplemented from other portions of the mineralized area. Workable ores are known to occur at a number of points, but the definition of their extent and quality awaits further exploration.

Origin.—The mineralized area at the Hidden Creek mine occurs in a larger predominantly argillaceous area surrounded and doubtless underlaid, although at a considerable depth, by granitoid rocks, and cut by dykes and stocks belonging to the same period of igneous intrusion. The argillites were irregularly compressed and folded at the time of the invasion and the deposit probably occupies an area more than ordinarily crushed and fractured, although this has been masked by subsequent alteration and deposition and is not apparent. A wide, broken zone, rather than a single fissure, is conceived to have afforded the means by which heated siliceous waters carrying iron and copper sulphides in solution ascended from the underlying batholith, altering the argillites in their upward passage and replacing them with silica and sulphides as the pressure and temperature conditions became less severe.

An origin of this kind would ally the deposit genetically with the loosely defined contact metamorphic group, although the ordinary contact metamorphic minerals, including the iron oxides, were not observed, and are either absent altogether or present only in very small quantities.

Deposits of the contact metamorphic group, that is, deposits situated on or near the contact of igneous masses with sedimentaries and formed by ore-bearing solutions, either aqueous or gaseous, emanating from the cooling intrusive, vary widely in character. Ordinarily they are described as bunchy, irregular masses, made up mostly

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LEGEND

Goose Bay argillite

Mineralized area

Quartz and silicified argillite

Lamprophyric and olivine basalt dikes

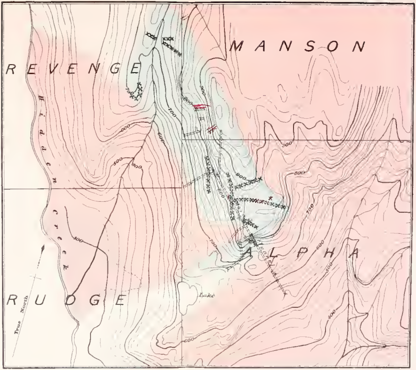
Surface deposit of Limonite

Symbols

Open cuts

Underground workings

Topography based on plans and drawings supplied by mine management.



Scale, 400 ft. to 1 inch

Diagram showing mineral deposits and workings on Alpha and adjacent mining claims, Hidden Creek, Observatory Inlet, British Columbia; Geology by R. G. McConnell, 1911.

To accompany Summary Report, 1911

of iron oxides, and iron, copper, lead, and zinc sulphides, in a gangue of secondary silicates, mostly garnet, epidote, augite, and tremolite. An eaxmination of numerous occurrences at various points along the west coast indicates, however, that neither shape nor the presence of any or the majority of the compounds mentioned are essential features. The shape is dependent on the channel followed, and in a broken region perfect vein forms produced by the complete replacement of the country between parallel fissure are not uncommon. The constituents are also dependent on the character of the parent intrusive, on conditions of deposit, and possibly on the aqueous or gaseous character of the emanations, and gradations occur from masses of pure or nearly pure magnetite to others made up largely of tremolite and iron and copper sulphides, and in some instances of quartz and sulphides. The present classification, based only on a broad genetic relationship, is far from satisfactory. The name of the group is also misleading, as it included deposits far removed from actual contacts.

Equipment.—Work on the Hidden Creek mine up to the present has been altogether of an exploratory character, but plans for working and equipping it on a scale commensurate with its importance and for transportation of the ores to the beach are now being formulated. A smelter will probably be erected to treat the ores, but the site of this was not decided on at the time of my examination, or at least was not announced. The present equipment includes a power plant situated on Falls creek and operated by water furnished by that stream, and a compressor and diamond drill plant.

Bonanza Group.

This group is situated about three-fourths of a mile up Bonanza creek, a small stream emptying into Goose bay about 2 miles below its mouth. Bonanza creek is a rapid stream about 20 feet wide, confined in a deep, narrow valley terminating below in a rock canyon 20 to 30 feet deep, excavated since the glacial period.

The Bonanza group of claims, six in number, were the first claims staked in the district, and were explored to some extent by Mr. M. R. Rogers before the discovery of the Hidden Creek group. Very little work has been done on them in recent years.

The general character of the deposit on which the claims are staked is similar to that of the Hidden Creek group. The country rock is a dark, somewhat altered, argillite cut by pegmatite and dioritic dykes, before it was mineralized, and by a later set of basic dykes after it was mineralized. The argillites are altered over a wide area into biotite and chloritic schists, some of it quite coarse, holding variable quantities of pyrite, pyrrhotite, and in places chalcopyrite. The sulphides are accompanied by some quartz, but this mineral is much less abundant than in the Hidden Creek mine. The altered and mineralized area has a width of over 500 feet, and is opened up by short tunnels for a distance of 600 feet along its strike.

The workings consist of 3 tunnels, one over a hundred feet in length, north of Bonanza creek, near the creek level, and two tunnels and some surface work on the south side. The most westerly of the tunnels north of the creek cuts 10 feet of granular pyrite near its mouth, beyond which are micaceous schists holding only a small percentage of sulphides. Little copper is present. A sample of the granular pyrite gave on assay 0·48 per cent copper, 1·25 ounce silver to the ton, and traces of gold. Some pyrrhotite holding specks of copper occurs in the middle tunnel. The east tunnel passes through micaceous schists sparingly mineralized with pyrite.

The two tunnels south of the creek expose schists holding pyrite in scattered grains and bunches, and occasionally some chalcopyrite. Some good looking chalcopyrite ore is exposed in a cut near the creek, but further exploration is needed to determine whether it occurs in workable quantities or not.

The Bonanza ground looks favourable enough to warrant a diamond drill exploration such as that in progress with such favourable results in the Hidden Creek property. The area of altered schists carrying iron and occasionally copper sulphides is very large and the present workings cover only a small portion of it.

A large quartz vein, fully 10 feet wide in places, occurs on the North Star claim, one of the Bonanza group. It holds some pyrite and chalcopyrite. A sample assayed yielded only 0·48 per cent copper and 0·20 ounce silver to the ton. A number of large quartz veins occur around Goose bay, most of which seem to be barren or nearly so.

Redwing.

The Redwing, staked in 1909 by Joseph McGrath, is situated about 2 miles up Glacier creek at an elevation of 1,820 feet above sea-level. Glacier creek is a short rapid stream issuing from a glacier which fills the upper part of its valley, and emptying into Goose bay near its lower end.

The country rock in the vicinity of the claim is an altered silicified greenstone, passing in places into a schist, lying between the argillites and the granite. Granite occurs a short distance to the south, and a wide dyke or spur crosses the valley at one point.

The claim is staked on a conspicuous oxidized zone in the greenstone running up the northern wall of the valley. The zone has a width of over 50 feet in places, contains some quartz stringers, and is paralleled on the east for some distance by a strong quartz lead. A basic dyke, made up largely of hornblende and fresh plagioclase and showing a diabase texture, crosses it at one point.

The mineralization is similar to that of the other occurrences described, consisting of iron sulphides with some irregularly distributed chalcopyrite. The only development work done consists of a tunnel 25 feet long, driven into the face of the cliff near the centre of the oxidized zone. This passes through the basic dyke mentioned above, then through 6 feet of nearly solid iron with some copper sulphides, the latter in grains and fair sized bunches, then through micaceous schists sparingly mineralized. Chalcopyrite occurs both in the tunnel and at other points in sufficient quantities to constitute a good copper ore, but more development work is needed to prove quantity. Assays of the sulphides are stated to show some values in the precious metals.

Red Bluff Group.

Looking up the wide valley of the Kitzault river from the head of Alice arm, a red patch shows prominently on the face of a mountain north of the river, distant about 4½ miles. A number of claims have been staked on the red area and grouped together under the name of the Red Bluff group.

A short visit to the showing was made in company with Mr. Young, one of the owners, but as little development work has been done, observation was limited to the general surface features. A rough trail leading up the valley of the Kitzault for some distance, then up a tributary stream from the north, has been brushed out to the foot of the red bluff.

The rocks in the neighbourhood of the showing consist mostly of fine and medium-textured, greenish, tufaceous sandstones alternating in places with bands of finer grained, dark argillaceous rocks. The tufaceous sandstones occur in wide, practically massive bands, showing little stratification. They are not much altered and consist mainly of rounded and angular feldspar grains, some quartz, and fragments of glass and volcanic rocks.

The mineralized area is very large, fully a thousand feet in width, and traceable for a long distance up the steep slopes of the mountain. The rocks are fractured and the pyrite oxidized to a greater depth than usual, and no large mass of sulphides is exposed on the surface. Copper carbonates in small quantities occur at a number of points, and a specimen consisting mostly of white pyrite in a siliceous gangue contained small specks of bornite. Some pyrargyrite in small grains was also found with pyrite in one exposure. This mineral does not occur, or at least has not been found, in the other large iron croppings of the district. A crust deposited by a spring bubbling up near the centre of the deposit was determined by Mr. R. A. A. Johnston as allophane, a hydrous silicate of aluminium.

The economic importance of this large pyritized area is uncertain. It contains some copper, and while the small amount of surface work which has been done has not exposed it in commercial quantities, the prospects certainly warrant further exploration. The presence of the rich silver mineral pyrargyrite, even in small quantities, is important.

Quartz Veins.

Aldebaran, Black Bear, Etc.

Quartz veins rich in silver occur on a group of claims, including the Aldebaran and Black Bear, located three-fourths of a mile north of the head of Alice arm, on the lower slopes of the mountains bordering the valley on the west. They were located in 1906, and the controlling interest is owned by Mr. Frank Roundy.

The principal showing is on the Aldebaran and consists of stringers of quartz cutting the argillites for a width of about 6 feet. The central vein has a width of 6-8 inches and a drift has been started on it. It is well mineralized, while the bordering quartz stringers are nearly barren. The strike is northwesterly, and the dip to the southeast at an angle of 45°. The minerals present consist of pyrargyrite or ruby silver in noticeable quantities, argentiferous galena, pyrite, chalcopyrite, and sphalerite. The vein, where exposed in the short tunnel, runs very high in silver, but has only been followed for a short distance. A small cut 100 feet from the tunnel in the direction of the lead shows a quartz vein 3 feet thick, and quartz also occurs in cuts 250 and 350 feet distant. It is uncertain if the small quartz veins in these cuts represent a continuation of the rich vein at the tunnel or are different veins lying in the same fractured zone. They contain some values but are less highly mineralized, and no pyrargyrite was noted.

Molybdenite Group.

These claims are situated north of Alice arm, about a mile east of the contact of the argillaceous series with the granite of the Coast range, and at an elevation of 1,100-1,400 feet above sea-level. The argillites are associated with some coarse feldspathic beds probably of tufaceous origin, and by pre-granite, altered, greenish dykes.

The showing consists of a series of quartz veins and stringers following a fractured zone striking in a northeasterly direction and traceable for over 1,000 feet. The strike of the veins is parallel to that of the zone as a rule, but occasionally they cross it diagonally. They vary in thickness from a few inches up to 4 feet.

The quartz veins contain molybdenite sometimes in considerable quantities, in scattered flakes, small bunches, and in lines parallel to the sides. Other minerals present in small quantities are iron pyrite, galena, and blende. A strong quartz porphyry dyke which crosses the trend of the lead is slightly mineralized with molybdenite and cut by small quartz stringers.

A specimen of the molybdenite-bearing quartz assayed in the laboratory of the Department of Mines, contained 2·60 per cent of molybdenum and traces of gold and silver. The owners state that fair gold values have been obtained from places along the lead.

Waterfront Claim.

This claim is situated on the north side of Alice arm, about half a mile from its head. It contains a strong quartz lead about 6 feet thick which outcrops near the water level and is said to be traceable in a northwest direction across the claim. It contains grains of iron pyrite, galena, and sphalerite, but is only lightly mineralized. Pyrargyrite is stated to have been obtained from it, but none was seen by the writer.

A galena showing on a branch of Lime creek in the mountains south of Alice arm, and a large iron showing high up, west of Goose bay, were not examined, as at the time of my visit (June 23-July 15) they were still buried in snow.

Maple Bay.

Maple bay is a small indentation in the coast of Portland canal, situated due west from the head of Goose bay on Observatory inlet. The argillaceous rocks of Goose bay extend westward across the mountain range separating Observatory inlet from Portland canal, and crop out along the shores of the latter in a wide band in the vicinity of Maple bay. They become more altered in their extension westward, and the dark argillites are represented by greyish and dark micaceous schists and the included greenstone bands, both clastic and massive, by chloritic schists.

The schists are cut in places by quartz veins, and one of these was mined on a considerable scale some years ago by the Brown Alaska Company. The vein worked is situated about a mile from the beach in a N.N.E. direction, and at an elevation of 980 feet above it. A road from the beach to the mine was constructed, a wharf built and a number of buildings, including bunkers, erected at the mine and wharf, and a compressor and boiler-house at the beach. All of these are now rapidly going to ruin.

The principal workings consist of a long tunnel measuring roughly 980 feet. The quartz vein was followed for 550 feet. It was then either lost or gave out, as little quartz was noticed in the last 430 feet. The vein strikes a few degrees east of north and dips to the east at an angle of 45°. It consists mostly of quartz with some enclosed schist, and ranges in width from 3 feet to about 12 feet. The principal metallic minerals noted are pyrrhotite, pyrite, and chalcopyrite. The percentage of chalcopyrite varies, and only in places is present in sufficient quantities to constitute an ore. Small values in the precious metals are reported.

Some stoping has been done and the ore shipped to a smelter on Prince of Wales island. The general tenor of the ore was not learned. The mine has been idle for several years.

II

SALMON RIVER DISTRICT.

Introductory.

A short description of the Salmon River mineral district was given in the Summary Report for 1910. During the past season more time was spent in the district and the geology roughly outlined and laid down on a map compiled from the Boundary Survey maps and sketches made by ourselves. The district is still difficult of access as no proper trails have been constructed, and except along the lower portion of the river where horses can be used all supplies and outfit needed must be packed in by men.

TOPOGRAPHY.

Salmon river parallels Bear river on the north and is separated from it by the long Bear River ridge. It is a short stream issuing from a large glacier, and after a course of 13 miles measured along the valley, empties into Portland canal near its head. The main stream is entirely in Alaskan territory, the International Boundary line crossing its valley near the lower end of the glacier.

South of the Salmon glacier, between it and Bear River ridge, is a broken ridgy tract of country, about 2½ miles wide, drained by Cascade river, a tributary of the Salmon. Most of the mineral occurrences are situated along this belt.

Cascade river heads in Long lake, plunges down a series of cascades through a recent rockcut channel into Silver lake, then continuing southward, joins the Salmon after a course of about 5½ miles measured along its valley. Its grade is exceptionally steep, averaging over 500 feet to the mile. It has a width of from 20 to 50 feet, flows a large volume of water, and if the prospects now being investigated develop into mines, will doubtless be utilized at several points for power plants.

A branch to the northeast, separated from the main stream by Slate mountain, a long ridge rising to an elevation of 4,000 feet, skirts the base of Bear River ridge to a point close to Long lake and at about the same elevation. It is fed by streams descending from the snow and ice-covered slopes of Bear River ridge, and near its mouth is almost equal in size to the main stream.

Long lake, the source of Cascade river, is a narrow stretch of water about a mile and a half in length, occupying a depression in a north and south trending valley separating Mt. Dillsworth[1] from Bear River ridge. Its elevation is approximately 3,250 feet. The valley beyond it rises slowly northward to a flat summit, then descends towards the Nass slope.

The principal elevations of the district include: the long Bear River ridge, bounding it on the east; Slate mountain, 4,000 feet high, between the two branches of Cascade river; the Big Missouri ridge, 3,400 feet, between Cascade river and Salmon glacier, and Mt. Dillsworth, a round, dome-shaped, completely snow-covered elevation, rising to an altitude of 5,600 feet between Long Lake valley and Salmon glacier. Skirting the southern base of Mt. Dillsworth is a narrow, broken, and hummocky belt sloping towards the Salmon glacier. Mt. Miter, so called by the miners on account of its notched summit, is a conspicuous object in the view up Long Lake valley. It has a broad spreading base deeply buried in snow and ice from which a bare, seemingly almost perpendicular, mass of rock shoots up to a height of over 8,000 feet.

The glaciers of the district are a prominent feature. Salmon glacier, the source of Salmon river, has a length of nearly 8 miles and occupies the summit of a through valley connecting the Salmon with the Nass. It is fed mainly by two branches from the west, one joining it at the summit almost at right angles and from this the ice flows east and west down both slopes. Its elevation at the summit is approximately 3,000 feet and at its termination in the Salmon valley 480 feet, the lowest point reached by perennial ice in this portion of the Coast range. The Nass branch ends in a lake at a much higher elevation. A number of small glaciers descend from the large permanent snow field which crowns Mt. Dillsworth, and a line of ice tongues creep down the slopes of the Bear River ridge, none of them reaching the valley. The western slopes of this ridge are less steep than those fronting on Bear river and American creek and large snow fields are more prominent.

The general aspect of the Salmon River district above an elevation of 3,000 feet is exceedingly bleak and arctic looking. Long lake at the time of our visit, August 2, was still covered with ice, and except on projecting rocky knobs and sunny slopes the preceding winter's snow lay thick everywhere. Below an elevation of 3,000 feet,

[1] Named after one of the pioneer prospectors of the district.

the valleys and mountain slopes are generally well wooded, principally with large hemlock and spruce of good quality.

Geology.

The formations represented in the Salmon River district are the Bear River greenstones, the Nass argillites, and the granitic rocks of the Coast Range batholith.

The eastern edge of the Coast Range batholith on the western slope of Bear River ridge, and in the Salmon River valley, occurs on the Alaskan side of the International Boundary and was not traced out. Following the boundary line, small granitic areas, some of which may be spurs from the main batholith, and large dykes, are crossed at intervals, but the predominant rock is greenstone. On the western side of the Salmon valley the eastern edge of the batholith trends to the north and crosses the International Boundary near the lower end of Salmon glacier. It follows the glacier for 3 miles, to a point above the first feeder, then turns more to the west and passes beyond the district examined.

A band of granitic and porphyritic rocks, roughly paralleling the main batholith at a distance of from 4 to 6 miles, crosses into the Salmon valley from the head of Goose creek, and extends in a northwesterly direction across Long lake to the base of Mt. Dillsworth, then bending more to the west crosses Salmon glacier to a mountain south of the main feeder at the summit. The width of the band is variable, in places exceeding half a mile and in others diminishing to a few hundred feet. West of Long lake, it becomes very narrow and soon breaks up along its course into a series of large parallel dykes dipping to the southwest.

The rocks in this band are usually porphyritic and in places pass into typical quartz porphyries made up of quartz, and plagioclase feldspar phenocrysts, with some white mica embedded in a fine-grained, micro-crystalline base. In the main batholith west of the Salmon glacier the prevalent variety, as shown in a couple of sections, is a coarse grano-diorite with hornblende often in well formed crystals as the principal dark mineral. The other essential constituents are plagioclase feldspar, quartz, and a little orthoclase.

Bear River Formation.

This is the most widely distributed formation in the Salmon River district. It occurs bordering the granite a little to the southwest of the International Boundary, on the western slope of Bear River ridge and in the Salmon valley, and except where overlain by occasional patches of the Nass argillites and cut by granitic dykes and areas, underlies the region east of the Salmon glacier as far north as examined.

The Bear River formation is predominantly a greenstone formation and represents the products of a long period of vulcanism. The rocks include fine, medium, and coarse volcanic breccias or agglomerates, tuffs, bands, and areas of massive porphyrites, and occasional argillaceous bands. The fragmental rocks are often difficult to separate from the massive rocks in the field and even in thin sections. They are seldom distinctly bedded or banded, and often appear massive through sections hundreds of feet in thickness. The fragments are angular or subangular, consist mainly of feldspathic porphyrites, and on fresh surfaces are often indistinguishable from the matrix, although plainly outlined where the rock is weathered.

In the Salmon valley, the greenstones are usually sheared and pass into coarse greenish and greyish schists, the lines of schistosity being roughly parallel to the eastern edge of the Coast Range granitic batholith and dipping towards it at a high angle. The sheariug is irregular, some areas being only slightly affected, and usually, but not invariably, increases in intensity approaching the granite.

Nass Formation.

The rocks of the Nass formation overlie the Bear River greenstone. They occur on the northern part of Slate mountain and extend northeasterly in a comparatively narrow band west of Long lake to the eastern shoulder of Mt. Dillsworth. A second area separated from the first by the erosion of the valley of the East Fork of Cascade river, is exposed east of Slate mountain in the western slopes of Bear River ridge. This area is largely buried in snow and ice and its upper contact with the greenstone was not seen. A third area, tentatively referred to the Nass formation, occurs bordering the Coast Range granitic rocks west of the Salmon glacier.

The rocks of the Nass formation are mainly dark argillites, always more or less altered and in places cleaved into slates. On Slate mountain they are fine-grained and very uniform in composition throughout. They rest on a massive-appearing, dark-coloured, volcanic breccia, below which are the greenish schistose fragmentals of the Bear River formation. On the western slope of Bear River ridge and north of Long lake, the argillites are associated with greenish and greyish beds and bands of tufaceous sandstone. The material in these consists mostly of angular quartz and feldspar grains with fragments of slate and calcite.

In the area west of the Salmon glacier they consist of hard, siliceous, dark and striped slaty rocks resembling quartzites in places.

The Nass argillites and associated granular and fragmental beds occupy the Long Lake depression, and rise to the south in Slate mountain and the western slope of Bear River ridge. They have been folded in the mountain-making movements, and in places crushed into the underlying Bear River greenstones. The dips and strikes, while irregular, indicate a double fold trending in a north-northwest direction. The formation extends northwards beyond the district examined and its thickness was not ascertained.

MINERALIZATION.

The mineral occurrences of the Salmon River district occur altogether in the Bear River schistose greenstones, and consist mostly of silicified zones often of great width, carrying varying quantities of iron, lead, zinc, and copper sulphides. Fissuring occurs in connexion with some of the deposits, but few of them are bounded by sharp walls and in most cases the cessation of the mineralization is gradual. The mineralized zones are really bands of country rock sometimes 50 feet in width, partially and in limited areas wholly replaced by silica and various sulphides. A few quartz veins occur in addition to the replacement deposits, and in some instances carry high grade silver minerals.

A large number of claims have been staked on these mineralized zones, extending in an almost continuous line, often several tiers deep, from the International Boundary, up Cascade river, along the Big Missouri ridge, and the lower slopes of Mt. Dillsworth to near the summit of the Salmon glacier. While staking has been active the progress of development and exploration work has been very slow, this consisting only, with the exception of a couple of short tunnels, of small open-cuts and cross trenches. None of the showings have been advanced beyond the stage of surface prospects. This slow progress is due in large measure to the absence of transportation facilities and the consequent extravagant cost of supplies. The building of trails has been delayed by the fact that while the showings are mostly on the Canadian side of the International Boundary, the road to the coast passes through Alaskan territory.

PROSPECTS.

The first camp reached ascending Cascade river is that of Bunting Bros. and Dillsworth, situated at an elevation of 1,050 feet on the eastern bank of the East Fork of Cascade river about a mile northeast of the International Boundary and 12 miles from Portland canal, following the Salmon valley. A joint stock company, under the name of the Cascade Falls Mining Company, has recently taken over the five claims owned by this syndicate.

The principal showing occurs on Cascade Falls No. 2 claim, and consists of a mineralized zone traversing the greenstone schists which form the country rock in an easterly direction. The schists for a width of over 30 feet are altered and strongly silicified and pyritized. In portions of the zone, galena is present in considerable quantities, associated with some zinc blende and occasional grains of chalcopyrite. A rough sample across 8 feet of the best mineralized portion of the lead assayed in the laboratory of the Department of Mines, yielded:—

Gold	0·14 oz. per ton.
Silver	7·00 ozs. per ton.
Lead	7·60 per cent.

Ore of this grade could doubtless be mined at a profit in the district if present in quantity, but the extent to which it persists either in depth or along the strike of the lead has not been demonstrated. The mineralization is irregular both across the lead and along its strike, portions of the zone containing little or no galena, the principal silver-bearing mineral; and the present workings are limited to a shallow cut in the steep hillside across the lead and some surface stripping. The prospects are, however, considered favourable enough to justify a considerable expenditure for further exploratory work.

Salmon-Bear River Mining Company.

This Company owns seven claims situated a short distance east of the Bunting-Dillsworth group, and about 1,000 feet higher up the western slope of Bear River ridge. One of them, Cascade Falls No. 4, contains a very wide showing. The schists are silicified, seamed in places with small irregular quartz seams, and impregnated with sulphides for a width of fully 75 feet. The sulphides are oxidized on the surface and the mineralized zone is traceable up a steep hillside for a distance of about 200 feet, beyond which it is concealed.

The workings consist of a shallow cut across the greater portion of the zone near the base of the hill and a short tunnel higher up the slope. These show the mineralization to be very irregular, portions of the zone being entirely replaced by sulphides and quartz and others only slightly affected. Quartz and the iron sulphides are the only minerals which persist across the zone. Galena occurs in small veinlets, bunches, and scattered through areas and bands in the zone, and some sphalerite and occasional grains of chalcopyrite are also present. The galena areas carry fair values in lead and silver and some gold, and the value of the deposit depends on their permanence. The present workings are, of course, wholly insufficient to determine this point.

The Pictou claim belonging to the same Company, situated about 1,000 feet northwest from the main showing, is crossed by a second, somewhat similar, but smaller zone, apparently following a strong diorite porphyry dyke. The schists for a width of 20 feet from the dyke, as shown in a small transverse cut, are silicified, heavily mineralized with pyrite and some galena, cut by numerous quartz stringers, and in places brecciated. A hundred feet to the northwest, a second cut exposes a similar zone on the opposite or southwest side of the dyke. The proportion of galena present in the cuts is small and its distribution is bunchy and irregular.

The Simpson claim in the same group, situated higher up the slope, contains an exposure of silicified schist cut by quartz stringers, some of which carry small quantities of native silver and chalcocite in addition to the ordinary pyrite and galena.

High assays in silver and some gold have been obtained from picked samples. The lead is concealed except at a couple of points, and no attempt to trace it out has so far been made.

Indian Mining Company.

This Company owns four claims, situated at an elevation of about 2,400 feet, near the southern end of the Big Missouri ridge between Cascade river and the Salmon glacier. The principal showing occurs on Portland No. 2 claim, and some development work was done on it in the season of 1910 by the Portland Salmon River Syndicate, and is described in the Summary Report of the Survey for that year. During the past season a couple of men were engaged extending an exploratory tunnel started by the syndicate.

The lead crosses diagonally a wide dyke or lenticular dioritic stock very much altered, which intrudes the greenstone schists, and is better defined than most of the showings in the district. A cut across it near the summit of the ridge shows it to have a width here of nearly 20 feet, and exposes from 5 to 8 feet of nearly solid galena bordered by quartz and silicified and mineralized country rock. The galena mass has been followed vertically for 20 feet, but apparently does not extend far along the strike. A second cut, 150 feet to the south-southeast, down a steep slope, shows little galena. The lead here consists mostly of altered and silicified country rock and carries average values in gold and silver of about $10 to the ton across a width of 10 feet.

The tunnel now being driven starts 300 feet south-southeast of the galena showing and will undercut it at a depth of 150 feet, as the surface falls rapidly in that direction. At the time of my visit the face was in low grade ore, a sample assayed in the laboratory of the Department of Mines yielding 0·11 ounce gold to the ton, 1·10 ounce of silver, and 5·12 per cent lead. The extension of the tunnel is important, as when completed it ought to furnish valuable information in regard to the general character of the deposits of the district.

Some surface prospecting was in progress during the season on mineralized areas and zones on the Siwash and other claims on the Big Missouri ridge north of the Portland group, but no conclusive results were obtained. The Big Missouri claims and the thirty odd claims held and prospected to some extent in the season of 1910 by the Golden Crown Mining Company were all idle, the bond on them held by that Company having been thrown up. The Martha Ellen and three other claims held under bond in 1910 by the Salmon Glacier Mining Company and situated farther to the north immediately above the Salmon glacier, were also idle although very satisfactory results had been obtained from the small amount of surface prospecting done. A trench across a mineralized zone on the Martha Ellen, roughly sampled for 17 feet, yielded 0·57 ounce gold to the ton, 3·76 ounces silver, and 4·64 per cent lead. The zone has a width of over 50 feet and the most highly mineralized portion is not included in the sampling, as a deep transverse pit filled with ice and water prevented access to it. Still farther to the north, between Mt. Dillsworth and the Salmon glacier, are the Fortynine and numerous other claims, all staked on oxidized zones and areas, but with little work done on them.

The Silver Flat, on a hill north of Silver lake, affords an example of a narrow lead confined between nearly vertical fissures. The lead has a width of from 2 to 3 feet and consists of quartz and silicified country rock carrying some galena, chalcopyrite, sphalerite, and pyrite. Assays of $21 to the ton in gold, silver, and lead are reported.

SUMMARY.

Characterizing the region generally it may be stated that it contains a large number of mineral deposits ranging in size from small stringers to wide zones and irregular lenses often 50 feet and more across, all traversing the more or less schistose massive and fragmental greenstones of the Bear River formation. The deposits plainly follow lines of fissuring and shear zones in some instances, and probably do so in all cases. With the exception of some narrow quartz stringers they all belong to the replacement class, and in origin and the irregular and hazy outlines of some of the masses resemble contact metamorphic deposits, but the characteristic non-metallic minerals which accompany these were seldom observed and are nowhere present in quantity.

The gangue is invariably the more or less completely silicified country rock, and the common metallic minerals are pyrite, occasionally pyrrhotite, galena, sphalerite, and chalcopyrite. Of these pyrite is much the most abundant, and in some cases is practically the only mineral present. In places it carries appreciable values in gold. A specimen of pyrite in a quartz gangue from Cascade Falls No. 2 yielded 0·24 ounce of gold to the ton and much higher assays are reported. Chalcopyrite was not observed in workable quantities. Galena is more abundant and usually carries silver values averaging about one ounce to the unit of lead. The distribution of the galena in the silicified and pyritized zones and areas is usually irregular, some portions carrying a good percentage while others are entirely barren.

Development work has been retarded by the lack of transportation facilities and consists only of some surface cuts, trenches, and a few short tunnels. These in several instances have exposed bodies of ore carrying values in gold, silver, and lead of from $10 to $20 per ton. Development work has not, however, proceeded far enough to show what persistence these ore bodies have either in strike or dip. The mineralizing solutions undoubtedly came from the underlying granite, and there is no reason why the deposits should not descend to considerable depths, but whether in irregular unworkable bunches or in continuous pay shoots still remains to be proven.

III

PORTLAND CANAL DISTRICT.

Introductory.

A description of the principal geological features and a somewhat detailed account of the mineral occurrences of the Portland Canal district, by the writer, were published in the Summary Report of the Survey for 1910. Further work was done in the district during the past season, and with the aid of a topographical map prepared by Mr. Malloch, the formations were outlined more correctly than it was possible to do the preceding season. Some of the more important mineral deposits were also re-examined.

Outline of Geology.

The Portland Canal mining district covers a portion of the Coast range extending from the head of Portland canal up Bear river and is practically co-extensive with the rugged region drained by that stream and its tributaries. The irregular eastern edge of the long granitic batholith of the Coast range forms roughly its western boundaries. The batholith is bordered on the east in this latitude by sedimentary and volcanic rocks which have been grouped into three main divisions and given the following names:—

Bitter Creek formation.. ..	Principally argillites.
Bear River formation... ..	Principally massive and fragmental volcanics.
Nass formation...	Argillites and tufaceous sandstones.

Bitter Creek Formation.

The Bitter Creek formation, the oldest series, consists mostly of dark argillaceous rocks cleaved into slates in places, but the principal partings in most cases follow the original bedding planes. They are usually more or less altered with a development of yellowish mica arranged parallel to the partings and in places pass into micaceous schists. The ordinary constituents are quartz, feldspar, and a dark carbonaceous dust. Zircon, pyrite, and secondary mica and quartz are also commonly present.

The slates or shales in places have a striped appearance, due to a rapid alternation of dark, fine-grained argillite with lighter coloured and more feldspathic layers. Other rock varieties of occasional occurrence are green bands consisting mostly of broken feldspar crystals and quartz, with chlorite, calcite, and other secondary minerals,—probably of tufaceous origin,—and beds and bands of greyish crystalline limestone. The proportion of limestone increases towards the east and on portions of the Mt. Gladstone ridge forms an important part of the formation.

The dip of the Bitter Creek argillite is generally to the southwest or towards the granite, usually at a high angle, in places reaching 90 degrees. No definite proof of faulting on a large scale or of overturns was obtained. This general uniformity of dip across the area covered by the formation results in some uncertainty in regard to the reference of the series as a whole to a position subordinate to the Bear River greenstones, as on the western slopes of the Cambria range they appear to overlie the latter at a high angle. There is little doubt that the western, and if the present dip is taken for a guide, the upper portion of the Bitter Creek argillites are older than the Bear River volcanics which adjoin them, as they are cut at various points by the intrusive members of this group and interbanded in places with sheets of porphyrite. Volcanic action, as evidenced by occasional tufaceous bands, was in progress near by during the whole period of the accumulation of the Bitter Creek argillites, and it is quite possible that portions of the wide-spread volcanic series grouped together as the Bear River formation may be contemporaneous witb, or even antedate them, in order of deposition. This point could not be satisfactorily determined in the small area studied.

Bear River Formation.

This complex volcanic group has a wide but exceedingly irregular distribution. It occurs all along the Bear River ridge, spreads eastward across the group of mountains between American creek and Bear river, then southward along the watershed ranges beyond the area examined, thus enclosing the Bitter Creek argillites on three sides. The rocks represented in it have a prevailingly green colour, and include porphyrites of various kinds, mostly of hyp-abyssal origin, tuffs, volcanic breccias and agglomerates, and occasional argillaceous bands. Small areas in various parts of the district have been silicified and altered into cherts. A strong schistosity approximately paralleling the eastern edge of the Coast Range batholith has developed in places, especially along American creek and in the Salmon River valley, but, as a rule, the rocks have not yielded to crushing. The alteration they have undergone is also very variable, ranging from specimens which have completely lost their identity to others comparatively fresh.

A marked feature of the formation is the general absence, except in the case of the argillite bands, not only of sharp but in most cases even of observable contacts, between the massive and fragmental members of the group. The massive porphyrites in thin sections often show flow structure, but appear to occur in irregular areas and either pass gradually in most cases into the fragmentals, or the contacts were obscured by the compression, alteration, and mineralization resulting from the granitic invasion of the Coast Range batholith, and the bordering stocks and dykes.

The fragmentals consist largely of angular greenstone fragments usually less than an inch across but often of large size, indistinguishable in composition from the massive porphyrites and enclosed in a massive or pyroclastic matrix. They show little bedding or banding and are often remarkably uniform in composition through sections thousands of feet in thickness.

Massive porphyrites predominate in the southern portion of Bear River ridge. Going north and east the proportion of fragmentals increase, and along Upper Bear river the bordering mountains are largely built of them.

The porphyrites are greyish, medium-textured, comparatively deep-seated rocks. They usually occur in a massive condition but in places have been sheared into coarse schists. A red variety, due to a development of red oxide of iron, is conspicuous in places.

A number of thin sections, studied and reported on by Mr. A. O. Hayes, my assistant in the field, show them to consist largely of plagioclase feldspar in two generations. In most of the sections examined the ferro-magnesian minerals are either absent altogether or present only in small quantities, and the rock consists largely of phenocrysts of plagioclase scattered through a fine-grained base of the same mineral. In a few sections the dark minerals are present in sufficient quantities to class the rock as an augite, and less commonly a hornblende porphyrite. Grains of black iron ore, usually titaniferous, are present in most of the sections, and apatite in small, well-formed crystals is very abundant. The common secondary minerals are chlorite, calcite, epidote, leucoxene, and the red oxide of iron.

The fragmentals occur as tuffs and volcanic breccias and agglomerates. The tuffs are made up largely of feldspar crystals, often broken, quartz grains and minute rock fragments lying in a dark, fine-grained mat, and are often difficult to distinguish in the field from the massive porphyrites. The breccias exhibit considerable diversity in character and probably originated in different ways. They consist mainly of angular porphyrite fragments, accompanied in places by slate, limestone, and rarely granite. The fragments vary in size from minute grains up to masses several feet across, but are often very uniform in size over wide areas. The matrix in the specimens examined is altered and difficult to determine but appears to be massive in some instances, although mostly clastic, and occasionally the rock has the appearance of having been crushed in place. The fragments are usually pressed closely together, but in some areas are widely separated and seem to have been thrown up and fallen back into a still liquid matrix.

Occasional dark argillaceous bands occur with both the massive and fragmental members of the Bear River volcanic group, apparently indicating that sedimentation occurred at intervals during the whole period of its accumulation. The bands are thin, seldom attaining a thickness of over 100 feet, and of little persistence. They have not been closely studied and it is possible that some of them may be built of fine tufaceous dust.

Nass Formation.

The rocks of the Nass formation overlie the Bear River volcanics in the mountains on both sides of Bear River summit, on Slate mountain and other places in the Salmon valley, and along the eastern edge of the Coast range. They consist largely of dark argillites very similar in most respects to those of the Bitter Creek formation, but less generally altered. They are seldom cleaved and in some sections might be classed as shales. Beds and thick bands of tuffs, tufaceous sandstones, and breccias occur with them in places but are of subordinate importance.

In the mountains north of Bear River summit, the Nass argillites alternate near their base with heavy bands of volcanic breccia similar to that occurring in the upper portion of the underlying Bear River formation.

The attitude of the Nass argillites in the summit ranges is flat or nearly so, while along the eastern edge of the Coast range the inclination is easterly at angles of about 45°, gradually diminishing to the east. In a previous paragraph the Bitter Creek argillites are stated to have prevailing westerly or northwesterly dips, thus giving the two formations the appearance of forming opposing limbs of a wide syncline, separated by the Bear River volcanic area. They were not found in juxtaposition, and the principal reason for classing them as two series is that while the Nass argillites definitely overlie the Bear River volcanics, the Bitter Creek rocks are cut and intruded by them at various points. The lithological character of the two formations also, while generally similar, exhibit some differences. Limestones occur in the Bitter Creek formation and the proportion of coarse fragmental rocks is much less than in the Nass formation.

No evidence as to the age of either the Bitter Creek or Nass formation was obtained, beyond the fact that both are cut by the granites of the Coast Range batholithic period usually assigned to late Jurassic or early Cretaceous.

Intrusives.

The intrusive rocks of the district include in order of age, areas of augite porphyrite; granitic, dioritic, and porphyritic stocks and dykes belonging to the period of the Coast Range batholithic invasion; and a later system of more generally basic dykes.

Augite Porphyrites.—A large area of augite porphyrite, about 2 miles across, occurs at the head of Glacier creek, intruding the Bitter Creek argillites, and a smaller elongated area outcrops along the upper part of Maude gulch. Other areas intruding both the Bitter Creek argillites and the Bear River volcanics occur on Bear river near the Cañon and north of the Bitter Creek glacier. The rocks in these areas are similar to the augite porphyrites which occasionally develop in the Bear River formation, and probably belong to its closing stages. They form distinct, easily traceable, masses where they intrude the argillites, but where they enter the greenstones of the Bear River formation, the boundaries become uncertain and in places they pass into breccias indistinguishable from common varieties of the Bear River rocks.

They usually occur in a massive condition, but on Bear river have been crushed in places into a schist.

The ordinary variety consists of phenocrysts of augite and plagioclase in a base of small lath-shaped plagioclase crystals, frequently showing flow structure. Black iron ore and apatite are the principal accessory minerals. Hornblende occurs, but is evidently in most cases an alteration product from the augite. Other secondary minerals are calcite, chlorite, epidote, and occasionally quartz.

Stocks and Dykes Genetically Connected with the Coast Range Batholith.—The district reported on lies immediately east of the Coast Range batholith, and satellitic stocks and apophyses from it in the form of dykes, often of large size, everywhere intrude the older rock. The petrology of these presents great variety and can only be briefly referred to here. In the stocks, the principal variety is usually a transitional phase between the granites and diorites and is classed as a grano-diorite, or when porphyritic, as a grano-diorite porphyry. The ordinary constituents are plagioclase feldspar, usually some orthoclase, quartz, biotite, and occasionally hornblende. In a few instances the stocks become very basic, augite develops in quantity and the rock passes into a gabbro. Very acid phases occur in a wide band which extends from Mt. Dickie northwesterly across the district into the Salmon valley. Typical quartz porphyries are common and specimens from exposures on Goose creek consist mainly of quartz in two generations with some orthoclase.

The dykes of this period are very numerous and less variable in character on the whole than the stocks. Ordinarily they are light greyish, medium-textured feldspathic rocks, usually only feebly porphyritic in hand specimens. In thin sections the porphyritic structure is more pronounced and they are classed as diorite porphyries. The minerals present consist of plagioclase, with biotite, hornblende, and augite either separately or together, and frequently a small quantity of interstitial quartz. Dark iron and sphene are common accessories.

Acid dykes ranging from granite to quartz porphyry occur occasionally but are less numerous than the more basic type. No pegmatite dykes common along other portions of the Coast range were observed.

Later Dykes.—The latest intrusives in the district consist of a wide-spread system of brownish weathering dykes. These cut all the older rocks and also some of the veins and mineral deposits of the district. They are sharply discriminated in this respect from the older dykes as the latter were intruded before the region was mineralized.

They are dark coloured, more basic on the whole, and somewhat finer grained than the older set but are closely related to them mineralogically, and in thin sections appear very similar. A study of a number of sections by Mr. Hayes led him to class them as diorite porphyries. The principal constituents, as in the older set, are plagioclase with varying quantities of biotite, hornblende, and augite.

MINERAL DEPOSITS.

The mineral deposits of the Portland Canal district occur mostly in the Bitter Creek argillaceous and Bear River volcanic formations, but are not restricted to these two series, as fissuring accompanied with mineralization occurs in the Nass argillites, in the grano-diorite stocks, and to a greater extent in the augite porphyrite areas, especially the one at the head of Glacier creek. The whole region in fact, at the close or shortly after the termination of the Coast Range granitic invasion, seems to have been crushed, fissured, and penetrated at innumerable points by mineral bearing solutions from the dying batholith. The resulting mineral deposits, while remarkable from their great number and wide distribution, are in the majority of cases bunchy and uncertain, and even where of considerable size only occasionally contain valuable minerals in sufficient quantities to make extraction profitable.

The deposits are classified generally as replacement deposits and veins, usually quartz veins. The two groups are not, however, except in extreme cases, sharply discriminated and examples occur which might be referred to either. Replacement often plays an important role in the formation of the veins, and fissuring and silicification in that of the replacement deposits.

The replacement deposits are especially abundant in the greenstones of the Bear River formations. Red patches and areas due to the oxidation of the iron sulphides are numerous and conspicuous along the bare slopes of Bear River ridge, in the mountains bordering Upper Bear river, and in those lying between Bear river and American creek. The shapes of the reddened areas are very variable. In places they are long narrow lenses, sometimes bordered by fissures and resembling veins, but usually the outlines are blunt, irregular, and defined only by the gradual cessation of the mineralization. They are often of large size, occasionally a hundred feet or more across.

The minerals present are mainly pyrite, pyrrhotite, and quartz, with, in places, subordinate and uncertain quantities of chalcopyrite, galena, and blende. Some calcite is usually present and barite and garnet in disseminated grains occur in places but are not common.

The replacement, except in limited areas, is seldom complete and the metallic minerals occur as a rule in grains and bunches scattered through the altered and partially silicified country. Small quartz veins, usually barren, cross some of the mineralized areas.

The valuable metals present are copper and lead with usually some silver and gold.

A large number of the deposits of this class have been roughly prospected, mostly with surface cuts, cross trenches or short tunnels, but so far with little success. A body of commercial ore has been developed on the Red Cliff and a few others examined are worth further exploration, but in most cases the quantity of the valuable minerals present has proved too small and their distribution too bunchy and erratic for successful exploitation.

Veins and fissured zones, with quartz as the principal filling, are common throughout the area covered by the Bitter Creek argillites and occur occasionally in the granodiorites and Bear River volcanics, and more frequently in the augite porphyrite areas, especially the one at the head of Glacier creek. The strike of the veins in the argillites is usually northerly or northwesterly, roughly parallel to the edge of the granitic batholith on the west, and the dips are westerly or towards it. In the massive rocks the strikes are more variable, occasionally trending east and west.

The quartz veins occur singly and in groups following shear zones. The principal zone in the argillites is that on which the Portland Canal mine is situated and may be called the Portland Canal fissure zone. This is clearly traceable from the Jumbo and Ben Bolt claims, situated near the head of the South Fork of Glacier creek, northwesterly to the Portland Canal mine, a distance of over 2 miles. Beyond this point the surface drops down into the deep valley of Glacier creek and exposures for some distance are infrequent. Occasional quartz outcrops, however, occur at intervals in the same strike, and there is little doubt that the zone continues across the valley. North of the valley the outcrops increase in number and the zone is easily traceable through a number of properties to the Sunbeam claim, a total distance from the Jumbo of over 4 miles.

The zone varies greatly in width and general character along its course. At the Jumbo it consists of a mass of crushed and brecciated slates over a hundred feet in width, silicified in places, and enclosing numerous small quartz stringers and kidneys but no large persistent quartz vein. Farther to the north, in the steep slopes rising up from the South Fork of Glacier creek, the quartz occurs mostly in a central band usually from 6 to 20 feet in width, bordered on both sides by crushed and partially silicified slates. Descending into the deep valley of Glacier creek, quartz outcrops occur over a width of fully 800 feet. The country here is mostly concealed and the veins have not been traced out. At the Stewart mine, half a mile north of Glacier creek, the zone has a width of 400 feet and contains four main quartz veins, the largest 27 feet wide. At the Sunbeam claim, near its northern termination, only one large vein is exposed.

While the general zone of fissuring and silicification appears to be continuous from the Jumbo to the Sunbeam, and is marked throughout its course by quartz croppings, the individual quartz leads contained in it have a more limited range. They die out when traced along the zone and are replaced by others at a different horizon. Some of them have considerable persistence, being traceable through several claims, while others are quite short.

The metallic minerals in the zone consist of pyrite, galena, and blende, with occasionally a little chalcopyrite, and in places some native silver. Concentrations of these minerals into ore bodies of various sizes occur at a number of points along the zone and are described in connexion with the mines.

Quartz veins, some of large size, occur in the argillites south of the Bromley glacier, and smaller ones in other parts of the district, but so far no important ore bodies have been found in them.

The veins in the Bear River volcanics in the argillaceous bands associated with them and in the augite porphyrite areas, are smaller as a rule than those in the main argillite area. Quartz is the principal gangue, but in places calcite, and less commonly, barite and siderite are present in considerable quantities.

Some of the veins cutting the augite porphyry area on the Middle Fork of Glacier creek contain small ore shoots running high in silver. The metallic minerals present are argentiferous galena, pyrite, tetrahedrite, tennantite, and blende. A considerable amount of exploratory work was done on these veins in 1910 and some high grade silver ore was mined and shipped, but the shoots encountered proved to have little persistence.

Free gold is reported from some of the quartz veins of the district; none was seen by the writer, and, if present, its distribution must be very limited.

MINING PROGRESS.

The boom years of 1909 and 1910 in the Portland Canal district when any prospect, no matter how small, commanded a price, has been followed by the inevitable reaction, and during the past season work was in progress on only a few of the numerous properties in the camp. The wide-spread character of the mineralization of the district, and the numerous ore croppings encountered everywhere, raised hopes which have only been very partially realized. As development work advanced it became evident that in the majority of cases the deposits were either too low grade or the valuable minerals were concentrated in too small bunches and lenses to be successfully worked. In a few instances, especially along the Portland Canal fissure zone, ore bodies of considerable size and persistence have been opened up. Steady development has been carried on, on these, with fairly satisfactory, but still not conclusive, results. The ore bodies enclosed in a wide shear zone are difficult to follow, and the cost of finding and following them has proved a more serious handicap than was anticipated as the grade of the ore is not high.

The future of the camp does not, of course, depend entirely on these as in the slump. Work has largely stopped not only on the poorer prospects, but on some with fair chances of success, and numerous showings have not been explored in any way. It will be difficult, however, to interest capital in their development until one or more of the prospects now being operated proves able to yield returns on the amounts already expended.

MINES AND PROSPECTS.

A large amount of work was done during the season on the long Portland Canal fissure zone, principally by: the Pacific Coast Exploration Company on the Jumbo and Ben Bolt; the Portland Canal Mining Company on the Lucky Seven and Little Joe, and the Stewart Mining Company on the George E. The Portland Canal mine has reached the producing stage, and shipments of concentrates aggregating over 1,000 tons have already been made. The other mines were engaged in exploratory work.

Jumbo and Ben Bolt.

The Jumbo and Ben Bolt are being opened up by the Pacific Coast Exploration Company, under the direction of Mr. Curran. They are situated south of Glacier creek, 4 miles from Bear river, following the valley of Glacier creek and at an elevation of about 2,500 feet above sea-level. A trail from Bear river up Glacier creek and its south branch has been built to the mine.

The claims are staked on the southern end of the exposed portion of the Portland Canal fissure zone, its further course, if any, to the southeast being concealed by drift. The zone at this point, while traversing the Bitter Creek argillites, skirts closely the southern edge of a massive augite porphyrite area and is intruded by apophyses from it.

The fissure zone in the Jumbo and Ben Bolt claims is exposed in a series of conspicuous silicified slate cliffs stained with iron, traceable for fully 2,000 feet. The width of the zone is not exactly known, but must in places exceed 100 feet. It is made up of silicified brecciated and crushed slates holding numerous small stringers and lenses of quartz, but contains no large persistent quartz vein such as crosses the Chicago claim on the same zone farther to the north.

The dip is to the west at an angle of about 30°, and the silicified zone has been explored at four points in a distance of 870 feet by cross-cuts starting in the exposed eastern face and driven into it for varying distances.

The principal workings are at what is known as No. 1 or the shaft cross-cut. At this point a zone of good ore about 5 feet thick is exposed at the surface. This has been followed by a drift in a southerly direction for a distance of 165 feet. The ore shoot is continuous along the first 80 feet, beyond which the sulphides occur only in scattered grains.

Other workings here consist of a shaft about 25 feet deep, sunk at the portal of the drift, and a short cross-cut to the west from it to reach the extension of the ore shoot exposed in the upper level. This was soon encountered, and at a distance of 38 feet from the foot of the shaft drifts have been run along it in both directions. The drift to the northwest exposes ore for a distance of 35 feet and the one to the southeast for 20 feet. Both drifts have been continued beyond the ore into waste. The ore shoot is poorly defined and difficult to follow, and the workings are as yet insufficient to show whether its limits are reached in the drifts or a change in the direction of the shoot carries it away from them.

The ore shoot exposed in these workings has a minimum length of 104 feet, and a proved extension along its dip of 50 feet. It has not been followed below the drifts from No. 1 cross-cut. Its width is variable, ranging from a few inches to 10 feet or more. It consists of iron pyrite, with smaller quantities of galena, sphalerite, and occasionally some chalcopyrite, scattered more or less densely in grains and bunches through a gangue of quartz or crushed and silicified slate. The limits of the ore zone are not marked by fissures and are defined only by a gradual, in places somewhat abrupt, diminution in the quantity of sulphides present. A diorite porphyry dyke follows the ore in the upper level, and a similar, probably the same dyke, is cut into in the lower level in a short extension of the cross-cut beyond the drifts. The dyke is altered and silicified in places and is referred to the older pre-mineralization series. The dykes of this series occur at several points in the district either adjoining or close to ore zones, but their genetic connexion, if any, is probably limited to shattering the slates and so forming a channel for the ore solution.

The ore at the Jumbo usually carries values of from $10 to $15 in gold, silver, and lead. The following assays are furnished by the management:—

——	Gold.	Silver.	Lead.	Cu.	Zn.
	Oz.	Oz.		%	%
Sample 14 feet across shoot No. 1 cross-cut	0·07	5·64	15·01	0·9	3·16
Average No. 1 tunnel	0·08	5·90	11·50	.....	4·70
Average No. 3 tunnel	0·06	5·77	15·50	0·11	8·5

No. 2 cross-cut, situated 265 feet northwesterly along the fissure zone from No. 1, has been driven in for a distance of 120 feet without encountering any considerable body of ore. It starts above the base of the zone, and an ore horizon may still be found in the lower unexplored portion. No. 2 cross-cut, 223 feet northwesterly from No. 2, penetrates 99 feet of silicified slates, then a wide diorite porphyry dyke dipping to the west, beyond which there is a small development of ore not yet followed up. No. 4 cross-cut is situated 380 feet in a southeasterly direction from No. 1, and, when visited, was in 50 feet without reaching ore.

The workings at the Jumbo and Ben Bolt have been planned on the assumption that the ore body encountered in No. 1 cross-cut continues north and south along the silicified zone which crosses the claims. While it cannot be said that this view is entirely disproved by the negative results of the still incomplete work on the three exploratory cross-cuts, it is more likely that ore will be found in separate shoots along the zone and probably at different horizons in it.

Chicago Nos. 1 and 2.

These claims are situated north of the Jumbo and Ben Bolt, on the same fissure zone. The zone is more contracted, exposures at intervals showing a quartz lead with included slate from 10 to 20 feet in thickness. Very little exploratory work has been done on the claim. An ore body outcrops on Chicago No. 2 and the extent of this is now being investigated.

Portland Canal Mining Company.

A description of the Portland Canal mine, ores, ore bodies, and equipment is given in the Summary Report of the Survey for 1910, and need not be repeated here. During the year, exploratory work, under the direction of Mr. W. J. Elmendorf, has been pushed steadily ahead with varying results and there has been a considerable extraction of ore to feed the mill.

The fissure zone, where it crosses the property operated by this Company, outcrops on the hillside sloping down to Glacier creek, and is opened up by three main tunnels known as Nos. 1, 2, and 3, at elevations of 2,505·06 feet, 2,464·47 feet, and 2,410·46, respectively. No. 3 tunnel, the lowest level, has been driven in for a distance following the curves of 750 feet. Ore was encountered at 410 feet and followed for 60 feet, when it either pinched or was lost. No. 2 tunnel has a length of 480 feet. An ore body was reached at 60 feet and followed for 160 feet, beyond which the drift enters and cuts a diorite dyke for 100 feet. A second important ore body was then found, practically resting on the dyke, which continued for 120 feet. This ore body extends downwards along the dip towards No. 3 level and has been partially stoped out, but so far has not been found on that level. It also probably continues upwards to the surface, as cuts in the fissure zone in the direction in which it ought to outcrop show similar ore. No. 1 tunnel, the upper level, has a length of 180 feet and follows ore for the first 100 feet.

The net result of the operations up to the present has been to expose two main ore bodies which may possibly be found to connect with each other as exploration proceeds. The first ore body has a width on the upper level of approximately 100 feet, widens to 160 feet on the second level, and narrows to 60 feet on the third. It has not been followed below this level. This ore body has been mostly stoped out between the first level and the surface, and partially between the first and second levels. Below the second level it is less regular and its outlines have not been satisfactorily determined. It has a proved length, following the dip from the surface to the lower level, of 240 feet. The second ore body, 120 feet in width, is known only in the extension of the second level beyond the first. It probably, as stated before, continues to the surface, a distance of 150 feet, and this ground is now being examined. The surface cuts show ore for some distance south of the underground workings and a considerable extension of the ore shoots in that direction is probable.

A large diorite porphyry dyke, first encountered in the second level, 230 feet from the portal, has added to the difficulties of exploration. The dyke striking and dipping in the same general direction as the ore zone, outcrops on the surface some distance below it. Its dip at the surface is somewhat less than that of the ore zone, and it gradually approached it, joining and underlying it at the second level. In the third level the dip has increased and it probably soon after bends beneath the ore zone. The dyke is comparatively fresh in some places, and in others so badly altered and silicified that it is difficult to distinguish from the ordinary siliceous gangue of the mine. It was evidently intruded before the formation of the ore bodies and shared in the mineralization. Similar dykes are common in the neighbourhood and throughout the district, and its presence in the ore zone does not appear to have any special significance.

The Portland Canal ores, which are mainly iron, lead, and zinc sulphides in a siliceous gangue, carrying values of from $11 to $12 per ton in gold, silver and lead, are crushed, concentrated and separated before shipment in a mill situated on Glacier creek, and operated by water-power furnished by that stream. During the year the nominal capacity of the mill was increased from 50 to 75 tons per day, and a number of improvements made. These include a larger Sturtevant crusher, an improved system of water classification, and the addition of 6 Wilfley tables. In the latter part of the season the mill was running at its full capacity and giving excellent results.

The Stewart Mining Company.

The Portland Canal fissure zone between the Portland Canal and Stewart mines, a distance of 1·2 miles, is known to contain a number of ore bodies, some small and others still unproved. The O.K., Portland Wonder, and Lulu, owned by the Glacier Creek Mining Company, all show ore, but the desultory development work so far done has not proved the existence of any large shoot.

The George E. claim, one of the group owned by the Stewart Mining Company, is traversed by four approximately parallel quartz leads all opened up for varying distances.[1] During the year the principal development work carried out consisted in driving a tunnel 570 feet in length, along No. 4 vein, the most westerly of the series. A diorite dyke overlies the vein or line of fissuring on the west, dipping and striking in the same general direction. Ore occurs at the mouth of the tunnel and was again encountered in a short cross-cut to the west, 120 feet from the portal. The ore here has a width on the tunnel level of 14 inches, but widens to 3 feet at the bottom of a winze, 50 feet long, sunk on it. It directly underlies the dyke, both dipping to the west at an angle of 48°. The ore shoot appears to curve across the drift a few feet beyond the winze, and little ore occurs along the further course of the tunnel until a point 540 feet from the portal is reached. Here a short cross-cut to the left cut a body of ore nearly 6 feet in width, striking a few degrees west of north. This ore shoot dips under the continuation of the dyke, which directly overlies the ore at the winze, but is separated from it by 15 feet of argillites. It has been drifted on for 37 feet north from the cross-cut but its full length is not yet known.

This is the largest ore body so far found in the somewhat extensive Stewart workings, and work is now in progress to determine its full extent. The ore is similar to that at the Portland Canal and Jumbo mines, consisting of iron, lead, and zinc sulphides in a quartz or siliceous slate matrix. Assays, by the management, of samples taken across the full width of the shoot along the cross-cut, gave the following values:—

[1] Described in Summary Report, 1910, p. 77.

	Gold.	Silver.	Lead.
	Oz.	Oz.	%
South side of cross-cut 6 feet. .	0·07	4·20	6·12
North " "	0·20	2·00	3·25

The Portland Canal fissure zone, north of the Stewart mine, traverses the George E, Ben Hur, and Sunbeam claims, and possibly continues to the Main Reef. An ore body 4 feet wide is exposed in an open-cut on the Sunbeam but has not been followed up. An assay of a general sample of the sulphide ore obtained from Mr. W. J. Elmendorf, showed gold, 0·20 ounce; silver, 5·8 ounces; lead, 7·41 per cent.

Redcliff Mine.

The Redcliff ore body and the workings up to September, 1910, are described in the Summary Report of the Survey for that year. The Redcliff is the principal mine so far developed in the Bear River formation. The country rock is a greenish feldspathic porphyrite, crushed in places into a schist and fractured irregularly, the fissures striking in different directions and dipping at practically all angles. Some of them show movement, but there is no evidence of extensive faulting. The ore occurs in irregular bodies and consists of pyrite, pyrrhotite, chalcopyrite, and some blende, and occasionally a little galena in a matrix made up of quartz and the silicified and altered country.

The ore body developed outcrops on a steep, bare hillside, west of Lydden creek, at an elevation of 100 feet above it, and about 1,000 feet above sea-level. A tunnel along it at an elevation of 950 feet shows it to have a length at that level of 75 feet and a width of from 5 to 17 feet. On the surface it has a length of 120 feet.

A tunnel about 1,400 feet in length intended to undercut the ore body at a depth of 260 feet was completed during the year, and connected by an upraise with the upper workings. The raise is in two sections, connected by a short drift 65 feet below the upper workings, known as the intermediate level. The first section follows a steep, well-defined fissure, bordered in places by bunches of ore. The second section is nearly vertical and reaches the ore body exposed in the upper workings about 40 feet beneath it. A number of exploratory drifts branching from the lower and intermediate levels have been run in various directions, some following fissures and others directly through the country. The results of this work have been disappointing on the whole, as while ore has been found at a number of points, none of the occurrences have much persistence as workable masses. The main ore body exposed on the surface and cut in the upper level has a downward extension, as shown in the raise, of 40 feet below that level, but so far has not been definitely proved to descend as a continuous mass to the lower levels as was expected. Above the upper level, it extends to the sloping surface, a distance of 100 feet at the highest cropping.

An assay of a general sample of an occurrence of ore in the intermediate level showed: gold, 0·13 ounce per ton; silver, 2·00 ounces per ton; copper, 4·89 per cent.

Other exploratory work in progress includes the extension of the upper level to undercut an ore body 100 feet long and from 4 to 6 feet wide which outcrops on the hillside above that opened up; only negative results had been obtained at the time of my examination.

A power plant was added to the equipment of the Redcliff mine during the year, and water-power obtained from Lydden creek has been substituted for steam to operate the compressor plant and furnish other power needed. The Portland Canal Short

Line railway was completed to the mine late in the season, and ore bunkers were erected. The bunkers have a capacity of 700 tons and are connected with the mouth of the lower tunnel by a gravity tram 800 feet in length.

None of the numerous prospects on the west side of American creek above the Redcliff were worked during the season, the Big Casino, Redcliff extension, and Mountain Boy being all idle. On the east side work was commenced on a small galena showing on the Glenora claim owned by the Northern Terminus Mines Company. The country rock in the vicinity includes both the massive and fragmental varieties of the Bear River greenstones. The workings at the time of my visit consisted of a pit 8 feet deep, sunk on the deposit. This exposed a diabase dyke, 2 feet wide, dipping to the east at an angle of 45°. Resting on the dyke is a seam of nearly clean galena with some blende, 8 inches in thickness. A second vein from 3 to 6 inches wide underlies the dyke and is followed at one point by 3 feet of silicified, altered country containing some galena. The veins have only been uncovered for 15 feet. The ore runs high in silver, a sample collected showing 146·59 ounces per ton.

On Bear river above American creek, work was continued on the Ruby claim owned by the Portland Bear River Mining Company. A quartz vein traversing a band of slate enclosed in the Bear River greenstones, here mostly coarse fragmentals, occurs on the claim. The workings consist of a drift 150 feet along the lead. The vein striking to the north and dipping steeply to the west was followed for 120 feet. It is also exposed for a short distance in cuts south of the portal of the drift. The width varies from a few inches up to 2 feet. The quartz contains numerous slate fragments and is stained yellow in places from iron. Pyrite in small scattered grains is the principal metallic mineral present. The surface croppings of this vein are reported to have shown free gold. A general sample of the vein material on the dump gave on assay: gold, 0·25 ounce, and silver, 12·60 ounces per ton.

Near the head of Bear river some prospecting was done on the Copper King and Queen, staked by William George and Frank Strohn. The claims are situated high up on the range of steep craggy mountains bordering Bear river on the south. The Bear River greenstones, which form the country, show shattering along a wide zone trending east and west. Along this there is a development in places of small irregular quartz veinlets, bunches, and seams of calcspar, and areas are heavily pyritized. Chalcopyrite is present in portions of the zone but has not so far been found in workable quantities.

On Bitter creek some exploratory work was done on the Olga claim, on the L. S. and H. group on Hartly gulch, and on a quartz vein traversing the Black Bear group, south of the Bromley glacier.

The Olga, situated east of Bitter creek, about half way to the glacier, shows a quartz lead carrying considerable chalcopyrite in places cutting the Bitter Creek argillites in a northeasterly direction, and dipping to the southeast. The workings consist of a cross-cut tunnel to the lead 72 feet in length, and a drift along it 130 feet in length. Chalcopyrite in bunches and small aggregates is exposed along the drift for a distance of 60 feet, but is too sparingly distributed to constitute a commercial ore.

Work on the L. S. and H. group consisted in running a cross-cut tunnel 100 feet to reach two leads exposed on the slopes above. The work was not seen. The owners report that the lower lead, where cut, has a width of 4 feet and contains values of $15 per ton in gold and silver. The upper and larger lead was not reached on account of a flow of water.

The quartz veins on the Black Bear group, southwest of the Bromley glacier, were the cause of a wild gold stampede in 1910. One of the veins was explored by a cross-cut tunnel. The vein, where cut, contains considerable pyrite but carried only insignificant gold values.

The claims on the Middle fork of Glacier creek, described in the Summary Report for 1910 as containing small shoots of ore with high silver values, were all idle during the season.

Reconnaissance Trip to the Nass Valley.

In August a short trip was made across the Coast range to the Nass valley to examine some quartz and placer properties staked on the east slope of the Coast range. The trip was made in company with Mr. Porter, a prominent prospector in that region, and Mr. MacIntolmy, a claim owner.

The route followed was up the Bromley glacier to McAdam point, near the southern end of the Cambria range. Here the Bromley glacier divides into three main branches, one swinging to the south along the base of Mt. Trevor towards the high snow-covered pass from Bitter creek to Marmot river, and the two others heading in a long, comparatively narrow snow field occupying a high longitudinal valley west of the Cambria range and extending southwards for an unknown distance towards the head of Hastings arm of Observatory inlet.

From McAdam point a steep ice slope 1,000 feet high was climbed, then turning to the northeast the snow-filled valley west of the Cambria range was followed, gradually rising for 5 miles to a flat, barely perceptible summit at an elevation of 5,750 feet, then descending slowly at first but with gradually increasing grade towards the Nelson glacier and creek tributary to the Nass. This great snow valley is an important feature of the Coast range. It has a width of from 1½ to 2 miles or more and a length of over 20 miles in a northeast-southwest direction, or nearly parallel to the general trend of the range. The elevation of its snow surface averages about 5,000 feet, and it is bordered by the highest and most rugged mountains in this portion of the Coast range, some of the peaks jutting up through snow fields to elevations of over 8,000 feet; Mt. Otter, the highest, attaining an altitude of 8,800 feet. Through breaks in the bordering ranges the accumulated snow, compressed into ice, pours westward towards the Pacific and eastward towards the Nass in a series of large glaciers, soon changing as they descend into roaring torrents. The Coast range is singular in having its watershed and highest mountains in this latitude along its western margin. To the east the mountains decrease gradually in height to elevations of from 4,000-5,000 feet, while to the west the surface drops quickly down to the level of the Nass valley.

In descending Nelson glacier and creek the rough topography of the highest portion of the Coast range is replaced in a few miles by the even contours and comparatively low levels of the broken plateau country bordering the Nass.

The Nelson glacier terminates at an elevation of 1,950 feet and the large stream issuing from it unites with Porter, Willoughby, and other streams to form White river, which empties into the Nass a few miles below the outlet of Meziadem lake.

From Nelson creek a ridge 5,520 feet high was crossed to Mr. Porter's camp on Porter creek, one of the objective points of the trip. This stream, like practically all the large streams descending the east slope of the Coast range in this neighbourhood, heads in a large glacier. A pass from the Porter glacier to the snow valley, previously described, affords a shorter route from Bitter creek to Porter creek than that followed and is used in winter and spring. Later in the season the glacier, which is very steep, becomes badly crevassed and is more dangerous than the longer and less broken Nelson glacier.

GEOLOGY.

Few rock exposures were examined along the route traversed, as the way led for most of the distance along snow fields and glaciers. Those seen show that the lofty

Cambria range and the succeeding one on the east, the marginal range of the Coast mountains, consist largely of the massive, and medium and coarse fragmental greenstones of the Bear River formation. An area of limestones and slates, only seen at a distance, occurs in the angle above the junction of the Nelson glacier with a branch from the northwest. The relationship of these to the greenstones was not ascertained. They may represent a highly calcareous portion of the Bitter Creek formation, which contains considerable limestone in places, or an older formation.

The greenstones of the Bear River formation are replaced along the eastern base of the Coast range by dark shales alternating, in places, with greyish and greenish feldspathic sandstones in bands up to 20 feet or more in thickness. These rocks are referred to the Nass formation. They overlie the Bear River greenstones, resting on them, as a rule, at angles of about 45°. The dip is to the east, and, as shown in the partially scarped sides of the plateau-like ridges extending eastward from the Coast range between the valleys, decreases going eastward to less than 25° in places. The rocks of the Nass formation are not highly altered, except in places near the contact with the Bear River greenstones, are seldom cleaved, and look favourable for fossils, but none were found in the sections examined. They look young, but are probably pre-Cretaceous, in age at least, as they are cut by granite dykes and bosses presumably belonging to the period of the Coast Range batholith. The contact between the Nass argillites and sandstones and the Bear River greenstones, where it crosses Nelson, Porter, and Willoughby creeks, is very even and suggests faulting. Farther to the north the Nass rocks extend westward into the Coast range, and are exposed, lying in a nearly horizontal position in the upper portion of several mountains, Strohn creek, and Upper Bear river.

PROSPECTS.

A wide zone, generally reddened by the surface oxidation of iron pyrites, occurs along the contact of the Nass argillites with the Bear River greenstones. A large number of claims have been staked on this zone, but up to the present little work has been done and no large body of pay ore discovered. The district, while only a few miles from Bear river, is difficult to reach, and all supplies have to be packed in either from Bitter creek, over dangerous glaciers and soft snow fields, or from the head of Bear river, following a rough foot trail down Strohn creek to Meziadem lake, then southward for many miles across a ridgy woody district practically destitute of trials. No effective work can be done until better communication is established and the cost of supplies greatly reduced.

Notwithstanding the adverse conditions, some development work has been done on the Bullion claim, staked by Mr. Porter and owned by Mr. James Mowat. The showing on this claim is situated on the hillside, north of the foot of the Porter Creek glacier, at an elevation of 500 feet above the valley, and consists of a fissured and partly silicified zone in the argillites of the Nass formation. The zone is about 7 feet wide, has a northwesterly strike, and dips to the northeast at an angle of 70°. Along the foot-wall, as shown in a short tunnel, is a layer of quartz interbanded with argillites from 1 to 2 feet wide. The quartz is copper-stained in places and contains some pyrite, galena, and zinc blende. Samples of the mineralized quartz are reported to have yielded high values in gold and silver, but a specimen collected by the writer was disappointing, as it showed only traces of these metals. This result may possibly be due to an irregular distribution of the precious metals along the lead. The fissured zone is concealed above the short tunnel and its length is not known.

The Bear River greenstones, near their contact with the Nass argillites, are heavily impregnated with iron pyrites in places, but so far no workable deposit of valuable minerals has been found.

PLACER DEPOSITS.

From Porter creek a ridge rising about 2,000 feet above the valley bottom was crossed to Willoughby creek, on which a number of placer claims have been staked.

Willoughby creek issues from a broken, branching glacier, terminating at an elevation of approximately 2,300 feet, and is a large, rapid stream usually from 30 to 60 feet across, with an average grade of 225 feet per mile. A large branch from the south joins it 3½ miles from the glacier. The valley for a mile and a half below the glacier is wide and bottomed with gravel flats. Below that it narrows in, and in places is confined in rock canyons often bordered by narrow benches.

Willoughby's camp is situated about 4 miles from the foot of the glacier. The creek here has a shallow box canyon through the shales and tuffs of the Nass formation. A rock terrace on the left bank, about 200 feet wide and 20 feet above the water-level, is covered by 25 feet of coarse gravel.

Some coarse gold is reported to have been found in a bar in the canyon. No work had been done on the bar up to the time of my visit, owing to the continual high water, and it will evidently be difficult to work at any time, as the stream is large, rapid, and its channel filled with boulders. A tunnel has been driven part way across the terrace in the hope of finding a pay channel at that level, but so far without success.

A number of claims have been staked on Willoughby creek above and below Willoughby's camp, on Little White river, and on Little Pat creek, a small foothill stream, but no effective work has been done on any of them.

Some gold occurs on all the streams issuing from the mountains along this portion of the Coast range. Moderately fine, flaky, but still rough gold in small quantities was panned out on Nelson creek, close to the foot of the glacier, and at other points. It is quite possible, although not yet proved, that concentrations may occur in the lower reaches of some of the streams, but unless these prove to be very rich the cost of working them, unless situated above the water-level, would be prohibitive. The streams are all large, are practically continuous rapids throughout, and, as they head in glaciers, high water lasts until late in the season.

Bench gravels occur in Willoughby creek and other places, but the deposits seen were all small.

The creeks staked as placer ground traverse the shales and sandstones of the Nass formation. These rocks, away from the mountains, contain few quartz veins, and the stream gold is probably mostly derived from the greenstones and associated rocks of the Bear River formation in which all the large streams head. No evidence of an old channel crossing the district independently of the present drainage system, firmly believed in by some of the miners, was observed. The bench gravels seen all belong to former higher levels of the present streams.

STROHN CREEK.

The return trip to Bear river was made by Meziadem lake and Strohn creek. Little White river, formed by the junction of Porter and Nelson creeks, has been bridged by the Provincial government a few miles above the mouth of Willoughby creek, and from this point a foot trail has been blazed, but very imperfectly cut out, across the wide wooded ridge separating Nelson from Strohn creek, the next large stream to the north. The ridge, where crossed, has an elevation of approximately 2,700 feet.

Strohn creek has recently acquired importance as a possible route to the Groundhog anthracite basin, at the head-waters of the Skeena, Nass, and Stikine rivers. It heads with Bear river, in a low glacier-covered pass, and flows eastward to Meziadem lake, the latter emptying by a short outlet into the Nass river. Strohn Creek valley has an estimated length of 9 miles, and a grade of approximately 100 feet to the mile.

The valley is flat-bottomed, usually half a mile or more in width, and offers no especial difficulty for railway construction.

The glacier at the summit heads in the high mountains to the south, and after reaching the pass alters its course and separates into two short branches, one flowing to the west down Bear river and the other to the east down Strohn creek. The combined length of the two branches is about 1½ miles. This portion of the route would have to be tunnelled. The Strohn Creek, or easterly branch of the glacier, terminates at an elevation of approximately 1,540 feet, and the Bear River branch at an elevation of 1,370, while the ice-covered summit, where crossed, has an elevation of 2,270 feet, measured by the aneroid.

Bear River valley, from the foot of the glacier at its head to its junction with American creek, the present terminus of the railway, has a length of about 9 miles. It is flat-bottomed along most of its course, but is narrower than Strohn Creek valley, and along one stretch, about three-fourths of a mile in length, contracts into a canyon. The grade averages about 100 feet to the mile. The bordering mountains are steep and some trouble would probably be experienced from snow slides.

The total length of a railway from the mouth of American creek to the Nass, following Bear river, Strohn creek, and Meziadem lake, would be approximately 32 miles. A tunnel 1½ miles in length would be necessary at the summit, and possibly a short one at the Bear River canyon. A railway to the same point from Nasoga bay, following the valley of the Nass, would have a length of at least 110 miles.

Geology.

The ridge crossed from Little White river to Strohn creek, as shown by occasional exposures, consists of the shales and sandstones of the Nass formation. The same rocks outcrop at points along Meziadem lake and in the ridges and mountains bordering Strohn Creek valley for a distance of about 5 miles above the lake. They are cut at one point north of the valley by a large granite stock, only seen at a distance. They dip to the east and approaching the mountains become harder and more altered. Four miles from the summit they are underlain and replaced by the greenstones, here largely volcanic fragmentals, of the Bear River formation. The contact between the two formations is concealed in the valley, but is plainly traceable, running a few degrees west of north in the mountains bordering the valley.

No mineral occurrences of importance are reported along Strohn Creek valley.

RECONNAISSANCE ON THE UPPER SKEENA RIVER, BETWEEN HAZELTON AND THE GROUNDHOG COAL-FIELD, BRITISH COLUMBIA.

(*G. S. Malloch.*)

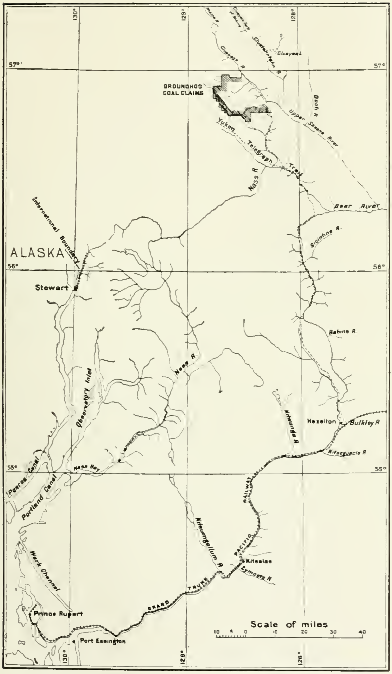
Introductory.

The special object of the writer's field work, during the past summer, was to gain information regarding an area of anthracite coal occurring near the head-waters of the Skeena river. This area is commonly called the Groundhog coal field, from the name of a range of mountains bordering its southern edge. As no reliable surveys were available to determine the geographic position and approximate elevation of the new field it was necessary to run a traverse to it from Hazelton, whose geodetic position was fixed in August by Mr. McDermaid of the Dominion Observatory. Sets of simultaneous aneroid readings were also made at convenient intervals along the trail to determine approximately the elevation of the basin. The time occupied in traversing the trail gave the writer an opportunity to study the geology and make topographic sketches of the route travelled, but limited the time in the coal field to seven weeks, a period much too short for the examination of a field whose area cannot be less than 2,000 square miles and probably exceeds that figure. The writer, seeing the futility of attempting to cover the entire basin, considered it better to make a somewhat detailed examination of a small portion which was being actively prospected by Mr. James McEvoy for the Western Development Company, and Mr. Campbell-Johnston for the British Columbia Anthracite Syndicate. A base was measured and triangulation extended to control an area, roughly, 6 miles by 12, and traverses were run of streams and trails. After leaving the basin, two weeks were spent in the vicinity of Hazelton examining some of the more recently discovered silver, lead, and copper prospects, and the Kispiox coal field situated some 15 miles north of the town.

A sketch map has been prepared to illustrate the position of the coal field, and the possible routes for railways which may be built to it. In the preparation of the map, use was made of a hitherto unpublished map of the lower Nass valley, made by Mr. McEvoy for this Department in 1893, while the upper part of the valley is taken from a sketch map made by a prospector, Mr. Anthony Kobes, to whom the writer's thanks are due for permission to make a tracing. The country at the divides between the branches of the Skeena and Nass is from a sketch map furnished by Mr. Campbell-Johnston. Acknowledgment is also made of the numerous kindnesses received from him and Mr. Moncton, and from Mr. McEvoy, at the coal field; from Messrs. Kinman, Pemberton, and the Harris brothers, at Hazelton, and from Mr. Hugh Taylor, Mr. Corner, Mr. Faulkener, and in fact from all the linemen and operators along the Yukon telegraph line from Hazelton to the fifth cabin.

Location and Area.

The Groundhog coal field is situated 140 miles north and slightly west of Hazelton, and about 90 miles northeast of the town of Stewart at the head of Portland canal. While only a small portion of the field was seen, it has been computed from



DIAG. 5. Diagram showing the location of Groundhog coal claims.

information obtained from prospectors that the strip of country underlaid by coal seams is approximately 30 miles wide and extends to the northwest for 70 miles or more. This would mean an area of 2,100 square miles, and as has already been stated, a much larger area may be underlaid by productive coal seams.

History.

The first authentic discovery of coal in the Groundhog field was made by Mr. James McEvoy in 1903, who staked a number of claims on his discoveries. His time was very limited, but he secured samples from a seam on Discovery creek which showed on analysis an anthracitic coal a little high in moisture and ash. In 1904, Mr. W. W. Leach visited the field with a small party, stripped several of the seams and staked additional claims in behalf of the Western Development Company, bringing the total area held by them up to 16 square miles. The field was revisited in 1908, and in 1909 a party sent out by the German Development Company, under Mr. J. Fred. Walter, opened new seams, and a number of samples were secured by Mr. C. Fergie.

In 1910, Mr. Campbell-Johnston staked a number of claims to the north and west of those belonging to the Western Development Company for the British Columbia Anthracite Syndicate, and Mr. Jackson performed a similar office for the British Columbia Anthracite Company. Mr. Jackson's claims practically surround those of the Western Development Company, except on the west, and extend for some miles to the east.

During the past summer the field was prospected by large parties under Messrs. McEvoy and Campbell-Johnston, and a large number of new claims were staked, until the total number now exceeds 400.

Previous Work.

No geological report has yet been published on the Groundhog basin, but the geological section is approximately the same as that in the vicinity of Hazelton, which was described by Dr. Dawson in the Report of Progress for 1879-80, and by Mr. Leach in the Summary Report for 1906-1910.

Dr. Dawson mentions the occurrence on the Skeena river of a belt of Mesozoic rocks about 57 miles in width, extending down the Skeena from Hazelton. On the western margin of the region porphyrite and other feldspathic and brecciated rocks occur, but eastward the strata are composed of comparatively soft sandstones, argillites, and carbonaceous argillites, and Dr. Dawson[1] inclined to the view that the rocks on the eastern edge were the younger, though he was evidently unable to secure direct stratigraphical evidence owing to the great number of folds traversing the region, and the scarcity of exposures on the river banks.

He adds that the general distribution over the district of carbonaceous shales containing impure coal, points to the occurrence of conditions such as are required for the deposition of true coals, and indicates the possibility, if not the probability, of the occurrence of coal beds of a workable character in some part of the region.[2]

Dr. Dawson's examination of the country was confined to the route he travelled, but the summary reports published by Mr. Leach show that he was correct in all his main conclusions. Mr. Leach notes, however, that the progressive change in character, from volcanic to sedimentary, of the strata of the Porphyrite group, takes place generally to the north and not to the east as Dr. Dawson deduced from his observations. The mistake will readily be explained by remembering that Dr. Dawson was travelling in a general northeasterly direction.

[1] G. and N. S. C. Report of Progress, 1879-80, B p. 103.
[2] Ibid, pp. 104-105.

Mr. Leach has proposed that the name Hazelton group be substituted for the Porphyrite group, and recognizes the coal-bearing strata as a distinct formation under the name of the Skeena series. He describes[1] them as consisting of 'Rather soft, thin-bedded shales and sandstones, the former, in places, carrying many clay-ironstone nodules and a number of coal seams. At the base of the series,' he continues, 'there is usually found a bed of coarse, crumbly conglomerate, but this, though fairly persistent, is not always present. The maximum thickness is in the neighbourhood of from 600 to 800 feet, and a number of fossils (chiefly plants) collected at various times show that the age of the beds is lower Cretaceous and about equivalent to the Kootanie of the Crowsnest pass.'

Mr. Leach's description of the Hazelton group contains the following sentences:—[2]

'Generally speaking, it may be said that to the south this formation is built up almost entirely of flow rocks, chiefly andesites, massive, and with characteristic dark red and green colours. At the top of the series, a few thin beds of fossiliferous sandstones and shales appear, a number of fossils from which have been determined to be of Jurassic or early Cretaceous age. On travelling northward, however, it was found that these flows gradually thinned out and were replaced by a considerable thickness of tuffs and tufaceous sandstones, although a few of the endesite beds extended as far north as Hazelton.' The fossils referred to above consist of marine invertebrates containing specimens of Inocerami and Astartes.

In the vicinity of Hazelton and south of it, both the Hazelton and Skeena series are cut by intrusions of granodiorites and diorite porphyrites, which have evidently played an important part in the deposition of the metalliferous deposits found in or near bosses and dykes of the igneous rocks.

Summary and Conclusions.

As a result of the summer's work the following geological facts were established. A thickness of 3,650 feet of strata, exposed in one section near the southern end of the Groundhog basin, is coal-bearing, though the most important seams occur in the upper 1,000 and lower 1,000 feet of the series. The rocks of the coal-bearing group form a series conformable with the underlying rocks, and both have been thrown into folds and faulted by pressure from the southwest. It is, therefore, quite possible that other areas of coal-bearing strata will be found, and perhaps some more favourably situated than the Groundhog coal basin for transportation of the coal. In the vicinity of Hazelton, many promising deposits of silver, lead, and copper ores are being prospected. The writer is also of the opinion that borings in the Kispiox coal field, near Kispiox post-office, might prove the existence of coal seams thick enough and sufficiently free from ash to make it profitable to work them.

General Character of the District.

TOPOGRAPHY.

Regional.

The topography of the region traversed between Hazelton and the Groundhog basin is mountainous, the differences in elevation between the valley bottoms and bordering ranges usually exceeding 3,000 and sometimes amounting to 7,000 feet. The highest mountains seen were only a short distance north of Hazelton, and this fact is all the more striking because there the valleys are less than a thousand feet above sea-level and are much wider than those farther north. There is also an absence at

[1] Geol. Surv., Can., Summary Report for 1910, p. 94.
[2] Ibid, pp. 93-94.

Hazelton of the prevailing northwest and southwest trend of valleys and ranges which prevails farther north, and which is more or less general throughout British Columbia. Even to the north, however, the Skeena shows great disregard for the course of the main valleys, sometimes turning at right angles to them and passing through narrow clefts in the enclosing ranges. Striking examples of these anomalous bends are found near the mouths of Babine river, which drains Babine lake, and Bear river, which also rises in a lake of the same name as itself. For a great part of its course, the Skeena occupies narrow canyons cut in places, as for example above the mouth of Deep creek, through thick, terraced deposits of river gravel, but more often the river boils through an extremely narrow gorge cut in the rock floor of the valley. Some of these gorges are nearly 200 feet deep, with nearly perpendicular walls. The tributary streams also occupy canyons in their lower courses, but above, many of them meander through marshy flats and head in cirque-like amphitheatres. The main divides, between the three great river systems, *i.e.*, the Skeena, Nass, and Stikine, are usually marshy flats often containing lakes. Examples of such divides between the two former occur at the heads of the Kitoumgaloon, Chitach, Kispiox, Shalangeese rivers, Currier and Beirnes creeks: while the divides between the several branches of the Skena and those of the Stikine are reported to be of the same general character.

Local.

The local topography of the Groundhog basin, or of the small part of it which was examined, is somewhat complicated. Strictly speaking, there are at least five parallel basins, but since the region underlaid by the coal-bearing strata contains few elevations exceeding 6,000 feet, while many in the surrounding country exceed 7,000 feet, it is permissible to speak of the whole area as a basin. The distinction was brought out to the writer when overlooking the basin from a peak in the Groundhog mountains, after a fall of fresh snow which remained only at elevations above 6,000 feet. While only a few of the summits within the area were capped with snow, long lines of white peaks bordered it on three sides, the boundary to the north being too far distant to be made out.

The basin is bordered on the south by a high and rugged range known as the Groundhog mountains. Many of the peaks exceed 7,000 feet in elevation and glaciers are quite common. This range is irregularly dissected by streams draining to the Nass and to the Skeena, and the route to the basin crosses it by a pass 5,100 feet in elevation. On the west the basin is bordered by the broad valley of the Nass, beyond which rise the lofty peaks of the Coast range. On the east the basin extends to the valley of the Cluatahntahn, or eastern fork of the Skeena. The western fork, or the Cluakaas, flows southeast through the centre of the basin to near its southern border, where it makes a sweep to the east and joins the Cluatahntahn outside the limit of the coal-bearing strata. The original discoveries were made on Discovery creek, a small tributary of the Cluakaas, and the claims of the Western Development Company, and the great majority of those belonging to the British Columbia Anthracite Syndicate, are situated in the valley of that fork of the Skeena. The elevation of the valley bottom is about 2,900 feet where the Cluakaas leaves the basin, and the gradient of the river is about 50 feet to the mile. Just before the Cluakass takes the bend to the east, it is joined by Currier creek which flows almost east and west, taking its rise near a large lake situated at the divide leading to Panorama creek, a tributary of the Nass. The elevation of this divide is 4,100 feet. About 10 miles higher up, Beirnes creek comes heading in a slightly higher divide with another branch of the Nass, known as Anthony creek. The valleys of the Cluakaas and of Currier and Beirnes creeks are wide, and rock exposures are comparatively rare, except in places where the streams hav cut canyons through the different strata. On the hills, especially above timber line (above 5,000 feet), exposures are naturally more numerous, but there are large tracts of rolling upland covered with residual soils, and continuous rock exposures must be sought at the highest elevations, which present a more rugged outline with many cirque-like hollows often separated by comparatively narrow ridges.

CLIMATE AND AGRICULTURE.

The climate at Hazelton is pleasant, without excessive rain or sonw fall, but farther north precipitation is somewhat greater. In some years the Hazelton district suffers from summer frosts, though those seem to be less frequent now that considerable tracts of land have come under cultivation. Farther north, and at higher elevations, frosts are of more frequent occurrence, and there is a lack of sunshine in the autumn to ripen grain crops. At Hazelton, oats and some of the hardier varieties of wheat have been grown successfully and root crops do exceptionally well. The construction of the Grand Trunk Pacific has made a large demand for hay, and it and potatoes seem to be the most profitable crops at present.

FAUNA AND FLORA.

Hazelton has long been an important centre for the fur trade, and though fur-bearing animals are not especially abundant at present, still the Indian population secure large numbers of skins in the early spring months. Big game is rather scarce for some distance north of Hazelton, but grizzly and black bears, moose, caribou, and goat are more numerous at the Groundhog basin. Beaver are quite plentiful and the whistling marmot is abundant.

Salmon ascend the Skeena to the head of the Cluatahntahn, but are not found in the Cluakaas branch. Bull trout are found in all the streams, but are not numerous enough to afford good sport. Rainbow trout were not seen far north, but abound in the small lakes draining to the Kispiox.

The principal trees of the district to the north consist of several varieties of spruce, balsam, aspen, and balsamiferous poplars (cottonwood). Some white birch and jackpine are also found, while, as is usual in British Columbia, the black alder abounds and often grows to a diameter of from 6 to 8 inches. Large red cedar were seen in the Kispiox valley, but apparently they do not extend far north of it. The underbrush is very thick at the lower elevations on the Skeena and there are many varieties of edible berries, though they do not reach elevations much exceeding 3,000 feet.

TRANSPORTATION.

The Groundhog basin is reached from Hazelton by following the Yukon telegraph trail to Blackwater lake, between the fifth and sixth cabins, and then to Slowmalda creek, and crossing a divide at an elevation of 5,100 feet and descending to the Cluakaas by Trail or Canyon creek. The latter part of the route was used by several parties during the Klondike rush, and the number of abandoned pack and riding saddles to be seen along it is eloquent testimony of the hardships they endured. The route south from Telegraph creek is reported to be as short and much drier, and there is an abundance of grass for the horses, which is scarce along the present route.

In order to obtain a market for the coal in the Groundhog basin, it will be necessary to build many miles of railway. The most direct route to tide-water would be to the town of Stewart, situated at the head of the Portland canal, which affords a splendid waterway for 150 miles from the coast, as well as an excellent harbour. A line of railway has already been built up the valley to Bear river for 12 miles from Stewart, but difficult rock work, a tunnel 2 miles in length, and grades of probably over 2 per cent would be entailed in extending it to the Nass valley, a distance of some 35 miles. These difficulties would be avoided by building a line up the Nass from Nasoga gulf, which offers the nearest suitable harbour. The length of railway, should this route be chosen, would be 85 miles in excess of the Stewart route, and some rock work would be necessary in skirting the shore before reaching the Nass at all. The grade would, of course, be low. Some coal has been reported on the eastern edge of the basin, but at a considerable elevation above the bottom of the Nass valley. Probably to reach the nearest seams, 90 miles of railway would be necessary from the terminus of the Stewart line, and to reach the centre of the basin it would be necessary to cross a divide either at the head of Panorama or Anthony creeks, both of which are above 4,000 feet in elevation, and would doubtless necessitate grades of at least 2 per cent in an easterly direction, though they would probably not amount to over 1 per cent for the haul westward. The route up the Skeena from Hazelton would mean 150 miles of railway, which, from the estimates of Mr. J. S. O'Dwyer,[1] would cost about $3,200,000, and the total distance to Prince Rupert by this route would be 300 miles.

General Geology.

TABLE OF FORMATIONS.

Quaternary	Glacial and river deposits.
Tertiary ?	Bulkley eruptives.
Lower Cretaceous (or upper Jurassic)	Skeena series (coal-bearing).
Jurassic	Hazelton group.

DESCRIPTION OF FORMATIONS.

Hazelton Group.

The rocks of the Hazelton group were the only rocks seen, except at the Groundhog basin and in the vicinity of Hazelton, where comparatively small areas of the Skeena series occur as well as intrusive batholiths and dykes of the Bulkley eruptives.

The group contains volcanic flows in the vicinity of Hazelton, as well as tuffs, tufaceous sandstones, and black and more or less carbonaceous shales. North of the Shegunia, however, no flows were seen, though nearly all the sandstones contained much tufaceous material and some true tuffs occur. As the Telegraph trail follows the strike of the beds, no reliable estimate of the exposed thickness of those beds could be made, and at no point were exposures sufficiently continuous to furnish valuable sections. The base of the formation was not seen, though it is likely that it rests upon the limestones of the Caché Creek series of Carboniferous age. The tufaceous material is especially abundant in the lower members of the group, and some of the tuffs there are light grey in colour and weather to yellow-brown and reddish tints. Those were seen on the northern slope of Poison mountain, a hill 60 miles north of Hazelton,over which the trail climbs to avoid a deep canyon on the Skeena. Higher up in the series the prevailing colours are sombre grey to black, and the sandstones, which are quite coarse in places, contain, besides volcanic ash, partially rounded grains of black shales. Plant remains occur throughout the formation, impressions of entire tree trunks being found in some of the sandstones. When this is the case, thin films of coal develop usually along the outer edge of the trunk, while the remainder of what was once wood is replaced by sand grains, now cemented, and showing an apparent difference from the rest of the bed. In some of the finer sandstones and shales delicate leaf tissues have occasionally left their impressions,

[1] See Railway and Canals Report No. 8, 1901, pp. 162-163.

but, in general, the deposition of material was probably too rapid, and most of the finer lines by which genus and species might be determined have been lost. Near the top of the horizon some dark calcareous shales contain numerous interior casts and some shells of marine invertebrate. The genera Astarte and Inocerami were determined by Dr. Raymond, but not the species. In the field this marine horizon was recognized at the crest of the mountain north of Deep creek, on one south of Blackwater lake, and in the Groundhog mountain immediately south of the basin. In all probability the age of this part of the group is Jurassic, but the lower part may be older.

Skeena Series.

As far as is definitely known, the coal-bearing Skeena series does not occur between the Groundhog basin and a point 18 miles north of Hazelton. It is quite possible, however, that it may occur at some points west of the Telegraph trail. Indeed, some thin seams of coal were seen overlying the fossiliferous bed at the summit of the mountain south of Blackwater lake and the strata in the valley to the west, apparently belonging to a still higher horizon. On the other hand, though the river drift was carefully watched, no extraordinary number of fragments of the conglomerates of the Skeena series were noted until the Groundhog basin was approached.

The occurrence of the Skeena series above the Shegunia river has already been noted by Mr. Leach,[1] and the strata outcrop on both the Skeena and the Kispiox, from the junction up-stream, for about 7 miles.

As noted by Dr. Dawson, rocks referable to the Skeena series occur on the Skeena below Hazelton, near the mouth of the Kitseguecla, and numerous areas on the Bulkley and its tributaries are mentioned by Mr. Leach, while other areas are reported on Babine and Bear lakes.

While there is a general resemblance between the Skeena series in the Kispiox area north of Hazelton and in the Groundhog, the differences are sufficiently pronounced to make it advantageous to describe the two areas separately. The points in common are the general yellow and brown tints of the sandstones and shales which serve to distinguish the series from the underlying Hazelton group. The sandstones of the Kispiox area are also yellow and brown in colour in the lower part of the series, which was all that could be found. Exposures are confined to the banks of the Kispiox and Skeena, and with the exception of a bare slide on the Skeena 7 miles above the junction, the exposures are widely separated and the beds too much faulted to give a satisfactory section. This slide has laid bare a face of rock 300 feet high, but the continuity of the section is broken by a fault. Measurements were made of the section exposed with the following results, in descending order:—

Big Slide Sections.

		Feet.
1.	Brown sandstone grey on fracture and moderately coarse, about	70
2.	Brown shale	30
3.	Coarse yellow sandstone	8
4.	Yellow and brown shales	60
5.	Yellow sandstone	30
6.	Coal	1·9
7.	Brown shale	10
8.	Yellow sandstone	58
9.	Coal	0·6
10.	Bone and coal	0·9
11.	Coal	1·3
12.	Yellow sandstone	40
13.	Yellow and brown shales	100
14.	Coarse yellow sandstone with stringers of calcite	20
		419·7
	Fault	?

[1] G. S. C. Summary Report, 1909, p. 67.

		Feet.
1.	Yellow and brown shales	220
2.	Coal	1·4
3.	Bone	0·9
4.	Coal	0·9
5.	Bone	1·5
6.	Coal	0·6
7.	Yellow and black shales	25
8.	Coal with 0·4 ft. bone	2
9.	Yellow shales with black bituminous bands and some brown sandstones	20
10.	Coal	1·3
11.	Similar series of shales	260
12.	Yellowish and grey shales alternating	56
13.	Black shale, bottom not seen	6
		595·6

Below the base of the lower section, exposures are missing for an interval of several hundred feet, after which the coarse, tufaceous sandstones of the Hazelton group were seen dipping under the Skeena series. The uppermost bed of these sandstones contained a number of pebbles of blue and green cherts, but these were not sufficiently abundant to constitute a conglomerate bed. As has been stated, Mr. Leach found a bed of conglomerate underlying the Skeena series, in some, but not in all the sections examined.

The Skeena series in the Groundhog basin has a thickness of over 4,200 feet, as measured on the crest line of the hills west of the Cluakaas, and 5 miles from the mouth of Currier creek. Probably the lower 400 or 500 feet should be placed in the Hazelton group. The section is in descending order.

Main Section.

		Feet.
1.	Massive bed of conglomerate with chert pebbles up to the size of hens eggs	107
2.	Brown shale	8
3.	*Coal* with 0·7 ft. bone	12
4.	Brown shaly sandstone	5
5.	Brown shale	10
6.	*Coal*	3·2
7.	Black shale	24
8.	*Coal* with 1 ft. bone near centre	4·5
9.	Black and brown shale	15
10.	Shaly sandstone	9
11.	Black shale	8
12.	*Coal*	2·8
13.	Brownish shales, and shaly sandstones	114
14.	Massive bed of siliceous sandstone with conglomerate pebbles especially in lower two-thirds. Slightly shaly above	37
15.	Black and brown shale with thin streaks of coal	250
16.	Coarse but poorly cemented sandstones	8
17.	*Coal*	2
18.	Hard siliceous sandstone weathering to reddish tints fairly coarse in places	34
19.	Black and brown shale with three thin seams of coal	33
20.	*Coal*	1
21.	Black and brown shale	16
22.	Shaly sandstone	16
23.	Brown sandstone with bands of calcareous shale below and conglomerate pebbles above	51
24.	Brownish shale with bands of fossiliferous sandstone concretions	23
25.	Brown sandstone with numerous pebbles in lower beds finer grained above	15
26.	Partly concealed probably brown shale	16
27.	Siliceous sandstone weathering red	6
28.	Black shale	8
29.	Shaly sandstone	4
30.	*Coal*	1·3
31.	Black shale	21

		Feet.
32.	Shaly sandstone	2
33.	Dirty *coal*	2·5
34.	Black shale and shaly sandstone with three streaks of coal	41
35.	*Coal*	4·5
36.	Black shale and a little shaly sandstone	41
37.	Beds of soft yellow sandstone with some conglomerate pebbles and bands of brown shale	39
38.	Coarse sandstone with conglomerate pebbles scattered through it	35
39.	Black and brown shale with streaks of coal	40
40.	*Coal*	1·3
41.	Black shale with streak of coal	22
42.	Coarse sandstone	2
43.	Black shale with streak of coal	11
44.	*Coal*	1·1
45.	Black shale	17
46.	Black shale and shaly sandstone	40
47.	Hard siliceous sandstone	20
48.	Black shales and shaly sandstone	142
49.	Black shales separated by brown shaly sandstones in thin beds	219
50.	Coarse brown sandstone	12
51.	Black shale	21
52.	*Coal* seam rather dirty	2
53.	Black shale	140
54.	Sandstone beds separated by a few bands of black shale	75
55.	Black shales with a few ribbons of coal	155
56.	Siliceous sandstone weathering red	2
57.	Black and brown shale	350
58.	*Coal*	0·5
59.	Black shale and soft shaly sandstone	88
60.	Coarse grey sandstone with rather weak cement weathering brown	46
61.	Black shale with coal seam not dug out	50
62.	Coarse grey sandstone showing concretionary forms in some parts	38
63.	Shaly sandstone	8
64.	Fine-grained sandstone with some shale and streaks of coal	41
65.	*Coal*, roof fallen in, at least	1
66.	Soft grey sandstones and beds of calcareous shale with numerous concretions	111
67.	Coarser grey sandstone	6
68.	Black shale	5
69.	Black shales and shaly sandstones partly concealed	153
70.	Brown shales and shaly sandstones with numerous concretions	61
71.	Black and brown shales and shaly sandstones	196
72.	Black shales and coarse sandstones, the shales predominating	214
73.	Hard siliceous sandstone weathering red	25
74.	Black shale	143
75.	Conglomerate	6
76.	Black shale	15
77.	*Coal*	0·4
78.	Black shales and grey sandstones, the shales predominating	73
79.	Massive bed of hard grey sandstone	38
80.	Black shales with a few streaks of coal and thin bands of sandstone	86
81.	*Coal*	0·3
82.	Black shales and grey sandstones	115
83.	Grey sandstone	7
84.	Black shale	30
85.	Grey sandstone	36
86.	Black shale with a few bands of sandstone	80
87.	Black shale and grey sandstones weathering brown, sandstone predominates	326
88.	Black shale with some calcareous concretions	36
89.	Hard grey sandstone	6
90.	Black shale, bottom not seen, at least	300
	Total	4273·4

It is not likely that a section a few miles from this point would correspond closely to the above section, and, indeed, the Skeena series, like the Kootanie series in the eastern ranges of the Rockies, is very irregular, several instances of contemporaneous erosion being observed even on comparatively small rock faces.

The section is, therefore, intended to serve as a general type section, and as far as is known, the main thickness of sandstone and shale can be correlated in different parts of the basin. On the whole there is a great similarity between the rocks of this Skeena series, in the Groundhog basin, and those of the Kootanie series as exposed in the eastern ranges of the Rockies. The hard, siliceous beds of grey sandstone, weathering to reddish tints, seem almost identical, but, on the other hand, a number of points of difference were noted. The most striking of these is the great development of conglomerate beds. A band of conglomerate, capping the formation, has a thickness of over 100 feet, in no part of which is the maximum size of the pebbles smaller than an ordinary marble. In the Kootanie such thicknesses are rare, though a bed 80 feet in thickness is reported from Fernie.[1]

While many of the pebbles of both formations, *i.e.,* the blue, green, and white cherts, seem identical, there are in addition in the Skeena series, pebbles of volcanic rocks notably softer than the cherts, and the various pebbles are not nearly as well rounded. These facts would suggest that the Groundhog basin was nearer to the scurce of tbe material from which the pebbles were derived, an inference which is supported by the fact that the shales show much more variety in colour than those of the Kootanie, brown and yellow being even commoner than the black, whereas, in the Kootanie section, brown colorations are comparatively rare in the shales and no yellows are found. This lack of colour would, of course, imply a chemical disintegration of the material and reduction of the iron by humic acids, so that it is present as ferrous iron carbonate.

Bulkley Eruptives.

The Bulkley eruptives form huge batholiths in the vicinity of Hazelton and for some distance north of it. The Roches de Boulées, Hudson Bay mountains, and the ranges on either side of the Skeena valley as far as Babine lake are largely composed of these rocks, which, owing to their hardness, form the precipitous crest lines characteristic of these mountains. In the vicinity of the Telegraph trail a number of dykes of igneous rock cut the Skeena series for 16 miles north of Hazelton, while the river float showed many fragments of igneous rocks as far north as Poison mountain; farther north the igneous material, while not altogether absent, was insignificant in amount. Mr. Leach describes the series as consisting of granodiorites and diorite porphyrites, but, as far as is known, no thin sections have been examined. The ferromagnesian minerals are usually hornblende, biotite, and pyroxene. Where the dykes cut the Skeena series, many interesting varieties of rock types were encountered, especially in the vicinity of coal seams, but those await further investigation.

An intrusion of a quartz porphyry seems to be connected with the rich silver lead veins visited, and some basic dykes were also noted.

PALÆONTOLOGY.

Hazelton Group.

Mention has already been made of species of Inocerami and Astartes, which were found in the Hazelton group a short distance below the Skeena series. Near the halfway house, between the second and third cabins on the Telegraph trail, a few plants were found, and Dr. F. H. Knowlton has identified *Baiere multanervis,* Nathorst, and probably *Podozamites lanceolatus* (L. and H.), Br., and says they appear to be Jurassic. The horizon here is evidently pretty well down in the group.

A collection from the vicinity of the Skeena bridge, 4 miles above Hazelton, contained the following *Gleichenia,* sp. ?, *Nilsonia,* sp. ?. Dr. Knowlton says that the horizon indicated by these is Kootanie, though lithologically the rocks at the bridge would be classified as belonging to the Hazelton group rather than to the overlying Skeena series.

[1] G. S. C. Annual Report, Vol. XIII, Part A, p. 87.

Skeena Series.

A marine shell, *Mactra utahensis*, Meek, was determined by Dr. Raymond, who says it indicates an horizon in the Cretaceous. The specimens were found on the east bank of the Cluakaas, 1,000 feet north of the mouth of Currier creek, and the horizon is probably near the top of the main section.

The remaining fossils and plants were examined first by Mr. W. J. Wilson and then sent to Dr. Knowlton, who has verified many of Mr. Wilson's determinations, and has extended the list. Dr. Knowlton says that he is not able to draw any stratigraphical conclusions from them, except that, in general, they indicate the Kootanie horizon. The localities and approximate horizons are given in each case.

Locality.	Horizon.	Series and Species.
Mt. Alec, north of Beirnes creek	Doubtful but low in series	*Cladophlebis virginiensis* Font.
Main Section	No. 64	*Cladophlebis Ficheri* Knowlton.
"	"	*Nilsonia parvula* (Heer) Font.
"	"	*Oleandra graminaefolia ?* Knowlton.
"	"	*Equisetum Phillipsii ?* (Dunker). Brongn.
"	"	
"	No. 24	*Nilsonia parvula* (Heer) Font.
"	"	*Oleandra graminaefolia* Knowlton.
Beirnes creek, below	Choquette seam	*Cladophlebis virginiensis* Font.
Beirnes creek, below	"	*Zamites montana* Dawson.
East bank Cluakaas	High in series	*Nilsonia* sp. ?
Main section	No. 2	*Cladophlebis ?* sp.

STRUCTURAL GEOLOGY.

North of the intrusions of the Bulkley batholiths the strata of the Hazelton group manifest great regularity in strike, the exceptions to a northwest and southeast direction being unimportant. The dips are prevailingly to the southwest, those to the northeast being much less common and usually at much higher angles. These facts were explained by finding, in many cases, monoclinal folds and thrust faults at many points near the mountain tops where extensive exposures of the strata could be viewed at once. In the valleys the exposures were usually too small and scattered to exhibit the true structure satisfactorily, though small thrust faults were observed at several points. These prevailing northwest strikes and southwest dips, and faulting with downthrow to the northeast, seem to indicate that the rocks, like those of the eastern ranges of the Rockies, have been subjected to pressure from the southwest. While in the Rockies this pressure has developed great fault planes and huge overthrust fault blocks of limestone, the pressure in the region north of Hazelton has developed more numerous faults, and a great deal of crumpling. The mountains climbed are not single fault blocks, but either complicated segments of strata thrust up along numerous fault planes, or the crests of sharp monoclinal folds. The difference in structure between these mountains and the Rockies is probably due to the absence of any great thickness of homogeneous strata offering a uniform resistance to the pressure, and which might be expected to break along a single plane when this resistance was overcome. In both regions the geological structure may be called imbricated, but the number of repetitions is much more numerous in the district now described than in the Rockies.

To the south, the intrusion of the Bulkley batholiths has tilted the strata, and in the immediate vicinity of the igneous bodies the dips are often *qua qua versal*, while in the case of the Skeena series, on the Skeena for some distance above the mouth of the Kispiox, the directions of dip and strike are so inconstant that the varying inclinations of the strata suggest a mammillary structure. Even in the vicinity of Hazelton, however, a northwest and southeast strike prevails, except near the intrusions.

The Skeena series in the Groundhog basin also exhibits strongly the effects of pressure from the southwest, and the ridges separating the five troughs, already mentioned, are either fault blocks or monoclinal folds raised by this force. The prevailing strikes on the ridges are northwest and southeast. at right angles to the supposed line of pressure, and the main fault lines run generally in the same direction. While this is true in a general sense, the basin type of structure is brought out along the southern edge of the portion of the field examined, by the presence of dips to the north, and strikes approximately east and west. These northerly dips prevail for several miles on each side of Trail or Cañon creek, and extend northward to its junction with Currier creek, and for some distance beyond. Farther north, along the west side of the Skeena, the strata still strikes east-southeast to east-northeast, but the dips are to the south, the locality where the highest strata might be expected being drift covered. This was also the case at most points on the borders of the area where the east and west strikes occur, so that its exact shape or the stratigraphical relation of its strata to those of the surrounding country were not worked out in detail.

Along the southern edge of the basin the width of the area with easterly strikes is fully 7 miles, but the area contracts northward, being only about a mile in width at 3½ miles north of Currier creek. Near the summit of the Groundhog mountains, the southern border of this area is characterized by much crumpling of the beds. At two points to the north, one on the Skeena, nearly 4 miles above the mouth of Currier creek, and the other in the north fork of Davis creek, the contact between the areas of the easterly and the northwesterly striking beds was seen, and in both cases the former dipped at very high angles and were apparently shoved over the others. To the north, in the vicinity of Beirnes creek, no distinct area of easterly strikes was observed, though a syncline traversing the beds near the Skeena river shows a distinct southerly pitch. Mr. Campbell-Johnston states that north of the divide, between the Cluakaas and the Stikine, this pitch is reversed, a condition which would suggest the existence of probably a large basin of coal-bearing strata on that river.

Economic Geology.

As has been stated in the introduction, visits were paid to some of the silver-lead and copper deposits in the vicinity of Hazelton, which had been discovered since Mr. Leach was in the district the year before. Descriptions of these deposits will be published as an appendix to his forthcoming report. The remaining subjects of economic interest are the Kispiox and Groundhog coal basin.

GROUNDHOG BASIN.

Sections and Correlation of Coal Seams.

The general section of the Skeena series, published[1] above, shows a total of fifteen seams of coal, ranging from 12 to $\frac{3}{10}$ of a foot in thickness, and there were, in addition, many streaks too small to be especially noted. The situation of these seams on the crest of the ridge between cirques, at the heads of Davis and Anthracite creeks, is not at all a favourable one for mining or handling coal, but it was hoped that seams occurring in favourable localities might be correlated with these seams, and that if this was possible, the general section would serve as a guide in prospecting in such places for the remaining seams, whose outcrop might be concealed by drift. Mr. Campbell-Johnston has kindly furnished a section which he and Mr. G. F. Moncton prepared after studying the exposures on Beirnes and Anthracite creeks. This section consists of two parts: an upper section of over 500 feet, containing two seams, and a lower one, 2,550 feet in thickness, which contains seven seams. The two portions of the section are separated by a gap, whose thickness was not determined by measurements. The following table shows a comparison of this section with No. 19 to 69 of the section given above in the description of the Skeena series.

Main Section.	Mr. Campbell-Johnston Sections.
No. 19. Black and brown shale..	33 ft. Shale not measured.
No. 20. Coal..	1 ft. = No. 3 Anthracite creek.
Nos. 21 to 24. Sandstones, shales and two coal seams..	223 fe. = Shales, 100 ft.
No. 35. Coal seam..	4·5 ft. = No. 2 Anthracite creek.
Nos. 36 to 39. Sandstones and shales with streaks of coal..	185 ft. = Gap in section not measured.
No. 40. Coal seam..	1·3 ft. = No. 1 Anthracite creek.
Nos. 41 to 48. Shales with some sandstone..	255 ft. = 300 ft. Shale.
Nos. 49 to 54. Sandstones predominate over shales..	478 ft. = 580 ft. sandstones.
Benoit seam not recognized..	Benoit seam.
Nos. 55 to 57. Black shales with ribbons of coal..	507 ft. = 554 unproved ground.
No. 58. Coal..	0·5 ft. = Scott seam.
Nos. 59 to 60. Shale and sandstone.. ..	124 ft. = 115 ft. shale.
Seam not dug out..	Garneau seam.
No. 61. Black shale..	50 ft. = 50 ft. shale.
Not recognized..	= Choquette seam.
Nos. 62 to 64. Sandstones..	87 ft. = 80 ft. shales.
No. 65. Coal roof fallen in at least..	1 ft. = Ross seam.
Nos. 66 and 67. Sandstones..	117 ft. = 150 ft. sandstones.
Nos. 68 to 76. Shales with a few sandstones..	819 ft. = 600 ft. unproved.
No. 69. Coal seam..	0·4 ft. = Pelletier seam.

The writer cannot be certain that this correlation is correct, for it is based very largely on the assumption that the coal-bearing horizons represented relatively long periods in which there was no deposition over the whole basin, and that between these periods the amounts of sediment deposited in different parts of the basin would be approximately equal, though the thickness of the different intervening beds of sandstones and shales might be expected to vary greatly at points a few miles apart. This variation would be particularly noticeable in the case of the coarser sediments. The section on Beirnes and Anthracite creeks is not given in detail, because of the scarcity of exposures, but except for the absence of outcrops of conglomerates, or sandstone containing conglomerate pebbles, the general nature of the beds seen was not greatly at variance with the correlation suggested above. A fossil plant, determined as *Cladophlebis virginiensis,* was seen above the Choquette seam on Beirnes creek, and *Cladophlebis Ficheri,* in No. 64, in the measured section, which would correspond with the strata between it and the Ross seam.

A second section was measured on a cliff at the western end of the ridge south of the junction of the two branches of Trail creek, as a number of seams had been observed at this point. The section is as follows:—

Section.

			Feet.
No.	1.	Beds of soft black and brown shales with some sandstone layers and probably coal seams, at least	200
"	2.	Siliceous grey sandstone weathering to yellow but sometimes red.	21
"	3.	Concealed probably brown and black shale	15
"	4.	*Coal*	4·3
"	5.	Black shale	3
"	6.	Hard siliceous sandstone similar to No. 2	18
"	7.	Black shale, partly concealed	16
"	8.	*Dirty coal*	1·4
"	9.	Black shale	42
"	10.	*Coal*	3·5
"	11.	Black shale	10
"	12.	Hard massive bed of bluish grey sandstone	27
"	13.	Black shale slightly arenaceous above	17
"	14.	Partly concealed, probably all black shale	46
"	15.	*Coal*	3·6
"	16.	Black shale	2·5
"	17.	*Coal*	0·9
"	18.	Light yellow shaly sandstone	15
"	19.	Black shale with a few thin sandstone beds near top	43
"	20.	Coarse yellow sandstone	5
"	21.	Partly concealed, probably all black shale	39
"	22.	Shaly sandstone	3
"	23.	Black shale rather arenaceous in places	42 +
			573·2

The following is a comparison of this section with Mr. Campbell-Johnston's, assuming that coal seam No. 4 is the Scott seam.

No. 4. Coal	4·3 ft. = Scott seam.
Nos. 5 to 9. Shales with sandstone beds and 1·4 ft. dirty coal	80·4 ft. = 115 ft. shale.
No. 10. Coal	3·5 ft. = Garneau seam.
Nos. 10–14. Black shales with bands of sandstone	90 ft. = 50 ft. shale.
No. 15. Coal	3·6 ft. = Choquette seam.

If this correlation is correct, the Ross seam, which occurs 80 feet below the Choquette in Mr. Campbell-Johnston's section, was not recognized in ours, but parts of the corresponding horizon, No. 21, were concealed.

Description of Coal Outcrops.

Western Development Company.—Though the number of coal outcrops on the property of the Western Development Company is large, in no case is any considerable thickness of strata exposed, while the variations of strike and dip of those which do outcrop are so pronounced that it is impossible to certainly correlate any of them with the seams in the general section. Two tunnels have been driven on Discovery creek into what is almost certainly the same seam. The exposures in the creek bed, between the two openings, are fairly continuous, and show a regular change in dip and constant strike. At the higher tunnel the seam strikes 151° and dips 19° to the east, a dip considerably steeper than the slope of the stream. About 3,600 feet farther down, where the lower tunnel is driven, the seam dips at only 5°, a lower slope than that of the stream. About three-fourths of a mile farther down there is a quantity of coal wash, which may have been derived from the same seam, though efforts to find it were not successful. In the upper of the two tunnels the following measurements were made: coal, 1·5 feet; bone, 0·6 foot; coal, 3·9 feet. At the lower tunnel almost the same thicknesses were obtained by our measurements, viz.: coal, 1·6 feet; bone, 0·4 foot; coal, 3·8 feet, and the shales forming the roofs of the tunnels were exactly similar. From the list of analyses given below, it will be seen that this seam was much the cleanest of any of the seams sampled, and in most cases even picked samples from other seams showed higher percentages of ash. It seems probable that this seam is the same as the 4·5 foot seam, No. 35, in the main section.

A somewhat similar seam was discovered on Abraham creek, a small tributary of Currier creek, about 1,500 feet from the Cluakaas, and a 20 foot tunnel has been driven on it. The measurements are: coal, 2·35 feet; bone, 0·5 foot; coal, 2·7 feet. This seam is within the area of east and west strikes, the strike being 54° and dip 16½° to the north. Consequently its relation to the above seam cannot be worked out from the dips, and the only outcrops in the neighbourhood consist of an arenaceous shale above the seam. Though this is similar to the shale above the seam just described, the coal is not nearly so clean, and the thickness of strata exposed to the south of Trail creek, all dipping to the north, would point to a higher horizon. Possibly it corresponds to the 4·5 foot seam, No. 8, in the section, and, if so, other important seams might be found near it. On Trail creek, 3,300 feet from Cluakaas, a tunnel has been driven into a dirty seam by Mr. Walter's party in 1909, and extended to a length of 50 feet last summer by Mr. McEvoy's party. The strike is about 133°, and the dip 17° to the northeast. Near the entry the total thickness of bone and coal is 7·6 feet, but in sampling only 6·5 feet were included on account of the large proportion of bone, and even with this deduction the sample showed over 40 per cent of ash, while Mr. McEvoy's sample, omitting as many partings as was possible, gave nearly 30 per cent. Possibly the horizon of this seam is that of the 1·3 foot seam, No. 40, in the section.

Near the mouth of Davis creek, Mr. McEvoy drove a 7 foot tunnel on a seam underlaid by 21 feet of black shales and overlaid by 29 feet of similar strata, containing many large concretions. Above there is 10 feet of hard grey sandstone. The strike is about 8°, and dip 21° to south. The thickness of the seam is 4·4 feet, and except for rather numerous pyritiferous concretions and quartz stringers it appeared fairly clean. The tunnel was so short that the effects of surface weathering were made apparent by iron stains from the decomposition of the pyrite. No suggestion as to the probable horizon of this seam can be offered.

On the west fork of Davis creek a seam was opened by a short tunnel, but solid roof had not been reached when the writer first visited it. At that time 4·3 feet of coal were seen, but, when the locality was revisited, the opening had been closed by a fall of the clay roof. Heavy coal wash was also found on this creek in a somewhat similar position to that on Discovery creek, and may have been derived from the same seam. Several openings were made on the east fork but no satisfactory seam was found.

British Columbia Anthracite Syndicate.—In his work on Beirnes creek, Mr. Campbell-Johnston was handicapped by the scarcity of natural exposures and by the heavy deposits of drift, which prevented him from obtaining the roofs for several of his seams, even after the expenditure of much time and trouble in trenching and tunnelling on them. The names and relative positions of the seams have already been given. A shaft some 30 feet in depth was sunk on the Pelletier seam, which is nearly vertical. A thickness of 5·2 feet was sampled. An anticline in the measures occurs just above this seam, and this fact, together with the steep dip, would make it doubtful whether this measurement represents the true thickness of the seam.

Work on the Ross seam had not advanced far enough to prove its true width, but the writer expects that it will show at least 3 feet of coal. It has a good sandstone roof. The Choquette seam was not measured, and, indeed, almost no clean coal was found in it. The Garneau seam showed 2·5 feet of clean coal, but was not sampled. The Scott seam is probably the most important; of it 5·3 feet were sampled (omitting 0·2 feet of bone), and above was about 3 feet of dirty coal. No true roof was found for the Benoit, but there seemed to be at least 2 to 3 feet of coal. The series of strata containing these seams all dip to the east, and 1½ miles above the Pelletier seam, on the other limb of the anticline, two good-sized seams were measured. The lower showed: coal, 2·4 feet; bone, 2·6 feet; coal, 5·8 feet. A fault occurred just below the point where this seam was measured, and its correlation with any of the preceding seams is at least problematic. The higher of the two seams gave 6 feet dirty coal, 8½ feet shale, 3 feet coal. No. 1, on Anthracite creek, gave the following measurements: bone and dirty coal, 4 feet; clean coal, 2·4 feet; No. 2 gave 4·2 feet coal. No. 3 was not visited. Strike at No. 2, 157°, dip 45° W.

Mr. Campbell-Johnston reports a 25 foot seam, a 10 foot seam, and four smaller seams near the forks at the head of Beirnes creek.

A picked specimen of coal from a 10 foot seam southeast of the head of Panorama creek was furnished by a prospector, Mr. Beeton.

British Columbia Anthracite Company.—This Company has done very little development work; two tunnels on Trail creek, one in wash and the other along a faulted seam, being the only ones of which the writer heard. A great deal of wash is exposed on Telfer creek, and in all probability two or more seams are represented, but no measurements could be made until they were dug out. The section measured on the ridge east of Trail creek has been given above, and in all probability the three seams in it might be traced down into the valley. A 3·4 foot seam (probably one of the three in the section) was measured on the northwestern slope of the hill 2·65 miles south of the mouth of Currier creek. It strikes 105° and dips 15° to the north.

A seam, perhaps 4 feet in thickness, was exposed on the hill northeast of the mouth of Currier creek at the head of Telfer creek, and a seam 16 feet in thickness is reported from the head of the small creek east of this hill. A number of small seams outcrop on Trail creek and on the stream coming in to the Cluakaas 4,000 feet below the mouth of Currier creek, but the strata are badly disturbed in both these localities.

Disturbances in Strata.

The most important disturbances of the strata noted have been described under the heading of Structural Geology. The results of the disturbances consist of monoclinal folding and overthrusting in lines running southeast and northwest, and are usually to be seen on the northeastern slopes of the ridges, though in many cases the strata are concealed and it is impossible to decide whether there has been faulting or only sharp folding. The borders of the area, where east and west dips prevail, are also an area of disturbance, for where the actual border of the area was seen the strata were broken by faults, crumpled, and even away from the borders many irregularities in dip and strike and some crumpling were observed. Quartz and calcite stringers traverse the strata in different directions, but seem thicker and more numerous near the fault lines. In some cases these stringers are themselves faulted by subsequent adjustments, though in no observed case did these movements throw the stringers more than a few inches out of line. On account of the irregularity of the strata, which may be more serious than is indicated by the limited number of outcrops, the writer would advise careful prospecting before the sites for tunnels and mine buildings are chosen.

Character of the Coal.

The character of the coal differs essentially from any hitherto described: it is anthracite, non-coking, and contains exceptionally high percentages of moisture. In many cases the coal has a resinous lustre, which is usually found in lignitic coal, and very likely the high moisture produces this lustre. In many of the seams the coal is much crushed, and in all the seams stringers of quartz or calcite occur. These stringers are usually from 1/16 to 1/4 of an inch in thickness, and when a lump breaks along one of them the foreign materials do not break free but stick to one or other of the faces. The number of points at which the coal has been opened are too few to permit of an estimate being made of the amount of this foreign material present, and some localities may be found where the coal is entirely free from them. As a general rule, the stringers seem to be more numerous in the lower seams, averaging, perhaps, three to the cubic foot, while in the two tunnels or the 6 foot seam on Discovery creek one veinlet to the foot would be a more likely figure.

The following are analyses of samples, by different samplers, from various seams. In each case the thickness of coal (exclusive of bone or shale streaks) is given and the locality. It is further stated whether the seam was sampled on the surface or at the face of a tunnel.

Seam.	Locality.	Sampler.	Moisture.	Vol. Comb. Matter.	Fixed Carbon.	Ash.	Sulph.	Cal. Val B.T.U.
5·5 ft. tunnel......	Small trib. of Currier creek	J. McEvoy.	1·17	6·05	76·20	16·58	0·72	12,215
"	" " ..	Malloch....	1·04	8·39	67·89	22·68		
5·8 ft. tunnel.......	Lower tunnel, Discovery creek	J. McEvoy.	1·17	6·54	83·37	8·92	0·74	13,238
5·8 ft. surface......	" " ..	" .	2·39	7·90	78·54	10·18	0·99	
1 ft. near top surface	" " ..	C. Fergie...	4·12	7·43	82·60	5·85	0·46	
4 ft. near bottom surface....	" " ..	" ...	5·95	8·00	82·00	4·05	0·49	
5·4 ft. tunnel.......	Upper tunnel, Discovery creek	J. McEvoy..	2·62	6·96	84·49	5·93	5·75	13,814
5·4 ft. surface.......	" " ..	W. Leach..	5·75	7·34	75·26	11·65		
"	" " ..	F. Walter..	4·45	8·75	79·25	7·55		
4·4 ft. tunnel.....	Near mouth Davis creek	J. McEvoy..	1·40	6·06	70·68	21·86	1·60	11,788
"	" " ..	Malloch....	1·57	7·55	65·52	25·36		
6·8 ft. tunnel.......	Trail creek near mountain.	J. McEvoy..	1·39	5·75	63·02	29·84	1·08	10,541
6·5 ft. "	" " ..	Malloch....	1·36	7·17	49·04	42·41		
5·2 ft. shaft.........	Pelletier seam, Beirnes creek	Malloch ...	1·35	7·69	61·90	29·06		
5·2 ft. tunnel... ..	Scott seam Beirnes creek	Malloch....	1·08	7·06	64·97	26·89		

The following are analyses of specimens of coal, *i.e.*, lumps taken from different seams or from surface outcrops:—

Seam.	Locality.	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.	Sulph.	Cal. Val. B.T.U.
Benoit	Beirnes creek	3·0	6·6	74·6	15·0	0·8	
Benoit	"	4·0	5·1	82·6	7·5	0·8	
Benoit	"	4·0	5·0	82·0	8·0	1·0	
Benoit	"	4·5	4·5	84·0	6·0	1·0	12,852
Benoit	"	4·5	4·6	80·1	10·0	0·8	
Scott	"	3·5	4·6	81·1	10·0	0·8	
Scott	"	11·17		75·66	13·13	0·4	
Scott	"	4·5	4·5	77·0	13·0	1·0	12,323
Scott	"	4·5	6·5	78·0	10·0	1·0	12,843
Garneau	"	4·0	4·0	82·50	8·5	1·0	13,455
Ross	"	9·33		80·94	8·96	0·77	
Pelletier	"	4·0	4·0	71·0	20·0	1·0	11,340
Pelletier	"	4·5	3·5	83·5	7·5	1·0	
No. 1	Anthracite creek	13·51		71·76	14·57	0·16	
No. 2	"	6·78		73·36	19·74	0·12	
No. 3	"	6·98		86·74	6·15	0·13	

These analyses were furnished by Mr. Campbell-Johnston.

The following three analyses of specimens were made by F. G. Wait, chemist of the Mines Branch.

Seam.	Locality.	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.
12 feet	No. 3 in Main Section	2·23	13·73	64·39	19·65
Pelletier	Beirnes Creek	1·07	6·53	75·25	17·15
10 feet	Head Panorama Creek	3·83	8·80	82·98	4·39

The great irregularity in the amounts of ash present is probably due in many cases to the inclusion in the samples and specimens of quartz or calcite stringers and to their absence from other specimens. The writer, in taking his samples, made no attempt to get rid of these materials, while Mr. McEvoy, and presumably the other samplers, were careful to exclude them. At the same time the high ash in many of the samples cannot be attributed to any foreign material, but must be due to impurities introduced during the deposition of the coal. Obviously, from the small part of the basin examined, and the difficulty in correlating the different seams seen, no estimate can be made of the amount of workable coal.

KISPIOX COAL FIELD.

As has been stated, rocks of the Skeena series outcrop on the Kispiox and Skeena rivers for some 14 miles above the junction of the two rivers. Exposures of coal seams occur on both rivers, but the strata are so badly disturbed that it would be unwise to spend any money in attempting to work them near the present outcrops.

The section measured at the Big slide on the Skeena shows that there are at least five seams in the lower 1,000 feet of the series, and while the thickness of coal in them is not great, there is at least the possibility that the seams may be thicker in other parts of the field.

In the Summary Report for 1909, Mr. Leach gives an approximate section measured on the east bank of the Skeena, between 2 and 3 miles above the mouth of the Shegunia river. It contains three seams, respectively, 2, 2·1, and 5·1 feet in thickness. The writer made an examination of the west bank last summer for 4 miles above the Kispiox, but the strata are cut by igneous dykes and sills and only two crushed and dirty seams were seen. On the Kispiox river the strata are also badly disturbed for 5½ miles, though the strikes and dips were not so irregular as on the Skeena and there are fewer dykes and sills. At the upper edge of this disturbed area, and on the western side of the river, a tunnel has been driven for a few feet into a 3 foot seam on the north limb of a faulted anticline, and a few tons of coal hauled on the ice to Hazelton and used in a blacksmith forge. On the eastern side, a little higher up, a 2 foot seam was found and beyond that exposures are not numerous. These would indicate, however, that the beds form a rather shallow and presumably a regular basin. A bed of black bituminous shale is exposed at low-water on the bend south of Kispiox post-office, and a large river flat a mile north of this would probably be as favourable as any for boring in the hopes of finding workable seams.

The following two analyses, copied from the 1909 Summary, are of the two lower seams on the east side of the Skeena. The three succeeding analyses are of the three main seams in the No. 6 and Nos. 9 and 11 in upper section, and Nos. 2, 4, and 6 in lower section; big slide sections are added.

Seam.	Locality.	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.
2·1	East side Skeena..........	1 42	18·76	58·20	21·62
5·1	" "	1 18	20·63	57·29	20 92
1·9	West "	1·07	20·43	51·26	27·24
0·65, 1·3	" "	1·19	10·33	64·77	23·71
1·4, 0 9, 0·6	" "	2·10	11·32	68·34	18·24

A specimen from the west side of the Skeena, 1½ miles above the mouth of the Kispiox, gave:—

Moist., 1·65; vol. comb., 22·86; fixed carbon, 50·02; ash, 25·47.

This and the 5·1 foot seam above were the only coals which coked.

I

GEOLOGY OF NANAIMO SHEET, NANAIMO COAL-FIELD, VANCOUVER ISLAND, BRITISH COLUMBIA.

(*Charles H. Clapp.*)

Introduction.

The greater part of the field season of 1911 was spent by the writer in a detailed geological examination of a district in the vicinity of Nanaimo, Vancouver island, B.C. The topographic map prepared in 1910, under the direction of R. H. Chapman, was used as a field map. This map is a 15 minute sheet, mapped on a scale of 1:48,000 (1 inch = 4,000 feet), with a contour interval of 20 feet. The total land area represented is about 175 square miles and includes the greater part of the Nanaimo coal-field. The surface geological mapping was completed by the middle of September. In this work the writer was very ably assisted by Mr. John D. Mackenzie.

Another month was spent underground and in getting data from the mining companies operating in the district. In this work all the operating companies, with one exception, gave the writer very hearty co-operation. Those who co-operated with the Survey are the Canadian Collieries (Dunsmuir) Company, Pacific Coast Coal Mines, and Vancouver-Nanaimo Coal Mining Company. Special acknowledgment is due to Mr. W. J. Sutton, geologist for the Canadian Collieries Company, who very kindly gave the writer much information and assistance and accompanied him in the field several times. During September and October visits were made to the Comox and the Suquash coal fields, the former visit being made in company with Mr. Sutton. A few days' work was done also in the vicinity of Duncan and Victoria and in southern Saltspring island.

Previous Work.

The character and age of the coal measures of the Nanaimo district were known and described as early as the late fifties, but little work of a general and correlative nature was done and no maps were published until the seventies. Then Richardson worked for five years on the coal-fields of the east coast of Vancouver island, his results being published in the Reports of Progress of the Geological Survey for the years 1871-72, 1872-73, and 1876-77. His last report summarizes his work, and is accompanied by a map on a scale of 4 miles to an inch. During Richardson's examination a great many fossils were collected, and these, with many others collected since that time, have been described, chiefly by Whiteaves. Much prospecting has been done and many private examinations have been made since Richardson's reports were published; but of the extensive information thus collected very little has been made public. In 1905 H. S. Poole collected some of the data, which appeared in the Summary Report of the Geological Survey for 1905. During the writer's previous work on Vancouver island little attention was given to the Nanaimo coal field, and in his reports very little was published concerning it. A large part of the data collected in the district is in the hands of Mr. W. J. Sutton, geologist of the Canadian Collieries (Dunsmuir) Company, and he has very kindly co-operated with the writer in the present examination.

Summary and Conclusions.

The larger part of the Nanaimo map area is underlain by sedimentary rocks, sandstones, conglomerates, and shales, of upper Cretaceous age, which are grouped together and called the Nanaimo series. They contain the coal seams of the well-known Nanaimo coal district. The series has been subdivided on lithological grounds into various formations, each with its more or less peculiar characteristics. They rest unconformably on crystalline rocks of various kinds, metamorphic volcanics of the Vancouver group and batholithic rocks, diorites and diorite gneisses, granodiorites and quartz diorites, and gabbro-diorites, intrusive into the metamorphic volcanics. The crystalline rocks within the limits of the Nanaimo map area form low ridges extending east from the crystalline rock highland west of the map area. These ridges surround and project into the sedimentary rock basin. The Nanaimo series are moderately disturbed, and have in general a simple monoclinal structure with a northwest-southeast strike and a low dip to the northeast. There are a few rather large open folds involving one or more formations, and many smaller and minor folds. There are also many minor faults, and in the southwest part of the map area are two reversed strike faults with a relatively large throw.

Following the folding of the Nanaimo series the basin underlain by them was reduced to a lowland, while the crystalline rocks surrounding the basin, being more resistant, remained surmounting it. The softer rocks of the series were worn down to wide valleys corresponding to the strike of the soft beds, while the harder rocks were left in slight relief. The region was glaciated in Glacial time, and above elevations of 400 feet there is a large amount of glacial till. In post-Glacial time the land apparently stood a few hundred feet lower than at present, for up to that elevation are found deposits of stratified sand and gravel derived from glacial till and probably of delta and estuarine origin. A recent uplift has brought the land into its present position and initiated the present erosion cycle, during which the revived streams have terraced the superficial deposits and have cut narrow canyons in the indurated rocks.

Coal is the principal mineral resource, the map area embracing all the producing mines of the Nanaimo coal district. The coal deposits have been the source of a flourishing industry for over fifty years, and the present production is over 1,000,000 tons per year. The coal is bituminous, of fair grade. It occurs in the three seams, the Wellington, the Newcastle, and the Douglas. The seams are remarkably persistent considering the great variability of the associated rocks, but vary greatly in thickness and quality. Sometimes a variation as great as from 2 or 3 feet of dirty slickensided coal or 'rash' to 30 feet of clean coal occurs within a lateral distance of 100 feet. It seems as if this extreme variation has been due to a folding of dirty or silty coal seams, when at least the clean coal was in a pasty condition, permitting it to flow away from the bends where an increased vertical pressure was developed, to the limbs of the folds where there was a corresponding decrease of pressure. There are also large, barren places in the seams due to silting or other similar causes, so that it is seen that the mining of the coal is attended with considerable difficulty, which, however, is very well overcome by the mine operators.

Some of the sandstones of the Nanaimo series have been quarried for building stone, although there was no production during the past year. Some of the sandstones are concretionary, others soft and friable. Some, notably the DeCourcy sandstone, are, as a rule, of good colour, easily worked (although not regularly jointed), and, although rather soft directly after quarrying, harden with seasoning.

The importance of the Nanaimo district in the coal industry may be more easily comprehended when it is realized that it produces over one-third of the entire coal output of British Columbia. Although the production of building stone has been small, the better sandstones have a considerable prospective value.

General Character of the District.

TOPOGRAPHY.

The area represented by the Nanaimo sheet is a part of the east coast lowland of Vancouver island, which was developed by the more rapid erosion of the less resistant sedimentary rocks fringing the east coast and lying on the more resistant crystalline rocks which form the axis of the island. These sedimentary rocks are of varying resistance and are moderately disturbed, their strikes being predominantly northwest-southeast and their dip northeast. The less resistant beds of the sedimentary rocks have been worn down nearly to a level, thereby forming extensive valleys along the belts of soft rocks. These valleys have, therefore, a general northwest-southeast trend, while their width varies, dependent upon the width of the soft rock belts. The valleys were probably reduced nearly to sea-level, but on account of a comparatively recent uplift have a present elevation of from 100 to 400 feet. The more resistant beds of the sedimentary rocks have been greatly reduced, but not to a level, and now form long ridges with a general northwest-southeast trend. The ridges have a gentle slope in the direction of the dip of their component rocks, and a very steep slope, often a nearly vertical cliff, in the opposite direction. The general elevation of the ridges increases from the eastern to the western part of the area, those in the eastern part ranging from 300 to 700 feet above sea-level, and those in the western part from 500 to 1,000 feet. In the western part of the area the valleys are much narrower than those developed along the belts of soft rock, and have a trend across the strike of the underlying rocks. They have been formed by the larger streams flowing eastward from the highland west of the area. These streams are the Millstone and Chase rivers in the northern part of the area, and the Nanaimo river and Haslam creek in the southern part. Along the western border of the area is the slope from the coast lowland up to the highland underlain by the more resistant crystallines. On this slope, in the extreme southwestern part of the area, the highest elevation of the area, 1,540 feet, is attained. Tongues of the crystalline rocks extend eastward from the highland into the area of the Nanaimo map-sheet and form low ridges with an east-west trend, rapidly increasing in elevation to the westward. One of these ridges occurs in the extreme northern part of the area; another, in the central part, is the flank of a mountain, about 3,300 feet high, to the west of the city of Nanaimo, known as Mt. Benson. A third ridge of crystalline rocks occurs along the southern boundary of the map area, and attains an elevation of slightly over 1,500 feet. In the central portion of the southern part of the map area is a nearly isolated mass of resistant crystalline rocks, which has been left in relief by the erosion of the surrounding, less resistant sedimentary rocks, and forms a large rounded hill, 1,460 feet high, called Mt. Hayes, the most prominent elevation in the area.

It seems as if at some time following the formation of the wide valleys in the soft sedimentary rocks the eastern part of the area was depressed below sea-level and the valleys drowned, thus forming the long, but often wide channels, passes, and harbours characteristic of the shore of this region. The hard rock ridges remain above sea-level as long points and islands which are characteristically long and occur in chains.

During the Glacial period the region was glaciated and the rock surfaces were smoothed off, and the valleys were deepened. Upon the retreat of the glaciers the region apparently stood a few hundred feet lower with respect to sea-level than at present. This conclusion is based upon the occurrence up to an elevation of 400 feet, of stratified sands and gravel, largely delta deposits, but possibly in part of marine or estuarine origin. These delta deposits have been built up at the former mouths of the larger streams flowing eastward from the highland west of the area, and occur at the confluence of the east-west transverse valleys and the wide longitudinal valleys developed in the soft rock belts. The deposits near the mouth of the river which formerly occupied the Nanaimo valley contain many ice-block or kettle-holes. A comparatively recent uplift has brought the deposits above sea-level, and they have been terraced by the streams revived by the uplift. The larger of the revived streams have also cut narrow canyons, from 100 to 300 feet deep, in the indurated sedimentary rocks. These canyons are the most picturesque feature of the physiography of the area.

CLIMATE AND VEGETATION.

The climate of Nanaimo and vicinity is similar to that of Victoria,[1] the temperature being remarkably uniform and the rainfall much less than in other portions of the North Pacific coast. The range of temperature is somewhat wider than that of Victoria, from an average of 40° F. in winter to an average of 60° F. in summer. The rainfall is slightly greater, about 35 inches, the greater part of the rain falling in the winter months, while the summer is dry.

The Nanaimo area was once heavily forested like other parts of the east coast of Vancouver island, the forest trees being chiefly conifers, Douglas fir, and red cedar greatly predominating. But a great deal of the timber has been cut, and in the wide valleys the land has been cleared and is now cultivated. Small fruit, garden truck, and grain are the chief agricultural products.

MEANS OF ACCESS.

There are many wagon roads and several railways in the area. The Esquimalt and Nanaimo railway traverses almost across the entire area from north to south, and there are several coal mine and lumber railways. The larger part of the area is, therefore, readily accessible, the extreme southwestern portion being the only part reached and traversed with some difficulty.

[1] Summary Report, 1910, Geological Survey, p. 103.

General Geology.

TABLE OF FORMATIONS.

Superficial deposits.. .. .. Pleistocene and Recent.
Nanaimo series.. .. .. Upper Cretaceous.

—	Lithological character.	Thickness. Minimum	Thickness. Maximum	Average.
Gabriola formation	Chiefly sandstones	1,400	1,400	1,400
Northumberland formation	Conglomerates, sandstones, and shales	1,100	1,200	1,150
DeCourcy formation	Chiefly sandstones	800	1,400	850
Cedar District formation	Chiefly shales	700	1,000	750
Protection formation	Chiefly sandstones, coarse gritty sandstones	600	750	650
Newcastle formation (Douglas coal seam).	Fine conglomerates and sandy shales, and contains Douglas seam	150	400	200
Newcastle coal seam.				
Cranberry formation	Flaggy and shaly sandstones and sandy shales, and gritty sandstones and fine conglomerates	150	500	250
Extension formation	Chiefly conglomerates, also shale and sandstone horizons and small coal seams	700	1,500	800
Wellington coal seam.				
East Wellington formation	Sandstone	25	50	35
Haslam formation (Marine shales) (Departure Bay calcarenites).	Chiefly shales	500	800	600
Benson formation	Basal conglomerate	0	400	100
	Total	6,125	9,400	6,785

Batholithic intrusives.......................Upper Jurassic and possibly lower Cretaceous.
Gabbro-diorite.
Quartz diorite and granodiorite.
Diorite and diorite gneiss.
Vancouver group.......................Lower Jurassic and Triassic.
Metamorphic volcanics....................... Chiefly andesite.

GENERAL DESCRIPTION OF FORMATIONS.

Vancouver Group.

The crystalline rocks upon which the sedimentary rocks of the Nanaimo series unconformably rest consist of metamorphic volcanics, which belong to the Vancouver group, and of intrusive batholithic rocks. They occur in three low ridges extending east from the crystalline rock highland to the west of the Nanaimo area. The first ridge occurs in the northwestern part of the area, north of Departure bay, and is the northern boundary of the Nanaimo basin. The second ridge is the east flank of Mt. Benson and is situated west of Nanaimo. The third ridge occurs along the southern boundary of the map area and is the southern boundary of the Nanaimo basin. The first two ridges are composed entirely of Vancouver volcanics and the southern one consists largely of batholithic rocks, although a small area of metamorphic volcanics does occur in its western part.

The volcanic rocks are uniform in appearance and typical of the volcanic members of the Vancouver group. They are largely dense, green altered andesites, greatly fractured and sheared, cut by numerous quartz and epidote stringers, and often mineralized along shear zones. No evidence as to the age of the volcanics is to be found in the area of the Nanaimo sheet, other than that they are pre-upper Cretaceous. They are, however, placed almost certainly, in the Vancouver group, which is known to contain lower Jurassic rocks and probably Triassic rocks also.

Batholithic Intrusives.

The batholithic rocks, which are intrusives into the Vancouver volcanics, are, as stated, virtually confined to the southern ridge of crystalline rocks. A very small boss also occurs on the Nanaimo river, near the extreme western border of the area. The rocks consist of granodiorite grading into quartz diorite, diorite chiefly gneissic in character, and a gabbro-diorite of a sub-porphyritic texture. The granodiorite, which is similar to the other granodiorites of Vancouver island, is the chief rock type. A very uniform body of it forms Mt. Hayes, which projects above the surrounding lowland underlain by the Haslam shales that lie unconformably upon the granodiorite. Along the north flank of Mt. Hayes occurs a diorite, frequently fine-grained and gneissic, which although doubtless related to the granodiorite, is much more basic, and is also intruded and brecciated by the granodiorite.

In the extreme southwestern corner of the map area is a body of gabbro-diorite, which has a sub-porphyritic texture. It is similar in appearance to the diorite porphyrites which are intrusive into the Sicker series of the Vancouver group, on southern Saltspring island and elsewhere.[1] The gabbro-diorite of the Nanaimo area is intrusive into the Vancouver volcanics, but its relation to the other batholithic rocks is not exposed.

Nanaimo Series.

Lying unconformably upon the crystalline rocks are the thick series of sedimentary rocks of upper Cretaceous age which contain the coal seams of the Nanaimo district. The lower members of this series are fossiliferous, and have been designated by Dawson[2] as the Nanaimo series (group). The entire series of conformable sediments is, however, generally known as the Nanaimo series or Nanaimo formation. As the upper unfossiliferous member (Gabriola sandstones) is very unlike the Eocene sandstones near the city of Vancouver, being much more indurated, it is very doubtful that it is of Eocene age as Dawson[3] suggests it might be. It seems best, therefore, to enlarge the scope of the name Nanaimo so as to embrace the entire conformable series of sedimentary rocks. None of the lower members of the Cowichan group[4] occur in the area of the Nanaimo map-sheet.

The Nanaimo series may be subdivided solely on lithological grounds, since all of the lower formations contain an identical fauna, while the upper formation is unfossiliferous. The various subdivisions or formations are more or less characteristic and well defined. They have already been enumerated in the table of formations, and their distribution and lithological characters are described below in order of age, the lowest or oldest formation being described first.

Benson Formation.

The Benson formation is the basal conglomerate of the series. It is exposed and apparently developed only locally, chiefly around the north flank of the east spur of Mt. Benson and in the extreme southwestern portion of the area; it is well exposed

[1] C. H. Clapp, Summary Report, Geol. Surv., Canada, 1910, p. 105.
[2] G. M. Dawson. "The Nanaimo group," Am. Jour. Sci., Vol. 39, 1890, pp. 180-183.
[3] G. M. Dawson. Bull. Geol. Soc. Am., Vol. XII, 1901, p. 79.
[4] C. H. Clapp. Summary Report, 1909, Geol. Surv., Canada, p. 89.

on Haslam creek. It occurs also on the shore of Departure bay. The basal conglomerate varies from a typical coarse conglomerate composed of large rounded fragments of the underlying rocks, where it occurs lying in hollows in the Vancouver volcanics along the north shore of Departure bay, to a rather fine-grained conglomerate, composed chiefly of rounded volcanic fragments, interbedded with arkose sandstones, which grade upward into interbedded arkose and shaly sandstones characteristic of the base of the overlying Haslam formation. The maximum thickness of the Benson conglomerate is about 400 feet.

Haslam Formation (Marine Shales).

Overlying the Benson conglomerate, and sometimes resting directly on the underlying crystalline rocks, is the Haslam formation. It consists chiefly of fine-grained shaly sandstones and sandy shales. Even the shaly sandstones are locally called shales on account of their pronounced difference from the prevailing coarse-grained sandstones of the Nanaimo series. The formation is locally called the 'marine shales' on account of the marine fossils which are occasionally found in it. The Haslam formation extends along the western border of the area in an irregular belt from one-fourth of a mile to 3 miles in width, and also underlies three narrow anticlines in the south central portion of the region. The shales are carbonaceous, being usually light to dark grey in colour. Interbedded with the typical sandy shales are thin beds of light grey, fine-grained, and often fairly siliceous sandstones. These sandstones average less than a foot thick, but sometimes occur in large numbers. Toward the base of the formation the interbeds of sandstone, although not more numerous, are thicker and usually of much coarser grain. They grade into a coarse arkose which, although interbedded with shale, shows an abrupt transition into the Benson basal conglomerate or lies directly upon the underlying crystalline rocks. Along the north shore of Departure bay the Haslam formation is composed of broken shells mixed with a large amount of sand; such a rock, composed of shell-sand, or limestone fragments, is known as a calcarenite, although in this instance the rock is an impure calcarenite. The thickness of the Haslam formation appears to be fairly uniform and averages about 600 feet.

East Wellington Formation.

The upper portion of the Haslam shales almost invariably grades upward into, or is limited by a uniform, fine to medium-grained and rather flaggy sandstone, called the East Wellington sandstone. The sandstone varies from about 25 to 50 feet in thickness, and sometimes contains thin interbeds of sandy shales, identical with the underlying Haslam shales. More rarely the sandstone is coarse-grained and contains interbeds of fine to medium-grained conglomerate.

Wellington Coal Seam.

The East Wellington sandstone is the floor of the Wellington coal seam. The seam is overlain by the Extension formation, and in places has a roof of sandy shale and in others a conglomerate roof.

Extension Formation.

The Extension formation consists chiefly of a very characteristic conglomerate. The formation underlies a broad belt extending entirely across the area with a N. 30° W. strike. The belt averages somewhat over a mile in width, except in the central part, where, on account of a repetition of the beds by folding and faulting, it is 2½ miles wide. The conglomerate is medium to coarse-grained, the fragments averaging about three-fourths of an inch in diameter. The fragments are sub-angular to sub-rounded and are composed almost entirely of quartz, having been derived from quartz veins and from the very fine-grained siliceous rocks of the Sicker series that resemble cherts, and are locally so called. Fragments of the normal metamorphic volcanics of the Vancouver group are rare. The fragments occur in a coarse, sandy matrix which, ordinarily, is in large amount, and the typical conglomerate grades into coarse-grained and pebbly sandstone. There are also a few horizons of sandy shales or shaly sandstones, in the Extension formation, the thickest being about 80 feet. The shale horizons are usually associated with thin coal seams or lenses. Neither the shale horizons nor the coal seams are persistent over large areas. In the central and southern parts of the belt underlain by the Extension formation sandstones and shales are confined to relatively thin interbeds in the typical massive conglomerate. In the northern part of the belt, however, in the vicinity of East Wellington, the lower 300 feet of the formation consists largely of sandstones and shales, and the upper 400 feet consist almost entirely of massive conglomerate. The thickness of the Extension formation varies from 700 to 1,500 feet, the greatest thickness being reached only in its southern part.

Cranberry Formation.

The Cranberry formation overlies the Extension formation, and occupies a belt which averages about half a mile in width, with a maximum width in the central part of over a mile on account of repetition due to folding and faulting. The formation consists chiefly of dark green shaly sandstones and more rarely sandy shales. In the central part of the belt, west of South Wellington, there are one or more thick horizons of conglomerate resembling the Extension conglomerate, although there are a larger number of fragments of volcanic rocks present. In this portion the Cranberry formation is not well defined, and grades downward into the Extension formation and upward into shales, characteristic of the overlying Newcastle formation. In its northern part it is fairly well defined and represents a very characteristic period of deposition. Its thickness varies from 150 feet to a maximum of 500 feet in its southern part.

Newcastle (Lower Douglas) Coal Seam.

The upper limit of the Cranberry formation is the Newcastle coal seam, or, as it is sometimes locally called, the Lower Douglas seam. The seam is overlain by the rocks of the Newcastle formation. It is well defined in the northern part of the area of the Nanaimo map-sheet and persists through the central part, but is poorly defined or absent in the southern part.

Newcastle Formation and Douglas Coal Seam.

The Newcastle formation, which directly overlies the Newcastle coal seam, contains the Douglas coal seam. The formation underlies a belt extending across the area of the Nanaimo sheet, from northern Newcastle island through the city of Nanaimo and town of South Wellington to Ladysmith. The formation, although having determinative characteristics, varies in different parts. In certain portions it consists of a fine conglomerate and coarse gritty sandstone with interbeds of dark green sandy shales. The conglomerate is distinguished by its fineness and by its well-rounded fragments, which are chiefly derived from the Vancouver volcanics. In other portions, practically the entire formation consists of dark green sandy shales or shaly sandstones, composed largely of detritus of volcanic rocks. Interbedded with these shales are, however, lenses of the characteristic fine conglomerate and gritty sandstones. The formation varies in thickness in its northern part from 250 feet, where it is chiefly conglomerate, to 150 feet, where it is composed chiefly of sandy shales; but in its extreme southern portion, although apparently composed chiefly of shales, it is approximately 400 feet thick.

The Douglas seam occurs in the Newcastle formation. Its floor and roof vary from fine conglomerate to sandy shale, corresponding more or less closely to the similar variation in the lithological character of the Newcastle formation. The former conditions prevail in the vicinity of Nanaimo and the latter at South Wellington, the two centres where the Douglas seam is mined. The seam lies from 25 to 100 feet above the Newcastle seam. It is well developed from northern Newcastle island to south of the Nanaimo river, the outcrop of the seam crossing the river near the Esquimalt and Nanaimo Railway bridge at Cassidy siding. Indications of the seam also occur as far south as Bush creek, a mile north of Ladysmith.

Protection Formation.

The Newcastle formation is overlain by a characteristic horizon of sandstone, which is the best horizon marker in the Nanaimo series. The horizon is called the Protection formation from its typical development on Protection island. It underlies a belt extending from Newcastle island to Ladysmith, 1 mile to 1½ miles wide in its northern portion and narrowing to less than one-fourth of a mile in width in its extreme southern portion where the dips are very high. The formation consists largely of a white or greyish sandstone, composed chiefly of rounded quartz grains with a coating of white kaolin. Associated with the sandstones are frequent interbeds of shaly sandstones and carbonaceous, siliceous, sandy shales. The formation contains also numerous small coal lenses, none of which are of commercial value. The formation varies from 600 to 750 feet in thickness.

Cedar District Formation.

Overlying the Protection sandstone is a formation of dark ferruginous sandy shales with a large number of interbeds of coarse-grained sandstone. This formation, which is one of the less resistant formations, underlies a wide valley extending almost north and south from the mouth of Nanaimo river to Ladysmith harbour. The larger part of the valley is in Cedar district, and the formation is, therefore, given the distinctive geographic name of Cedar district.[1] This formation is fairly uniform throughout its entire thickness, which is about 750 feet with a maximum thickness of 1,000 feet in its southern portion. A peculiar feature of this formation is the large number of sandstone dykes which cut the shales. These dykes, which have a maximum thickness of 3 to 4 feet, usually protrude from the interbeds of sandstone and are irregular and branching, following joints in the shales.

DeCourcy Formation.

Overlying the Cedar District shales, with a transition zone 100 to 200 feet thick, is a thick and uniform horizon of sandstones called the DeCourcy formation from its typical development in the group of islands known as the DeCourcy group. The DeCourcy formation extends from Jack point, a long narrow point east of Nanaimo, to the high range of hills on the east side of Ladysmith harbour. On account of a number of open folds the outcrop of the formation has a maximum width in its southern part of about 4 miles. The formation consists chiefly of a grey, rather coarse-grained sandstone usually weathering to a yellowish brown. It contains also

[1] The name Cedar has already been used to designate a formation of Juratriassic age in California.

thin horizons of shaly sandstone and carbonaceous sandy shales, with which are associated thin lenses of impure coal, none of which are of commercial value. The thickness of the DeCourcy formation averages about 800 feet, but in its southern part has a maximum thickness of about 1,400 feet.

Northumberland Formation.

The DeCourcy formation is limited by an overlying, persistent horizon of shales. These shales are similar to the Cedar District shales; but in their upper portion, both in vertical and lateral directions, grade irregularly into or, more strictly, are replaced by sandstones and coarse conglomerates composed of a great variety of fragments. This formation, consisting of shales, sandstones, and coarse heterogeneous conglomerates, is called the Northumberland formation, and is exposed chiefly to the northeast of Northumberland channel along the southwest shore of Gabriola island. The Northumberland shales are exposed also along the northeast shore of Gabriola island, showing the presence of a syncline which extends through the island. The thickness of the formation varies from about 1,100 feet to about 1,200 feet.

Gabriola Formation.

Overlying the Northumberland formation and separated from it by a more or less persistent horizon of shales is a very thick series of fairly uniform, massive sandstones, which since they compose the larger part of Gabriola island are called the Gabriola formation. This formation is the uppermost of the Nanaimo series. The sandstones are medium to coarse-grained, rather siliceous and characteristically concretionary. The concretionary structure and soluble cement causes them to be eroded into fantastic forms or 'gallerys' where they are subject to solution by saltwater spray and by wind and wave erosion. The formation is about 1,400 feet thick in the area of the Nanaimo map-sheet, but increases in thickness to the southeast to a maximum of over 3,000 feet.

Structure of the Nanaimo Series.[1]—The rocks of the Nanaimo series have as a whole a general northwest-southeast strike and a prevailing dip to the northeast. At the northern rim of the basin, in the vicinity of Departure bay, the general strike turns to the northeast and east, while the dip is to the southeast and south. With the exception of the major fold which outlines the basin, the entire series is not involved in any large single fold. There are, however, many smaller folds involving one or more formations. Of these, the largest and most important are an anticline whose axis underlies Extension valley, another anticline pitching to the northwestward, whose axis underlies Trincomali channel, and a syncline on Gabriola island. The two anticlines may be called the Extension anticline and the Trincomali anticline, and the syncline the Gabriola syncline. Along the axis of the extension anticline the Haslam shales are exposed, with the East Wellington sandstone, Wellington coal seam, and Extension conglomerate exposed on either side in the ridges fronting the anticlinal valley. The axis of the Trincomali anticline is largely under water, but the Protection sandstone is exposed on a small island, called Round island, near the axis. The DeCourcy islands along the northeast flank of the anticline and the shore of Vancouver island along the southwest flank are underlain by Cedar District shales and DeCourcy sandstones.

Minor faults, seldom more than sharp rolls with a very small actual displacement, are common. In the west central part of the basin are two large reversed or compression faults. These two faults, which occur to the southwest of Extension, have north-

[1] See accompanying map of the general structure.

west-southeast strikes and steep dips to the northeast. Along the larger fault, the northeastern, the Haslam shales on the southwestern and upthrown side of the fault are in contact with Extension conglomerate on the northeastern and downthrown side. The throw of the fault is about 300 feet. The Wellington coal seam also is brought to the surface on the upthrown side of the fault. The smaller fault is as stated of the same character, the southwestern side upthrown. The throw decreases from about 100 feet. where the fault is first recognized near the old No. 1 mine of the Wellington Collieries Company, to nothing, about a mile to the southeast. The faulting has been traced in the underground workings of the No. 3 Extension mine.

Superficial Deposits.

A very large portion of the Nanaimo basin, especially the parts underlain by the soft, less resistant beds, is covered with unconsolidated superficial deposits of various kinds which are, however, almost entirely referable to the Glacial period. The superficial deposits may be classified as unmodified glacial till, stratified drift, detritus, and recent alluvial and beach deposits. Glacial till is rather uncommon below elevations of about 400 feet above sea-level aud in the larger valleys. It does occur, however, below that elevation near the coast on the sides of rock ridges. It is found in greatest abundance along the western border of the basin on the slope from the coast lowland to the highland west of the map area. In the southwestern section of the map area, underlain chiefly by the Haslam shales, the indurated rocks are exposed only along the various stream courses.

The stratified deposits consist chiefly of sand and gravel. Sandy clays occur but are in relatively small amount, far less than in other parts of southeastern Vancouver island,[1] and smooth plastic clays are very uncommon. The deposits are chiefly of river origin, although the finer-grained and more easterly deposits are probably of lake or marine (estuarine) origin. No marine fossils were found in the drift as have been found in the similar drift in the vicinity of Victoria. The river deposits, consisting of cross-bedded, coarse glacial sands and gravel, are best developed in the south central part of the area where the valleys of Nanaimo river and Haslam creek merge into the coast lowland. They appear to be delta deposits, as they have a typical delta structure, with conspicuous fore-set beds, and apparently have been formed at the mouths of the rivers which previously occupied the Nanaimo River and Haslam Creek valleys, when the land stood a few hundred feet lower with respect to sea-level than at present. The deposits, as already mentioned, have been terraced by the present revived streams after the uplift which brought the land into its present position. At the head of these delta deposits, especially between Nanaimo river and Haslam creek, are many well developed kames and kettle or ice-block holes, features which are developed near the terminus of large glaciers, so that it seems as if the valleys were filled with ice during at least part of the deposition of the delta deposits.

The so-called detritus or detrital deposits consist of small to large angular fragments of the immediately underlying rocks, chiefly sandstones, mixed with more or less glacial till and sometimes with stratified drift. Deposits of this character are virtually confined to the islands of the map area, notably Gabriola island. They appear to be due to the breaking down by mechanical agencies of the underlying sandstone in post-Glacial times. The sandstone must have been subject to rapid mechanical disintegration following the removal of virtually all its covering of residual soil or drift by the powerful scouring action of the large glaciers which occupied the Sound region between Vancouver island and the mainland.

Recent alluvial deposits occur in small depressions in the drift, especially in the wide northwest-southeast valleys, and at the mouth of Nanaimo river where a

[1] C. H. Clapp. Summary Report, 1910, Geological Survey, Canada, p. 107.

delta is rapidly filling the drowned valley between Nanaimo and Jack point, underlain by the Cedar District shales. A similar, but much smaller delta, is being formed at the head of Ladysmith harbour. Along the shore are small narrow beaches between rocky headlands, and rarely, where the superficial deposits have been cliffed by wave erosion, small barrier beaches and sand bars have been built.

Economic Geology.

Of the mineral resources of the Nanaimo map area the coal deposits are of much the greatest value, and have been the source of a large flourishing industry for over fifty years. The only other products derived from the mineral deposits are building stone, sand and gravel, and common brick. Other deposits which have been prospected are the Departure Bay impure limestones (calcarenites) and the mineralized shear zones and veins in the crystalline rocks.

COAL.

There are at present three productive coal seams in the Nanaimo district, the Wellington, the Newcastle, sometimes called the Lower Douglas, and the Douglas. The lowest seam, the Wellington, lies at the base of the Extension conglomerate and rests on the East Wellington sandstone. The Newcastle occurs at the base of the Newcastle formation, and the Douglas is contained in the Newcastle formation. Another small seam called the Little Wellington overlies the Wellington locally at a distance of 20 to 50 feet. The Little Wellington was mined at the Old Wellington collieries, and is reported to have been mined at East Wellington within the limits of the Nanaimo map area.

The Wellington seam has been mined at East Wellington and Northfield, and is at present being mined by the Vancouver-Nanaimo Coal Mining Company at the New East Wellington mine. The seam was also mined farther to the south in the vicinity of Harewood plains, and is at present extensively mined by the Canadian Collieries (Dunsmuir) Company near Extension. They have four producing mines, the output of Nos. 1, 2, and 3 mines being brought to the surface through the Extension tunnel, Nos. 2 and 3 occurring on the southwest and upthrown side of a reversed strike fault of about 300 foot throw. The No. 4 mine is located 1½ miles to the southeast, and the seam is reached by a shaft 280 feet deep.

The Newcastle and Douglas seams, which are only from 25 to 100 feet apart, are usually worked together and have been extensively worked in the vicinity of Nanaimo. There are at present two producing mines operated by the Western Fuel Company. The largest output is from No. 1 shaft situated near the shore in the southern part of the city of Nanaimo. Their other mine, the Brechin, is situated on Pimbury point opposite Newcastle island. Only the Newcastle seam is mined at the Brechin mine, although the workings of the mine are connected with older workings in the Douglas seam. There has also been a large production from the Douglas seam south of Nanaimo, notably at Chase river, Southfield, and South Wellington. There is only one mine producing at present in this district, the South Wellington or Fiddick mine, operated by the Pacific Coast Coal Mines. South of Chase river the Newcastle seam, although it can be readily located, has not been worked and appears to be of doubtful value.

The coals of the various seams, although having their individual characteristics, are, as a whole, much alike, and furnish a bituminous coal of fair grade, the amount of fixed carbon in the best quality ranging from 50 to 60 per cent and the percentage of ash from 5 to 10 per cent. The most striking feature of the seams is their great variability in thickness and character. The thickness varies from nothing to over 30 feet, sometimes within a lateral distance of less than 100 feet. This variation is caused by irregularities in either the roof or floor, and occasionally in both. The Wellington seam rests on a firm sandstone floor which is fairly regular, although a few sharp rolls do occur in it. The roof, however, is very irregular. The average thickness of the Wellington seam is from 4 to 7 feet, but the seam occasionally pinches down virtually to nothing and then suddenly thickens to 10 or 12 feet. The floor may be nearly smooth, but the roof may show a very sudden roll which is sometimes even overturned so that there is an overlap of several feet. Invariably at the thin places or pinches in the seam the coal is dirty and slickensided, while in the swelled out portion it is clean and unbroken. It appears, therefore, as if the variation were due in large part to a folding which affected the coal seams when the clean coal was in a pasty condition. This conclusion is especially well substantiated in another part of the Wellington seam where it is composed of several sub-seams separated by dirty slickensided coal, or as it is called locally, 'rash.' In the deposition of the seam conditions in which the carbonaceous matter alone was deposited must have alternated with those during which a large amount of silt was deposited with the carbonaceous matter. When the seam was folded the clean coal was apparently forced away from the tight bends where the folding caused an increase in the vertical pressure and left the seam at these places composed almost entirely of dirty slickensided coal or 'rash.' The clean coal flowed to a point where there was a corresponding relief of vertical pressure forming a swell in which, except for the 'rash' at the top and bottom, the seam consists of clean bright coal. Besides the barren places or 'wants' of this nature there are large 'wants' due solely to the silting which must have persisted throughout the period of coal formation.

The coal of the Douglas seam is, as a rule, dirtier and more variable than the Wellington coal, and contains irregular partings. The pinches and swells are caused by irregularities of the floor, the roof being fairly smooth. The seam varies from nothing to 30 feet in thickness and averages about 5 feet, although over a large area the average thickness of the mineable coal is between 3 and 4 feet.

The Newcastle seam is more regular than the Wellington or Douglas, but is thinner, varying from 20 to 45 inches where mined, and contains more numerous and regular partings. It is also less extensive in area than the other two seams.

The coal output of the district for the year of 1910 was 1,094,765 long tons,[1] which is slightly over one-third of the entire production of British Columbia.

SAND AND GRAVEL.

The stratified deposits which occur in the south central part of the area, that is the delta deposits built up at the former mouths of the Nanaimo River and Haslam Creek valleys, furnish an abundant supply of sand and gravel. Except in a very limited way, these have been quarried only near the various railways for filling and grading purposes on the railway. The deposits could be used for all other purposes to which sand and gravel may be put. But although they could be quarried cheaply they are not favourably situated for cheap water transportation to the city of Vancouver, the chief market at present for sand and gravel.

CLAYS.

The surface clays of the Nanaimo map area are, as a rule, very sandy, and have been utilized only to a small extent for the manufacture of common brick. Brick has been manufactured from the surface clays underlying the marshy flat bordering the Millstone river midway in its course, but at present no brick is being made. There are other localities where common brick could be manufactured from the

[1] W. Fleet Robertson, Rept. Minister of Mines, British Columbia, 1910, pp. K 183-K 197.

surface clays, but, as stated, by far the greater number of the surface clays are sandy and non-plastic and would make a weak brick of an inferior grade.

The various shale horizons of the Nanaimo series are also possible sources of clay for the manufacture of brick and of various kinds of semi-porous ware and stoneware. The greater portions of the various shale horizons, notably those of the Haslam, Cedar District, and Northumberland formations, are very sandy and of very low plasticity. They also contain too large a percentage of iron and lime to be considered fireclays, as they are sometimes called. The shales of the other horizons are very sandy and impure and may be left out of consideration. Certain portions of the Haslam shales, notably an horizon about 100 feet below the East Wellington sandstone, and to a less extent, small horizons in the Cedar District shales, are comparatively plastic and may be used in an auger machine or press for the manufacture of brick and tile and cheaper grades of stoneware. In East Wellington, just to the west of the area of the Nanaimo sheet, the shale from the upper part of the Haslam formation has been tested and the products of the tests are apparently of good grade.

STONE.

Some of the sandstones of the Nanaimo series furnish a building stone of fair quality. Three of these sandstones have been quarried, the Protection, the DeCourcy and the Gabriola. The Protection sandstone has been quarried on Newcastle island, and a small amount has been quarried in the city of Nanaimo, the latter quarry having been abandoned for some time. The Newcastle Island quarry is situated on the west shore opposite Pimbury point. A single bed about 16 feet thick has furnished most of the sandstone. The sandstone is typical of the Protection formation. It is greyish white in colour but weathers quickly to a dirty or brownish grey, and is composed chiefly of quartz fragments coated with kaolin. The rock is rather friable and weak. It is not regularly or greatly jointed, and irregular blocks as large as 4 feet × 6 feet × 3 feet have been quarried. The sandstone can, however, be easily cut. Sandstone for building stone has been the only product. The quarry has not been in operation for a few years.

The DeCourcy sandstone has been quarried at Jack point, east of Nanaimo. It has been quarried from two beds of massive sandstone separated by about 5 feet of sandy shale and shaly sandstone. It is a medium to coarse-grained, light greenish-grey sandstone, weathering to buff. It is composed chiefly of rounded quartz grains with a large percentage of feldspar and volcanic fragments. The fresh rock is strong although rather soft, but hardens with seasoning. The bedding is regular but the cross joints are irregular. The joints are few, and as large blocks as can be conveniently handled can be quarried. Sandstone for building stone has been the only product. The quarry was not in operation during 1911.

The Gabriola sandstone is quarried at North Gabriola on Gabriola island. The quarries are situated in a 25 foot bed of grey, coarse-grained siliceous stone in which are many concretions ('boulders'). It weathers to a darker and more brownish grey. The stone is strong and hardens with seasoning. There is no regular system of jointing, but large blocks may be obtained. The numerous concretions are its chief disadvantage. Sandstone for building stone has been the only product, but the quarry has not been in operation for a few years.

Up to the present time there has been no commercial production of crushed stone from the Nanaimo map area. The rocks of the Nanaimo series are of little value as sources of crushed stone, but the less altered and less fractured volcanics of the Vancouver group afford a material of fair grade. Stone of this quality conveniently situated for shipping is to be found north of Departure bay.

LIME.

The impure limestones or calcarenites of the Haslam formation, which are exposed on the north shore of Departure bay, have been opened up by a test quarry to obtain material to be burned for lime, but the percentage of lime, 42·41 per cent, equivalent to calcium carbonate 75·73, is too small for the rock to be used for lime, and since the calcium carbonate is mixed largely with quartz sand the rock is not suitable for the manufacture of cement.

METALLIC DEPOSITS.

The crystalline rocks of the Nanaimo area are greatly fractured and sheared, and many of the shear-zones are impregnated with pyrite and chalcopyrite. A few prospects have been located on these mineralized shear-zones, but the bodies are too low grade to be of any commercial value. The granodiorite of Mt. Hayes is cut by aplite and quartz veins. Both kinds of veins are mineralized, the former very sparingly; but the latter contains chalcopyrite and bornite in attractive amounts. Molybdenite is also an accompanying metallic mineral. One of these veins on the Thistle claim has been very thoroughly and carefully prospected, but the vein is too small to be commercially productive. It is from 2 inches to 1 foot in width, but it branches, and the branches thin out to nothing. The average width is a little more than 4 inches. It follows the chief or master jointing in the granodiorite and is closely associated with the aplite veins.

II

NOTES ON THE GEOLOGY OF THE COMOX AND SUQUASH COAL FIELDS, VANCOUVER ISLAND.

The Comox and Suquash coal fields were visited by the writer only in order to compare their geological conditions with those existing in the Nanaimo field, and, therefore, only a few notes can be given concerning them, but they may serve to show some of the similarities and differences of the various coal fields.

Comox Field.

In the Comox field the coal is found in several seams that occur in a sandstone formation closely resembling the Protection formation of the Nanaimo series. Three of the seams have been mined. The formation, which may be called the Comox formation, consists chiefly of a white or greyish-white sandstone, composed largely of rounded quartz grains with a coating of kaolin, and with accessory chloritic micas. Interbedded in the sandstone are thin beds of carbonaceous sandy shale, with which the coal is usually associated. The formation has a maximum thickness of about 800 feet and rests directly on the metamorphic volcanics of the Vancouver group. It is overlain by a thick group of shales, called the Trent River shales, which are very much like the Cedar District shales that overlie the Protection sandstone in the

Nanaimo district. The sediments of the Comox basin have a much simpler and more regular structure than those of the Nanaimo basin, and form, in general, a simple monocline with a low uniform dip of about 10 degrees to the northeast. The coal seams are more regular than those of the Nanaimo basin, and must be the result of a more uniform condition of sedimentation, although a similar uniformity of conditions appears to have existed in the Nanaimo basin during the deposition of the Protection formation. However, the coal seams of the Comox district show, but to a less degree, the pinching and swelling and sharp rolls so characteristic of the Nanaimo coal seams. Large 'wants' due to a replacement of the coal by silt are probably more frequent in the Comox field. One peculiar feature met with in the Comox field is not met with in the Nanaimo field. The lowest seam of the former field occurs very near the base of the Comox sandstone, and as the Comox basin resembles the Nanaimo basin in that the crystalline rock surface, on which the sediments were deposited, was very irregular, many of the higher irregularities of the base remained above the depositional level when the lowest seam was deposited, and in consequence the lowest seam is frequently cut out by knobs of the underlying volcanics projecting through it. There is also another feature which is not met with in the Nanaimo field. North of the producing mine in the Comox field, between Browns and Puntledge rivers, a dacite porphyry has broken through the Comox sandstone and forms a flow or intrusive sheet, which overlies it. Near the dacite porphyry intrusion, which occurs near the outcrop of the lowest seam on Browns river, the coal is broken, partially coked, and rendered valueless. It is probable that the intrusion of dacite porphyry occurred in early Tertiary times and was a phase of the wide-spread Eocene volcanic activity.

Suquash Field.

Conditions in the Suquash field are similar in many respects to those in the Comox field. Several seams of coal occur in a formation consisting chiefly of a grey, siliceous sandstone resembling that of the Comox and Protection formations. Interbeds of shale in the Suquash sandstone are, however, thicker and more numerous, and the shale is finer-grained and more plastic, some of it being a clay shale apparently of excellent quality. The structure of the measures is very regular and appears to be, in general, a broad syncline, striking about N. 60° E., and pitching slightly to the northeast. The dips are very low, less than 10 degrees, and although there are several local rolls there are no sharp ones. The measures are broken by a few normal faults of very small displacement. The coal seams are also very regular and do not pinch and swell as do those of the Nanaimo and Comox basins. The known seams are, however, thin, and the seam mined at present contains a large number of very persistent partings of various kinds. As in the case of the Comox basin, the coal measures have been intruded by Tertiary volcanic rocks, in the Suquash field by a trachyte porphyry. The trachyte porphyry occurs in the southern part of the basin, on Haddington island, where it is quarried extensively and furnishes the best grade of building stone on the coast. It probably occurs as an injected body.

The present knowledge of the Suquash field is meagre since the measures are largely drift-covered and only a few bores have been put down. The development work is also small in amount and confined to two seams. The basin is, however, somewhat larger than generally supposed, containing Malcolm and Cormorant islands and possibly extending southwest to Quatsino sound. On account of the uniformity and regularity of the coal seams and strata and their small amount of disturbance, the mining conditions are excellent. The coal is of good quality, burning with a long flame and little smoke. The large number of partings in the seam which is at present being worked, and the thinness of the other known seams are the chief disadvantages of the field. The conditions are such, however, as to greatly encourage further development and prospecting, especially in the lower part of the measures.

I

FRASER CANYON AND VICINITY.

(*Charles Camsell.*)

Introduction.

What is usually known to travellers over the Canadian Pacific railway as the Fraser canyon is that part of the valley extending up from Yale to within 2 miles of North Bend, a distance of 24 miles; and although the canyon has been used as a means of entry from the coast to the interior of British Columbia for more than half a century, our information of its geology is very meagre and confined to the immediate banks of the river. Such information is contained in the reports of Dr. A. R. C. Selwyn in 1871-2, and of Dr. G. M. Dawson in succeeding years.

With the object of obtaining additional information, especially on the ore deposits of this district, a month was spent in it, from August 15 to September 15. While the writer spent most of his time in the canyon itself, his assistant, A. M. Bateman, worked in the basin of Siwash creek and his report on the geology of that district accompanies this.

Topography.

The Cascade Mountain system, which lies to the east and south of the Fraser valley, is separated by that valley from the Coast system which lies to the west and north; and although these two mountain systems are topographically distinct and do not coincide with each other, they are structurally and genetically the same, and are strongly alike in general character. Their summits rarely exceed 4,000 feet in elevation in the immediate vicinity of the valley, and are usually rounded in outline and heavily wooded to the tops. A few miles back from the river they are much more rugged and higher in elevation, and occasionally reach above timber line. Although the annual precipitation is heavy, practically all the snow disappears from the mountains during the summer months.

The Fraser valley is here a deep, trough-like depression incised in the solid rock. It has an almost true north and south trend and cuts at a very sharp angle through the mountain axis.

In its upper part the valley is distinctly U-shaped, giving evidence of modification by glacial action, but in its lower part it is notched to a depth of 100 feet or more in the solid rock of the broader upper valley floor. This lower valley marks the depth of post-glacial deepening by stream erosion. Above and below the canyon portion the valley is wider, and notching of its old glacial valley floor is not so noticeable a feature.

The grade of the Fraser river above Hope is steep, and in the canyon portion is about 8 feet to the mile. Yale is the head of navigation, and no attempt is ever made to pass through the rapids and canyons above that point.

No large streams join the Fraser river in the canyon, the most important tributaries, Anderson river and Coquihalla, enter at the upper and lower ends, respectively. All the tributary streams entering the canyon do so through narrow canyons and in a series of heavy falls. They thus occupy hanging valleys, for the valleys above the falls are more broad and flaring.

The relation of Fraser canyon to geological structure is as significant as it is to physiographic control. The river runs in a canyon only when it lies within the limits of the Cascade and Coast Mountain systems, and its most marked canyon features are developed across a line which forms the axis of these two systems.

When the geology of the canyon is studied the fact becomes apparent that as soon as the river leaves the soft argillaceous rocks of the Caché Creek formation and enters the massive igneous rocks of the Coast Range batholith it enters the canyon and it continues in it for 25 miles to Yale. Below Yale, although the river traverses rocks of the same age and character, these rocks have been severely fractured along a north and south line, and this line of weakness is followed by the river, which cuts out a broad open valley in consequence.

From the very brief study given to it, the formation of Fraser canyon appears to be due in a minor degree to geological structure and relative hardness of the rocks, and to a greater degree to gradual uplift along the axis of the Coast and Cascade Mountain systems since the course of the valley was first defined, and to a continuance of that uplift even into post-Glacial times.

General Geology.

The district described lies on the eastern border of the Coast Range batholith, and contains rocks referable to two main classes, namely, the granitic rocks of the batholith itself, and older stratified rocks that have been intruded by the batholith. A small unimportant area of Cretaceous is also present.

The following table of formations gives the various rock bodies that outcrop in the district:—

Gravels and sands	Quaternary.
Sandstone, slate conglomerate	Cretaceous.
Batholithic igneous rocks	Post-Carboniferous.
Cache Creek rocks, embracing quartzite, argillite, limestone, and volcanic rocks	Carboniferous.

CARBONIFEROUS ROCKS.

Rocks referable to this formation, and called by A. R. C. Selwyn the Boston Bar series, are found in the Fraser valley from Anderson river northwards. They here form a narrow band lying between Cretaceous rocks on the east and granitic rocks on the west. From the mouth of Anderson river southward they lie on the east side of Fraser river at a distance never exceeding 2½ miles, as far as Saddle rock, where they cross the river to the west side, cutting across a sharp bend in the stream. They occupy most of the area of Siwash Creek basin, and are there locally described by Bateman as the Siwash series. They are exposed again on the east side of Fraser valley from Emery bar down to Hope.

The Carboniferous rocks consist of black and grey slates, cherty quartzites, small bands of limestone, and some serpentine. These rocks are everywhere more or less metamorphosed, but more particularly where they occur as inclusions in the batholith or on its contact, in which case they are altered to mica and chlorite schists, gneisses, and siliceous and garnet schists. They stand, as a rule, in vertical or highly inclined attitudes and their strike conforms, on the whole, to the general trend of the batholith, which is about N. 20° W.

At the northern end of the canyon these rocks were first called by Selwyn the Boston Bar[1] series and afterwards correlated by Dawson with the Cache Creek formation.[2]

BATHOLITHIC IGNEOUS ROCKS.

The large igneous bodies of the district cannot all be referred to the same period of intrusion, but range from Jurassic to Tertiary. A part may be even earlier. No attempt has been made to define the areas of each. These are the rocks through which the Fraser canyon is cut, and they are exposed on both sides of the valley from the mouth of Anderson river to Hope.

The prevailing type, and that which is undoubtedly the oldest, is a coarse-grained granodiorite, somewhat gneissic in structure, and containing orthoclase, plagioclase, quartz, biotite, and hornblende. It contains many basic segregations. In places it is sheared and cut by small quartz veins, but it is usually fresh looking. A large shear zone traverses it in a north and south direction in the Fraser valley between Yale and Hope, and here the rock is shattered, leached, and otherwise much altered.

At least two igneous bodies of smaller dimensions are found in the district, and both are younger than and intrusive into the main body of granodiorite. One of these is a medium-grained biotite granite, and the other is a porphyritic granite. The latter variety, on account of its structure, is often used in the masonry of the railway line.

All of these rocks form part of the Coast Range batholith. They are accompanied by a host of dykes of both acid and basic composition.

CRETACEOUS.

A long narrow band of Cretaceous rocks, consisting of sandstones, shales, and conglomerates, occupies the eastern slope of Fraser valley above North Bend, and extends southward up the valley of Anderson river. These rocks are referred to as the Jackass Mountain group in previous reports.[3] What is presumably an outlier of the same formation is exposed at the river's edge below Hope station. This is a coarse conglomerate containing boulders, largely of igneous origin, cemented together by coarse sand. Neither its structure nor relation to other rocks could be determined.

QUATERNARY.

Superficial deposits of gravel and sand, deposited by stream action, are abundant in Fraser valley both above and below the canyon, where they form terraces on both slopes up to several hundred feet above the river bed. In the canyon itself such deposits are not very abundant because of the narrowness of the valley and the force of the stream. The lower of these deposits have been very important in the past because of their gold content, and have been worked in many places in this portion of the river. Sections of these lower deposits are well shown in the railway cuts, and in old placer workings. Most of them show from 10 to 20 feet of a coarse, free-washing gravel resting on a fine stratified sand which often exhibits cross bedding. The coarse gravel usually carried gold and was often mined for that metal.

ECONOMIC GEOLOGY.

Deposits of some economic importance are found at three different localities in the vicinity of Fraser canyon, namely, at Silver creek, Gordon creek, and Siwash creek.

[1] G. S. C. Report of Progress, 1871-72, p. 62.
[2] Geol. Surv., Can., Vol. VII, p. 43 B.
[3] Geol. Surv., Can., Report of Progress, 1871-72, p. 60.
Geol. Surv., Can., Report of Progress, 1877-78, p. 107 B.

Siwash Creek district embraces a considerable area and is the most important of these. A separate report by A. M. Bateman on that district accompanies this.

SILVER CREEK.

A group of three mining claims, known as the Jumbo group, is situated on the west side of Silver creek about 4 miles southwest of Hope. The claims lie in a steep narrow gorge at an elevation of about 1,100 feet above the sea. The country rock is massive granodiorite, in places sheared and traversed by fissures. The ore deposits lie in the fissure veins and have a width averaging about 8 inches. They contain dull-coloured arsenopyrite and a little chalcopyrite in a gangue of quartz, and carry gold as the principal valuable metal. The value of the ore in the fissures ranges from $10 to $60 to the ton. The claims are developed by three tunnels of varying length and several open-cuts.

GORDON CREEK.

A group of ten claims staked for asbestos on a belt of serpentine, and owned by A. M. Herring, is situated on Gordon creek, about half a mile west of Fraser river.

The serpentine is associated with black slates, belonging to the Cache Creek formation, and is intruded on the west by a fresh-looking granodiorite, and on the east is in contact with sheared gneissic granite. It forms a band about 500 feet wide striking north and south. It is a dense black rock showing occasional grains of chromite, and so shattered and broken that good samples are hard to obtain.

The asbestos occurring in it is almost entirely slip fibre developed in the fracture planes. The only visible cross fibre is in very minute veins, which are not in sufficient quantity to be important. The shattered character of the serpentine at the point examined is not favourable for the development of good veins of cross fibre.

The development work on these claims consists of several open-cuts and a few short tunnels.

II

GEOLOGY OF A PORTION OF LILLOOET MINING DIVISION, YALE DISTRICT, BRITISH COLUMBIA.

Introductory Statements.

Towards the close of the season a rapid reconnaissance was undertaken into the country west of the town of Lillooet and tributary to Bridge river. This reconnaissance was made more to determine the needs of that district for geological work and its importance from a mining point of view than to undertake any geological examination at tho time.

The Lillooet district lies immediately west of the Fraser river, between latitudes 50° and 51°. The town of Lillooet is the only place of importance in the district, and is reached in a day by stage either from Ashcroft or from Lytton, on the main line of the Canadian Pacific railway.

Considerable placer mining was at one time carried on in the Fraser valley and other valleys of the district, but this work is now almost abandoned. Quartz mining has been attempted at Cayoosh creek, and carried out to a small extent on ledges outcropping at Cadwallader creek and McGillivray creek, but the amount of gold extracted has not yet amounted to a great deal, for the reason that the owners of mines worked with the most primitive methods and virtually without capital.

No geological work had previously been carried out in this district by the Survey, and the only available authentic information is that obtained from the report of the Provincial Mineralogist for British Columbia, who made a brief reconnaissance of the district in the autumn of 1910.

Eight days were spent in making a rapid reconnaissance of the district with a view to obtaining information on which to base plans for more extended geological and topographical work. The route followed from Lillooet led up Seton lake to the Mission, thence northward across the divide to Bridge river and up that stream to Cadwallader creek. Three days were spent in an examination of the mines and region adjacent to Cadwallader creek, and the return to Lillooet made via Cadwallader and McGillivray creeks, and Anderson and Seton lakes.

Topography, Etc.

The topography of the Lillooet district is mountainous and becomes increasingly so to the westward. The eastern edge of the district, embracing the Fraser valley and the lower part of Bridge river, lies in the Interior Plateau region. The central and western parts lie in the Coast range. These two features merge gradually into each other, the boundary between them following a line running northwest from the town of Lillooet. Mountain summits in the eastern portion of the district reach an elevation of a little more than 7,000 feet, giving a vertical relief of about 6,500 feet. In the western part of the district many points reach 9,000 feet and some exceed that elevation, and the maximum vertical relief is over 8,000 feet.

The district enjoys a dry, pleasant climate. It does not contain much land suitable for agriculture, and all of it is confined to the bottoms of main valleys. It is a favourite hunting ground for big game parties, and there is an abundance of grizzly bears, goat, deer, and sheep.

General Geology.

The geological information obtained on this district is very meagre and only covers the line of route followed. The formations encountered are classified as follows:—

Stream and glacial deposits; Volcanic ash	Quaternary.
Sandstone, argillite; Conglomerate	Cretaceous.
Quartzite, argillite, limestone and volcanic flows	Carboniferous.
Plutonic igneous rock	Post Carboniferous.

CARBONIFEROUS.

Rocks which are referred by Dawson to the Lower Cache Creek formation have been mapped by him at the town of Lillooet and as far westward as Seton lake. The same formation has been found to extend northwestward to Bridge river and westward to McGillivray creek. It is exposed on Bridge river from the big bend to Cadwallader creek, and, except where replaced by igneous rocks, extends from the mouth of Cadwallader creek southeastward to Anderson lake.

The formation consists largely of interbedded quartzites, argillites, and volcanic rocks, associated here and there with thin beds of limestone and some serpentine.

The rocks have, in general, a northwest strike and high dips. In detail they exhibit many close folds and are much fractured and faulted. They contain many small veins and lenses of quartz. They have been intruded by later granitic rocks and are cut by many dykes.

CRETACEOUS.

Rocks of this age are found in Fraser valley about a mile north of the town of Lillooet, and extend as a narrow band southward down Fraser valley and northward along the divide between the Fraser and the North Fork of Bridge river.

They consist of hard black argillites, dark-coloured sandstones, and some conglomerate. They have been much shattered and metamorphosed, and dip at high angles to the east.

IGNEOUS ROCKS.

The main body of the Coast Range batholith lies some distance to the west of the district examined, but many outliers from this body were encountered within the district. A broad band of granite extends from the north shore of Seton lake northwestward across Bridge almost to Tyaughton creek. Two other bodies of granite are found, one at Roaring creek on the north shore of Anderson lake, and the other on McGillivray creek. A small body of diorite, in which lie the most important ore deposits of the district, is exposed on the east side of Cadwallader creek near its mouth.

All of these bodies are elongated in a northwest and southeast direction and are intrusive into Carboniferous rocks. The age of the various bodies may be Jurassic or later.

QUATERNARY.

The surface deposits consist largely of glacial and stream deposits which are scattered widely over the lower parts of the whole district. The importance of the stream deposits depends on the presence in them of placer gold, and at many points on the stream, gold has been and is still being extracted from the gravels.

One of the most recent surface accumulations is a deposit of white volcanic scoriæ. This is found on the summits of many of the hills, on their slopes, and on the river benches of the Upper Bridge river and its tributaries. It is thickest on the summit of Tyaughton mountain, where it is said to be about 4 feet deep. At the mouth of Cadwallader creek a section of 18 inches in thickness is exposed in a recent cut. It is estimated that it covers at least 1,000 square miles of territory. The material is white in colour, and so light and porous that it floats on water. The grains vary in size from a fine powder to pieces 1 inch in diameter or more. It probably represents the outburst of some volcanic eruption in quite recent times.

Economic Geology.

So far as our present knowledge of the economic geology of the district goes, it contains two classes of ore deposits of proven value, namely, gold placer deposits and gold quartz veins.

Placer deposits have been worked for a number of years at different localities, the most important of which are on Cayoosh creek, Cadwallader creek, Bridge river, and on Fraser river. Recently, however, there has not been a great deal of activity in this class of mining, though a number of hydraulic leases and placer claims are still held with the avowed intention of working them.

No attempt was made by the writer to examine placer deposits, and only a very cursory examination was made of some of the gold quartz deposits, the intention being to make a more complete examination later.

The gold quartz deposits examined are situated on Cadwallader creek near its junction with the South Fork of Bridge river, and about 75 miles by trail and wagon road from Lillooet. They were discovered in 1897, and since 1898 have been worked every season.

The quartz veins outcrop on the eastern slope of Cadwallader creek at an elevation of nearly 4,000 feet above sea-level. The valley slopes are well forested and covered with a heavy mantle of drift which makes surface prospecting difficult.

The rock formation in which the quartz veins lie is a diorite consisting essentially of feldspar and hornblende. It has a stocklike form elongated in a northwest-southeast direction, and extends from Bridge river up to the Pioneer mine on Cadwallader creek, with a width of probably half a mile. In texture and relative proportion of its constituent minerals it is variable, and in structure massive, though traversed by a network of small quartz veinlets. The ore-bearing veins are of later formation than the veinlets and run in two well-marked directions, namely N. 20° E. and N. 80° W. magnetic.

The diorite is intrusive on the southwest into serpentine, and on the northeast into black and grey slates and andesites, which belong to the lower Cache Creek formation. The diorite probably belongs to the same period of intrusion as the Coast Range batholith, but is older than other plutonic igneous rocks in the district.

The ore deposits are in fissure veins, which traverse the rock in two main directions, namely N. 20° E. and N. 80° W. magnetic. They range in width from a few inches up to 6 and 8 feet, and are remarkable for their regularity in dip and strike. The N. 80° W. system of fissures appears much stronger than the other, and one fissure, at least, has been traced for about 1,500 feet along the surface.

The ore itself consists of a gangue of white quartz containing pyrite, tetrahedrite, and free gold sparingly disseminated through it. It often has a well-marked banded structure indicating deposition in an open fissure. The walls of the veins are clean and their faces show some movement along the plane of the vein. The wall rock has been somewhat altered by vein solutions, and contains much crystalline pyrite derived from the vein.

Free gold can be seen in many of the veins, and can be obtained by panning from almost any of the outcrops. In places the ore is exceedingly rich.

It would be difficult to give an estimate of the average value of the ore in this camp, because of its richness in certain places and leanness in others. It is safe to say, however, that some of the ore shoots mined must have yielded $50 or more to the ton, while at the same time no parts of the veins so far mined have proved to be entirely barren of gold.

The mineral claims on which quartz are known to outcrop and the number on each claim are as follows:—

Lorne group	5 veins
Blackbird	4 "
Coronation group	2 "
Pioneer	2 "
Ida May	2 "
Countless	2 "
Forty Thieves	1 "

At the present time the only claims on which much development work has been done and from which gold has been extracted are: the Lorne group, the Pioneer, and the Coronation group. On all of these the gold was at first extracted from the ore by the crude method of milling in arrastres operated by water-power. More recently a 5-stamp mill has been erected at the Lorne, and a 10-stamp mill at the Coronation group. Both of these use water as the motive power.

It is stated by the owners of mines in the district that the yield in gold, since the discovery of the deposits in 1897, from the Lorne and Coronation groups alone, amounts to $155,000. The official report, however, of production from the whole Lillooet district up to 1910, is given by the Provincial Department of Mines as $137,744.

The conclusions drawn from the brief examination made of Cadwallader Creek district are that it contains some promising properties which, if not burdened with too heavy a capitalization, could be worked so as to yield a fair margin of profit; also that further prospecting in the diorite should disclose other gold-bearing quartz veins, because all the ground likely to prove productive has not yet been thoroughly prospected on account of the covering of drift.

A promising feature of the deposits is the number of known quartz veins—all of which carry some gold—and the strength and persistence of some that have been followed out. If the depth to which the veins will extend is proportional to the length of their outcrop, then there is hope that they will continue to considerable depth, since the country rock in which they occur is plutonic, and of deep-seated origin.

The diorite is the only formation in that district, from which gold ores have been mined, and it is stated that no workable deposits have yet been found in the slates and serpentine through which the diorite is intruded. Gold-bearing quartz veins, however, do occur in the slates, but they have not proved to be as strong and persistent as those in the diorite and are on that account less promising.

III

GEOLOGY OF SKAGIT VALLEY, YALE DISTRICT, B.C.

Introduction.

In July and part of August a geological reconnaissance was made of the Skagit district from the 49th parallel northward for about 15 miles. This region was the scene of considerable mining excitement during the spring of 1911 on account of the reported discovery of high-grade gold ores on Steamboat mountain. The examination of the district easily demonstrated that there was no legitimate reason for any mining boom in that particular locality, though there are some prospects in adjacent portions of the district.

In the geological work A. M. Bateman proved to be a very competent assistant and is responsible for virtually all the work in Siwash Creek basin. The topographic work done both in the Skagit district and at Siwash creek was undertaken by B. Rose and F. M. Allan.

The Skagit river rises in the Cascade mountain a few miles north of the International Boundary line, and after flowing southward into the State of Washington empties finally into Puget sound. That portion of its valley here reported on extends from the Boundary line northward to the mouth of the Sumallo river, a distance in a direct line of about 15 miles. A belt approximately 5 miles in width, whose median line is the Skagit valley, was geologically examined and mapped.

The area covered by this examination is, roughly, 75 square miles.

The district is at present not easily accessible and is most conveniently reached by pack trail from Hope, which is distant 23 miles from the north end of the district. Steamboat mountain, which was the centre of the mining excitement, is 15 miles farther down the valley. The cost of transporting supplies from Hope to this point is about 8 cents per pound. It is probable that the new Trans-provincial government wagon road, now being built, will pass through the middle of the district and make it more accessible.

Before the work of the present survey was made little was known of the geology or minerals of the Skagit valley. The only geological work known to have been done in the district previous to 1911 was that by H. Bauerman,[1] who was attached as geologist to the International Boundary Commission of 1859-61. His report, however, merely covers that portion of the valley in the immediate vicinity of the Boundary line.

In 1877 Dr. G. M. Dawson[2] reported on the country traversed by the Dewdney trail between Hope and Princeton, and skirted the northern border of this district.

Placer gold is known to have been found in small quantity in the Skagit river as early as 1858,[3] but the quantity was so small that no serious attempts have ever been made to mine it. In 1879 some fairly rich placer ground was discovered on Ruby creek, a tributary of the Skagit river, in United States territory, and, since the easiest means of access to that region was through Canadian territory from Hope, many prospectors passed through that portion of the valley now reported on. It is significant that no discoveries either of placer or lode metals are reported to have been made in it at that time.

In August, 1910, announcements were made in the Vancouver daily newspapers of the discovery by two prospectors, Greenwalt and Stevens, of high-grade gold ores on Steamboat mountain in Skagit valley. This announcement at the time created little stir in mining circles, and it was not until later in the season, when samples were exhibited which were stated to have been brought from that locality, that much interest was taken in it. After the winter had come on and that district was deeply buried in snow, a boom was gradually worked up with the aid of the press and purely on the word of the original locators. Speculators then began to go into the district or to send in men to locate claims for them. By the spring, at least 1,200 mineral locations had been made in the surrounding country, three townsites staked out, and hotels, stores, and other buildings erected for the carrying on of business.

Early in the summer of 1911 owners of mineral claims and others who had bought shares in the numerous companies floated began to realize that it was time other opinions than those of the original locators were obtained on the properties. Expert advice was then sought, but almost a year had already elapsed since the discovery was first announced, and much money had already been expended in various ways. On the mineral claims, which were the primary cause of the excitement, strongly adverse opinions were expressed as to their value, and work was discontinued by the owners. In the meantime Greenwalt and Stevens had disappeared.

Although it was becoming apparent by the time the survey was begun in the Skagit district in July that the possibilities of the district had been very much overestimated, there was still some prospecting being done and other discoveries were being made which might prove of permanent value. It was thought advisable, therefore, to carry out the survey as originally outlined and make a geological examination of Steamboat mountain and the adjacent district.

The principal results of the survey have been to prove that the original Steamboat Mountain claims did not contain the high-grade ore that they were stated to contain, or indeed any ore at all, and that there was no legitimate reason for the boom that took place over this district.

The only value of such a boom consists in the information that has been obtained by prospecting the surrounding country and in the discovery of certain deposits in

[1] G. S. C. Report of Progress, 1882-83-84, p. 5 B.
[2] G. S. C. Report of Progress, 1877-78.
[3] G. S. C. Report of Progress, 1876-77, p. 143.

the northern part of the district that may possibly prove to be of some importance. It is doubtful, however, whether the results are worth the price.

The Steamboat Mountain incident illustrates the value of having independent and reliable expert advice on mining properties, and it cannot be too strongly urged on would-be-investors in mining property the importance of obtaining such advice.

General Character of the District.

The Skagit district lies entirely within the limits of the Cascade Mountain system, and the Skagit-Klesilkwa valley forms the dividing line between two of the ranges which constitute that system, namely, the Skagit and the Hozameen ranges. The Skagit range lies to the west of the valley and the Hozameen range to the east.

At the International Boundary line the highest points in the Hozameen range exceed 8,000 feet in elevation, but in the northern part of the range the summits are not quite as high.

In the Skagit range the highest points are also in the southern part of the district, where some peaks reach an elevation of 9,000 feet. Both of these ranges are characterized by rugged broken topography, and hold, especially on their northern slopes, many mountain glaciers and snow fields.

The maximum vertical relief in the district is somewhat over 7,000 feet, rising from an elevation of 1,750 feet in the Skagit valley.

From the Boundary line up to the Klesilkwa river the Skagit occupies a broad U-shaped valley averaging about a mile in width, through which the stream meanders with a comparatively easy gradient. Above Klesilkwa river the valley becomes very narrow, the slopes are steeper and the grade of the stream is greatly increased.

Klesilkwa river is the chief tributary of the Skagit, and flows in a broad U-shaped valley similar to that of the lower Skagit. The width of the valley is about three-fourths of a mile, and its gradient is very low. This valley is the continuation of the lower broad Skagit valley, and from information gathered the same characteristics continue to the head of the Klesilkwa and down Silver creek to the Fraser river. This feature forms the most natural dividing line between the Skagit and Hozameen ranges in their extension north from the International Boundary line.

The streams tributary to the Skagit and Klesilkwa rivers in this district are all short and descend quickly to the main streams. Some of them rise in glacial cirques and most are fed from melting snows.

The Cordilleran ice sheet overrode the whole district up to an elevation of 7,000 feet and left its traces in a modified and subdued topographic outline. Above that level the topography is more rugged.

Valley glaciation has also left its traces in developing a U-shape in the trunk valleys and in facetting the ends of projecting ridges.

A number of well-marked gravel benches can be identified on the slopes of the Skagit and Klesilkwa valleys up to an elevation of 1,000 feet above the stream.

The climate of the Skagit valley is more nearly that of the Pacific coast than of the Interior Plateau. This is evident in the forest growth which is very dense in the valley bottoms and for some distance up the mountain slopes. The elevation of the timber line is approximately 7,000 feet above sea-level.

No ranching or farming was being carried on in the district during the summer of 1910, and only at two points—Whiteworth's and Gordons—have any attempts been made to follow these pursuits on anything but a very small scale. This is due not so much to the unsuitability of the region as to the difficulty of access.

General Geology.

The geological formations occurring within the Skagit district range from Carboniferous to Quaternary and embrace some igneous rocks as well as sedimentary.

They are, on the whole, fairly well exposed, but on account of the nature of the survey their boundaries have not been very accurately defined. They are classified as follows:—

Surface deposits	Quaternary.
Skagit volcanics	Tertiary?
Granodiorite Granophyre and other intrusives	Mainly Tertiary.
Pasayton formation	Lower Cretaceous.
Hozameen series	Carboniferous.

HOZAMEEN SERIES.

This series was so named by Dr. R. A. Daly and first described at the International Boundary line, where it is found exposed on both slopes of Skagit valley. From the Boundary line it is exposed continuously on both sides of the valley northward as far as the mouth of Sumallo river. On the east it passes within a few miles underneath the Pasayton formation, and towards the west it extends for an unknown distance until cut off by later igneous intrusives belonging to the Coast Range batholith.

The Hozameen series consist of cherty quartzites, argillites, some limestone, and much volcanic material. The quartzites are thin-bedded, fine-grained rocks, usually bluish-grey in colour. They are generally fractured at right angles to the bedding planes, and are traversed by small veinlets of quartz. The argillites are generally dark coloured, and thin-bedded, and have often been so compressed as to become phyllites. The limestones at the south end of the district occur in narrow bands and are often crystalline, but to the north they are more massive and frequently show thicknesses of several hundred feet. The volcanic rocks are flows and breccias of a dark green colour and an andesitic composition.

A section of these rocks as exposed on the valley side, near the mouth of Sumallo river, shows the following succession:—

	Feet.
Andesitic flows	400 +
Interbedded quartzite and argillite, about	1,500
Massive blue and white limestone, about	700
Impure limestone, argillite, and breccia	1,000 +

The rocks of the Hozameen series have all suffered a great deal of deformation and metamorphism. The strata dip at high angles and have been folded into a series of anticlines and synclines striking and plunging towards the south. They are all much fractured and frequently faulted, and in detail the thin-bedded rocks show close folding and contortion.

The Hozameen series is overlaid unconformably by the Pasayton formation, with which, in places, it forms a faulted contact. It also exhibits an unconformity with the Skagit volcanics. It is intruded by granodiorite, and granophyre, and cut by many granite and syenite porphyries and lamprophyre dykes.

Although no fossils have been found in the Hozameen series, their lithological characters and structure are so strikingly like those of the lower Cache Creek rocks that the writer has little hesitation in correlating them with those rocks. Apart from that they have been traced almost continuously along their strike northward to the Fraser river, where they join with rocks that have been referred by Dawson to the lower Cache Creek formation.[1]

PASAYTON FORMATION.

The Pasayton formation occupies the whole of the eastern border of the district, and extends from the Boundary line northward to Cañon creek. Its western border

[1] G. S. C. Vol. VII, page 43 B.

follows along the crest of the hills which form the eastern edge of Skagit valley, and is in direct contact with the Hozameen series throughout.

The formation contains siliceous and feldspathic sandstones, coarse conglomerates, black and grey argillites, and at the base a thick flow of volcanic rock of andesitic composition. The whole formation has been estimated by Daly to have a thickness of over 30,000 feet.

The strike of the beds is on the average slightly west of north, and the dip, which in this district is always towards the east, is usually about 45 degrees or more. Minor folding has taken place in the formation, and faulting is common.

The Pasayton formation is traversed by many dykes and sheets of granite and syenite porphyries, and has been intruded by a body of granophyre. Its relation to the granodiorite is clearly shown by an intrusion of the latter into it. With the Hozameen series it shows a faulted contact, or in places an unconformity.

The age of the Pasayton formation has been determined from fossils found in it at different points. Daly places it in the lower Cretaceous from fossils collected at the Boundary line. The lower Cretaceous fossil, *Aucella piochii,* was this year obtained from these rocks on Lightning creek, and last year *Prionocyclus* was obtained from Mamloos creek to the east of the Skagit district.

GRANODIORITE.

Plutonic igneous rocks are only represented in the district by granodiorite, which occurs in two separate bodies at either end of the district. The southern body is dyke-like in shape, and extends from the mouth of Galena creek northwestward towards the upper waters of Klesilkwa river. The northern body is exposed on the north side of Sumallo river and in the angle between that stream and tbe Skagit.

The granodiorite is a light-coloured, medium-grained rock, containing orthoclase, plagioclase, quartz, biotite, and some hornblende, with accessory magnetite and titanite. It is quite fresh and unsheared.

Both bodies of this rock are intrusive into the Hozameen series; and the northern one cuts the Pasayton formation as well, and is consequently younger.

GRANOPHYRE AND OTHER INTRUSIVES.

Tbe dyke rocks of the district include lamprophyre, diabase, granophyre, syenite, and diorite porphyries. The diorite porphyries were, in many instances, thought to carry gold and were covered by mineral claims. Assays, however, proved them to be barren. They are all much altered and decomposed, but are seen in the thin section to consist of plagioclase, feldspar, chlorite, and calcite.

Granophyre occurs as a large sill about 500 feet thick, intrusive into the Pasayton formation at the head of Twentyfourmile creek. It is a fresh light-coloured rock of medium grain, containing quartz, feldzpar, biotite, and chlorite and titanite, with much secondary calcite.

SKAGIT VOLCANICS.

A small area of these rocks is found at the Boundary line on the western side of Skagit valley. They consist of massive beds of volcanic breccia containing angular fragments of quartzite, andesite, and plutonic rocks in a cement of andesite. Associated with these are some andesite flows.

These rocks are fresh, and have been very slightly disturbed. The beds dip at low angles to the west, and rest unconformably on the upturned edges of the Hozameen series.

No conclusive evidence has been obtained as to their age; but from the fact that they are lying nearly flat and show no evidence of metamorphism they are probably of late Tertiary age.

SURFACE DEPOSITS.

The bottoms of the Lower Skagit and Klesilkwa valleys are covered with a thick deposit of gravels, and patches of these gravels can also be seen clinging to the sides of the valleys up to an elevation of 1,000 feet above the stream. Glacial drift is found covering the surface of the district up to an elevation of 7,000 feet above the sea.

ECONOMIC GEOLOGY.

Although the Skagit valley has been known to prospectors and explorers for a great many years, it has never been considered to be mineral-bearing until last year, when in August two prospectors, Greenwalt and Stevens, announced the discovery of rich gold ores on Steamboat mountain, a mountain formerly known as Nepopekum, or Lost Musket, situated on the east side of Skagit valley, about 10 miles north of the International Boundary line. A large influx of prospectors took place during the autumn and winter, and by spring the whole surrounding country was covered by mineral claims.

In the spring of 1911 development work on several of the claims was started, but was soon abandoned on account of the unsatisfactory results obtained. By July the district was almost deserted.

Some work, however, was carried out during the summer in the vicinity of the mouth of Sumallo river, where conditions were more promising.

The results of the examination of this district show that the deposits on and around Steamboat mountain do not carry gold, and that those at the mouth of the Sumallo river—known as Twentythreemile Camp—while being more promising, are of low grade.

DISTRIBUTION AND CHARACTER OF THE DEPOSITS.

The deposits of the Skagit valley on which development work was done fall into three main divisions:—

(1) Quartz veins and porphyry dykes supposed to carry gold.
(2) Contact metamorphic deposits in limestone containing copper and gold.
(3) Silver-lead deposits.

Deposits of the first class are situated ou Steamboat mountain and in the surrounding district, and were the primary cause of the boom in that region.

The rocks in which they occur belong to the upper part of the Hozameen series, which consists of thin-bedded, interbanded quartzites and argillites, small bands of limestone, and much volcanic material. They have been folded, fractured, and metamorphosed, and are traversed by dykes of diorite porphyry, diabase, and lamprophyre. They hold many short discontinuous lenses of white quartz which occupy the saddles of the minor folds. The quartz lenses, as well as the country rock, have been fractured, and pyrite has been deposited in the fracture planes. The mineralizing action appears to have been connected to some extent, at least, with the intrusion of the diorite porphyry dykes, which are also mineralized to a small extent by pyrite.

Deposits of this class are of no economic importance whatever, though much of the development work of the district was done on them.

The copper-gold deposits are situated at Twentythreemile Camp, near the junction of the Skagit and Sumallo rivers. They are also found in the Hozameen series, but in a lower horizon than that of the first class, where the limestone beds are thicker. These limestones have been altered in many places to hard compact lime-silicate rocks by the contact metamorphic action of many andesite and granophyre dykes.

The ore bodies have a very irregular outline, though, in general, following the strike of the andesite intrusives. Their boundaries are very indefinite.

The ore consists of a mixture of pyrrhotite, pyrite, arsenopyrite, chalcopyrite, and some magnetite occurring as bunches or scattered disseminations in a gangue of quartz and lime silicate minerals. These minerals are epidote, hornblende, pyroxene, wollastonite, and garnet. Beyond the borders of the main deposits are a few small stringers containing quartz with galena, pyrite, and arsenopyrite, apparently the hydrothermal end phase of the contact action.

The geological association, the irregular outline, and the intimate intergrowth of admixed sulphides indicate that the deposits are of contact metamorphic origin. The value of these deposits still remains to be proven, but it is certain that they are of low grade.

The silver-lead deposits occur at the head of Galena creek, near the International Boundary line, and are quite distinct from the others.

The country rock in which they are found is a flat-lying andesitic breccia of volcanic origin, which lies unconformably on the Hozameen series, and is probably of Tertiary age. The ore deposits are banded fissure veins cutting the breccia, and containing sulphides of lead, copper, iron, and zinc in a gangue of quartz. The deposits are valuable principally for their silver content, which, however, is not high.

DESCRIPTION OF PROPERTIES.

Steamboat Mountain Gold Mines.

This group comprises three claims located in June, 1910, on the west slope of Steamboat mountain, at an elevation of 3,950 feet above the Skagit river.

The development work consists of a number of open-cuts along the outcrop of a diorite porphyry dyke, and a tunnel 62 feet in length driven to cut the dyke below the surface. Lower down the slope a tunnel penetrates the hill for a distance of 120 feet, from which a cross-cut 18 feet in length has been driven along a lens of quartz.

The country rock consists of a series of interbanded quartzites and argillites. This is cut by a diorite porphyry dyke which is considered to be the ore deposit, and varies in width from 4½ to 8 feet. It is exposed along the outcrop for a distance of 350 feet, and is sparingly mineralized with pyrite and chalcopyrite.

The quartz lens exposed in the cross-cut of the lower workings occupies a small saddle in a fold of the country rock. Its greatest width is 7 feet and length 22. Both the lens and the adjacent country rock are mineralized sparingly with pyrite and chalcopyrite.

The following samples from this property were assayed in the laboratory of the Department of Mines:—

(1) Sample taken across the face of the porphyry dyke in upper tunnel—gold, none.
(2) Sample across quartz lens in lower tunnel—gold, none.
(3) Sample of mineralized country rock in lower tunnel—gold, none.

Yellow Jacket.

This is a group of four claims, staked in October, 1910, on the east side of Skagit valley, opposite the mouth of Silver Tip creek. The claims lie in the quartzites, argillites, and volcanic rocks of the Hozameen series. Large boulders of a yellowish decomposed porphyry dyke rock are strewn over the surface, and these are considered to be the ore deposit. Samples of this rock taken for assay yielded no trace of gold.

Ella Group.

This group of seven claims is situated on Red mountain and adjoins the Yellow Jacket on the south. The development work consists of a few open-cuts on a soft yellowish oxidized rock resembling that on the Yellow Jacket. Assays of this yielded no trace of gold.

Utah Group.

This group of four claims is situated on the west side of the Skagit and about 900 feet above it, opposite the Yellow Jacket. A tunnel 37 feet in length has been driven in on a bed of oxidized ferruginous limestone. The limestone is cut by small stringers of quartz containing pyrite and chalcopyrite which are also scattered through the country rock. A sample from the tunnel containing quartz, calcite, pyrite, and chalcopyrite yielded on assay no trace of gold.

Diamond Group.

This group, consisting of four claims, is situated on the west slope of Skagit valley, about a mile below the mouth of Sumallo river.

The deposits occur in an impure limestone which is cut by dykes of andesite and granophyre, altering it to a lime silicate rock. The ore body, as shown in the large open-cut, is roughly 40 feet in length and 26 feet in width, fading off on all sides into low-grade rock. Its general trend is parallel to that of an andesite dyke underlying it. The ore consists of a mixture of pyrrhotite, arsenopyrite, pyrite, and chalcopyrite in a gangue of quartz and the lime silicate minerals epidote, garnet, hornblende, and wollastonite. Some native copper appears in the fracture planes of the surface rock. Extending beyond the boundaries of the main deposit are a few small stringers, rarely more than 4 inches wide, of quartz holding galena, zinc blende, arsenopyrite, and pyrrhotite. Specially selected samples—one of clean arsenopyrite and the other of mixed chalcopyrite and pyrrhotite—were taken for assay to determine where the gold and silver values lay. The results show that the arsenopyrite only carries a trace of gold, while the chalcopyrite and pyrrhotite yielded 0·06 ounces in gold and 34·10 ounces in silver.

Horseshoe Group.

A group of three claims under this name is situated on the south side of Sumallo river about a mile above the Skagit.

The country rock consists of massive, impure and crystalline limestones cut by diabase, lamprophyre, and granophyre dykes. The ore body, as exposed in an open-cut, lies in the limestone on the upper side of a diabase dyke. It is 12 feet in width and has been traced for over 150 feet along the strike. The ore minerals are pyrrhotite, chalcopyrite, and pyrite in a gangue of quartz and lime silicate minerals. The gold and silver values are low.

International Group.

This is the oldest group of mineral claims at present held in the Skagit valley, having been staked in 1906. They are situated at the head of Galena creek within half a mile of the International Boundary line.

The country rock is an andesitic breccia which is traversed by a strong fissure running southwest up the creek bed. The fissure is filled with banded vein matter, consisting of successive layers of quartz, galena, and chalcopyrite, with the middle of the vein filled with pyrite, chalcopyrite, and quartz. The actual width of the fissure where exposed in the workings is 4 feet, but the wall rocks are altered and mineralized for a distance of about 6 feet on either side of the vein. The chief values are in silver and copper, gold being very sparing.

Whipsaw Creek District.

Whipsaw creek is a tributary of the Similkameen river, lying to the northeast of the Skagit district. Claims were taken up at the head of this stream in 1908 and 1909, and a certain amount of prospecting and development work done on them. They lie on either side of the main Dewdney trail and are most conveniently reached from Princeton, which is distant about 20 miles.

In this area a gneissic granodiorite is intrusive into hornblende and chlorite schists, which strike N. 20° W. and dip to the west. The granodiorite has produced considerable contact metamorphism in the schists and sends many apophyses into them. Both rocks are traversed by acid dykes.

The mineral deposits belong to one type, namely, fissure veins carrying lead and zinc. The veins are found in the schists in the zone of contact metamorphism, and occupy a cognate set of fissures striking N. 2° W. and N. 45° W. Fissuring and ore deposition are probably both connected with the intrusion of the granodiorite.

The Lucky Pair Group.—The Lucky Pair group consists of three mineral claims lying on the south side of Whipsaw creek. Most of the development work on this group was concentrated in a tunnel 230 feet in length. Owing to a miscalculation this tunnel does not cut the vein, which was afterwards found by a 10 foot cross-cut 45 feet from the tunnel entry.

The ore deposit is a well-defined fissure vein, 18 inches wide, in a zone of brecciation, cutting the schists and striking N. 45° W. The vein has a banded structure and is filled with zinc blende, galena, chalcopyrite, and pyrite in a gangue of quartz. The whole is greatly oxidized and much of the sulphides have been leached out. The deposit is of low grade and the chief valuable metal is silver.

The Marian Group.—The Marian group consists of five mineral claims located on the north side of Whipsaw, near its head. The country rock in these claims is granodiorite, in which are exposed three distinct veins, respectively 3 feet, 34 inches, and 12 inches in width. They all contain blende, galena, chalcopyrite, and pyrite in a gangue of quartz, and are much altered by surface oxidation. Samples taken for assay show the ore to be very low grade.

The S. and M. Group.—The S. and M. group adjoins the Marian group on the east and is developed by a number of open-cuts and three short tunnels. The country rock is a schist, the surface of which is very much decomposed, and holds hard nodules of ore. None of the tunnels have penetrated into the solid rock beyond the zone of oxidation.

IV

NOTE ON THE OCCURRENCE OF DIAMONDS AT TULAMEEN, AND SCOTTIE CREEK NEAR ASHCROFT, B.C.

At the beginning of the season the Tulameen district, where field work had been carried out the preceding year and where an interesting discovery of diamonds was made in the peridotite of that district, was again visited for the purpose of searching in the gravels of the streams and other places for diamonds of a larger size than those previously found in the solid rock. The season of the year at which the examination was made was not favourable for such work, because the streams were at high-water stage and the most likely gravels could not be reached. Nevertheless some tests were made both on the gravels in the stream beds and on the decomposed rock which was already known to carry diamonds. Concentrates obtained by panning from each of these localities were submitted to Mr. R. A. A. Johnston for examination, and in both samples Mr. Johnston was able to detect diamonds, not, however, of a commercial size.

In this connexion some work was also done towards the close of the season on the gravels of Scottie creek, a tributary of Bonaparte river near Ashcroft, where diamonds are known to occur under similar geological conditions; but here, also, no diamonds larger than those previously found in the rock in place were obtained from the gravels.

GEOLOGY OF FRASER CANYON AND VICINITY, B.C. SIWASH CREEK AREA.

(*A. M. Bateman.*)

Introduction.

During the past field season, work of a preliminary nature was carried on from August 22 to September 16, under the direction of Mr. Camsell, in the Siwash Creek district of southern British Columbia. The work consisted of reconnaissance areal geology based on a topographic sketch map, and a brief examination of the ore deposits.

The Siwash Creek district forms a part of the Yale Mining division in southern British Columbia, and is situated on the eastern border of the Coast range. It covers a portion of the drainage basin of Siwash creek, which flows into the Fraser river at a distance of 2½ miles above the town of Yale. The area forms a rectangle 6 miles long by 5 miles wide, the western side of which is bounded by the Fraser river.

Attention was first directed to the district some 50 years ago by the discovery of placer gold near the mouth of Siwash creek. Since the first period of operation, placer mining has been carried on in a desultory manner. At present, preparations are being made for the reinstallation of an hydraulic plant. The gold extracted from gravels has been estimated at about $1,000,000, but information is too unreliable to bear much weight.

Quartz prospectors followed up the placer miners, and in 1891 and 1892 mineral claims were staked around Siwash Forks. Little work was done until 1896, when a 3-stamp prospecting mill was erected, followed in 1905 by two larger mills. Interest was renewed in the district last spring, when several lodes were discovered containing free gold in quartz; but development work has progressed slowly and the camp is still in the prospecting stage.

Summary and Conclusions.

The rocks underlying the area consist of a metamorphosed sedimentary series represented by slates, garnet-schists, mica-schists, siliceous-schists, quartzites, and thin bands of crystalline limestone. This series is intruded by the Coast Range granitic batholith and its accompanying acid and basic dykes. A small remnant of volcanic tuff overlying the granitic rocks is exposed in one locality. Glacial deposits are found along the borders of the stream.

The gold, without exception, is associated with porphyry dykes and occurs in the porphyry itself, or in quartz veins along, or adjoining, the contact of the porphyry with slate. The gold is thus seen to be genetically dependent on the dykes, and the great number and wide distribution of these dykes makes it a promising field for prospecting.

Some of the gold deposits have rich surface showings, but are usually pockety, and the gold appears to have undergone considerable surface enrichment. Large superficial areas may contain a sufficient number of rich stringers and pockets to be worked commercially, while the others would only justify inexpensive mining methods.

Topography.

The most prominent topographic characteristic of the district is its youth, as shown in the steeply-notched stream valleys, in contrast with a more gentle sloping, mature topography of the higher levels. The streams are short, with steep gradients in their upper courses, less steep in their intermediate parts, but plunging rapidly by a series of falls into the Fraser river. The range in elevation is from about 200 feet at the Fraser river up to 5,700 feet, the general elevation being about 3,600 feet —3,800 feet above sea-level. Along the canyon of the Fraser river which forms the western boundary of the sheet, the hills rise abruptly and are much cut up and deeply notched by small streams, giving the region a very broken character which becomes less marked towards the east.

The topographic break between the more gentle upper slopes and the lower steep slopes signifies uplift of this region in late geologic time. Glacial till, occurring as high as 400 feet above the streams which have cut through it, indicates that this uplift was accentuated in post-Glacial time. Siwash and Eightmile creeks have relatively easy gradients in their intermediate courses but enter the Fraser with a precipitant gradient. This sudden break in their profiles shows them to be hanging valleys.

An example of stream capture is illustrated in the case of the upper North Fork whose waters appear to have originally entered the Fraser by way of Eightmile creek, but which now flow into Siwash creek. At present the divide between the North Fork and Eightmile creek is only a few feet above the stream-level.

General Geology.

The rocks and rock formations represented in the Siwash Creek area are provisionally classed as follows, in order of relative ages:—

Glacial deposits.
Volcanic tuff.
Hidden Creek series—sandstones and greywacke.
Acid and basic dykes.
Coast range granitic rocks.
Siwash Series—Slates, schists, and crystalline limestone.

SIWASH SERIES.

The Siwash series covers the greater part of the area. It is largely made up of dense fissile slates, garnetiferous schists, mica schists, quartz schists, and thin bands of impure crystalline limestone. The general strike is to the northwest with steep dips to the southwest.

Along the Fraser river the series is much mashed and contorted, and it shows the effects of regional metamorphism. To a minor extent contact metamorphism has occurred where the series is intruded by the granitic rocks. The Siwash series is cut by the rocks of the Coast Range batholith, and is tentatively referred to the lower Cache Creek formation.

COAST RANGE GRANITIC ROCKS.

The Coast Range granitic rocks outcrop on the eastern and western portions of the area, and in the central portion are intruded as sheets and dykes into the Siwash series. The batholithic invasion has taken place by the removal and engulfing of portions of the overlying series. The cover has been removed deep enough in the eastern part of the area to expose a zone of slates with intruded granitic apophyses grading into a zone of granite containing numerous inclusions of slate. The granite immediately surrounding the inclusions takes on a greenish hue, probably due to the partial assimilation of them.

The rocks range from light-coloured, medium-grained biotite granites to dark-coloured dioritic varieties. The dominant dark mineral is generally biotite, sometimes hornblende. Along the Fraser river they are mostly gneissic in character.

DYKE ROCKS.

With the batholithic intrusion, injections into the overlying Siwash series took place in great profusion in the form of sheets and dykes. Some show foliation due to subsequent folding. The acid dyke rocks are nearly all light-coloured, fine-grained types, sometimes porphyritic, containing large phenocrysts of feldspar and locally known as "bird's-eye" porphyry. The different varieties are syenite porphyry, quartz syenite porphyry, granite porphyry, syenite aplite, and pegmatites. It is with the acid dykes that the ore bodies are associated.

The basic dykes are fine-grained, dark-coloured hornblendic varieties, or peridotites largely altered to serpentine. A sheet of serpentine with a width of over 400 feet, which can be traced for over 3 miles, is exposed on Siwash creek. It contains chromite and is the result of alteration from peridotite. It is locally called the "Nickle dyke," and is reported to contain nickel and cobalt, but some samples collected from the dyke, when assayed, were not found to contain either of these metals.

HIDDEN CREEK SERIES.

This name has been applied for convenience in describing them to a series of arkoses and greywackes occurring in the vicinity of Hidden creek, a tributary of Eightmile. The rocks are made up of quartz, feldspar, calcite, and small fragments of andesitic and trachitic tuff. Their relation to the Siwash series and granitic rocks has not been definitely established.

VOLCANIC TUFF.

One isolated outcrop of andesitic tuff occurs between the North and Middle Forks of Siwash creek. Only a small portion of it is exposed and its extent could not be determined, but it probably covers only a very small area.

GLACIAL DEPOSITS.

The glacial deposits consist of unconsolidated till, made up of subangular boulders and gravels. They are found along the valleys of Eightmile creek, and the North, South, and Middle forks of Siwash creek, and occur as high as 500 feet above the present stream-level.

ORE DEPOSITS.

The deposits of proven value are of two classes, namely:—

(1.) Gold veins associated with porphyry dykes.
(2.) Placer gold deposits.

All the lode deposits so far discovered are situated in the area included between the three forks of Siwash creek, and in the vicinity of Hidden creek. The placer deposits extend from the mouth of Siwash creek up to the Forks.

The lode deposits that were examined are directly connected with the intruding porphyry dykes. They are found as quartz veins along the contact between the slate and porphyry, or as quartz veinlets traversing the porphyry and slates. The form is irregular and the gold appears to occur in small pockets.

The mineralogy of the deposits is simple. Pyrite, chalcopyrite, and small amounts of galena are contained in the quartz and porphyry. Small globules of quicksilver and lead carbonate are reported to have been found in pannings from three different properties. The gold appears as disseminated grains and as secondary flakes surrounded by iron oxides, associated with quartz veins in the slates and porphyry.

In only one place are the workings below the zone of oxidation, so that we are dealing almost entirely with superficial secondary minerals. The quicksilver and lead carbonate were probably derived from the sulphides, cinnabar, and galena. The pyrite has become oxidized, imparting a yellowish colour to the porphyry, and the gold has undergone concentration. It is to be expected then that the gold value will be greater on the surface than below the zone of oxidation.

The deposits owe their origin to the intruding granitic batholith. The porphyry dykes and sheets were later phases of the granitic intrusion injected into the Siwash series. Mineralizing solutions accompanied some of these dykes, and gold, sulphides, and quartz were deposited along the contact, and in fractures in the porphyry and slate.

DESCRIPTIONS OF PROPERTIES.

Ward Claims.

The two Ward claims, owned by the Martel Mining Company, are located near the forks of Siwash creek. Work is being carried on in a large surface excavation, about 300 feet above the creek, from which two tunnels are being driven into the hill. Another tunnel 75 feet above the creek penetrates underneath the open-cut for 300 feet.

The ore is associated with quartz-syenite-porphyry dykes which intrude slates. The dykes vary in width from 1 foot to 50 feet, and constitute in the vicinity of the workings about 50 per cent of the rock exposed. They are irregular in outline and have forced apart and enclosed masses of slate. Five of these dykes are cut in the lower tunnel, two of which are sheared parallel to the schistosity of the slates, while the others are normal. The slates are hard, dark coloured, and fissile, and dip at high angles.

Ore is at present being removed from a shallow surface excavation 150 feet wide by 250 feet long. The portion mined consists of bunches and stringers of quartz, which occur along the contacts and in the adjoining rocks, and of mineralized porphyry. Because of the method of mining no estimate can be made of the proportion of porphyry that is milled.

The gold occurs in the quartz and porphyry in a finely divided state, generally coated with a film of iron oxide. Pyrite is scattered through the gangue, and occasional globules of quicksilver have been reported.

The ore is carried in 1-ton cars from the open-cut to the mill by means of a 500 foot gravity cableway, and the oversize from the grizzly passes through a jaw-crusher to the stamp-bins. After being crushed in two 3-stamp batteries it passes over amalgamating plates and then through blanket sluice boxes to the slime pond.

The following samples were assayed in the laboratory of the Department of Mines:—

	Gold to ton.
1. Representative sample of mineralized porphyry from open-cuts....	$20 87
2. Representative sample of quartz with small amount of porphyry from ore bins..	3 10

Lake View Mines.

This group of three claims was located in June, 1911, on Hidden creek, a tributary of Eightmile creek. Only a small amount of surface open-cutting had been done at the time of examination, but preparations were being made to carry on more extensive development.

The country rock is slate with an easterly strike and steep dip to the north. Intruding this and parallel to the schistosity is a syenite-porphyry dyke containing large phenocrysts of feldspar, and known as "bird's-eye" porphyry.

The porphyry dyke, with included quartz stringers, constitutes the ore deposit. The width of the dyke is 12 feet, its length is undetermined. On the surface it is yellowish coloured, soft, and decomposed. Three quartz stringers, from ½ inch to 2½ inches wide, cut diagonally across the dyke. The quartz stringers and the porphyry adjacent to the stringers carry the gold which can be seen readily with the naked eye. It appears as small grains disseminated through the quartz, and in greater amount as loosely adhering flakes and grains surrounded by oxide of iron along the fracture planes of the quartz and porphyry. A minor amount of quartz and galena is associated with the gold.

The following samples were taken and assayed:—

	Value of Gold per ton.
1. Sample of quartz and porphyry collected from the dump..	$ 4 76
2. Representative sample of all quartz stringers exposed in upper-cut.	14 28
3. Sample of porphyry remote from quartz stringers................	20

Mount Baker and Yale Mining Company.

This Company controls a group of eight claims located at the forks of Siwash creek, adjoining the Ward claims. They were staked in 1891, but practically no work was done on them until 1902, when a 10-stamp mill was erected and a number of open-cuts and tunnels started. The mill is not being operated at present and the entries to most of the tunnels have caved in.

The geological character of these claims is similar to that of the Ward group.

The ore was originally taken from a few small open-cuts and tunnels scattered in the vicinity. The tunnels, now inaccessible, penetrate porphyry dykes which contain only a little quartz. To the west of the mill a 50 foot tunnel penetrates a porphyry rock slide, but does not break the solid rock. Oxidized porphyry from the rock slide when panned showed colours of gold, but an assay of a representative sample gave only a trace of gold.

Roddick Claim.

The Roddick is the Discovery claim of the district, and is located on Roddick creek, 450 feet above the Marvel Mining Company's stamp-mill. A porphyry dyke, 25 feet wide, and containing numerous small quartz stringers, cuts the slates. An open-cut a few feet from the dyke exposes to view a parallel series of short bunchy lenses of quartz, ½ inch to 4 inches wide, included in the slates. Gold, associated with iron oxide, occurs in pockets with the quartz, and some remarkably rich specimens have been found. Samples taken for assay, however, only yielded a trace of gold.

Dolly Varden Group.

This is a group of three claims, staked in April, 1911, and located between the North and Middle forks of Siwash creek, and at an elevation of 1,700 feet above the creek. The development work consists of a number of open-cuts spread for 625 feet along the outcrop of a porphyry dyke. A tunnel is being driven to intercept the dyke.

A quartz vein varying in width from 12 inches to 24 inches occurs along one wall of the porphyry dyke, and the slate and porphyry on either side of the quartz vein are intersected by a network of quartz stringers. Pyrite, chalcopyrite, and galena occur in the quartz and porphyry. Colours of gold may be obtained by panning the surface material.

Reciprocity Claim.

This property is similar in occurrence to the Dolly Varden, and is located on what is probably a continuation of the Dolly Varden dyke. Specimens of quartz, rich in free gold, have been found in some of the small irregular pockets.

BEAVERDELL MAP-AREA, YALE DISTRICT, B.C.

(*L. Reinecke.*)

Introductory.

The season of 1911 was spent in geological field work in the Beaverdell map-area, on the West Fork of Kettle river, British Columbia. The topographical map of this area was completed during the autumn of 1909 and the summer of 1910. Work began on May 25 and continued until October 12. Besides the mapping and examination of deposits within the area, about a week was spent in visiting promising claims on the Kettle and West Forks rivers outside the area of the map-sheet. Mr. W. J. Wright acted as field assistant during the summer.

Two summary reports have already been written on this area[1] and the final report is now being prepared for publication. Some idea of the general topographical and geological features of the area, as well as the economic deposits and the history of mining, can be obtained from the two summary reports mentioned above.

Topography.

The area examined is a part of the Interior Plateau system of British Columbia and lies along its eastern edge. Uplands of moderate relief are cut by steep-sided and often deep valleys. The maximum difference of elevation within the map is about 3,500 feet; the main valley flats are from 800 to 1,500 feet below the near-by hilltops. The greater part of the area is drained by the West Fork and its tributaries, while a small area in the southeastern corner drains directly into the Kettle river. One of the interesting phases of the topography is the part played by glacial débris in determining the direction of drainage in the uplands.

General Geology.

A series of metamorphosed sediments and crystalline rocks occupies perhaps one-third of the area examined; they are intruded by quartz diorite and granodiorite batholiths, both of which cover extensive areas. Small patches of Tertiary volcanic flows and sediments are found in scattered localities over the map. The river bottoms are generally covered with unconsolidated alluvial deposits, while glacial debris is found in varying thickness everywhere in the district.

TABLE OF FORMATIONS.

Pleistocene and Recent	River deposits, glacial till.
Miocene?	Basalt, andesite, and dacite flows.
Oligocene?	Dense white tuff, coarse sandstones, and conglomerates.
Jurassic?	Augite porphyrites, quartz porphyries. Granodiorite. Quartz diorite. Diorite.
Pre-Jurassic	Andesite stocks and flows. Dense argillites. Crystalline limestones. Quartzites. Green mica hornblende schists.

[1] Summary Report of the Geological Survey Branch of the Dept. of Mines, 1909, pp. 118-122.

PRE-JURASSIC.

The pre-Jurassic series consists of metamorphosed sediments of uncertain age, mica hornblende schists of igneous origin, and stocks and flows of andesite. A batholith of diorite was intruded into the sediments and andesites some time after their deposition. The upper surface of this intrusion was extremely irregular, due to the injection of molten matter into cracks in the roof above, and to the sinking of detached blocks of that roof into the diorite. A section of this roof, such as is now exposed in a great many places, gives a patchwork of sediment and crystalline, in which the two members are distributed in so irregular and haphazard a manner that their separation is, for practical purposes, impossible. The diorite has, therefore, been mapped with the older series.

Following this intrusion there was a period of crustal disturbance which brecciated and metamorphosed both the diorite and the older rocks.

JURASSIC?

In Jurassic time there were further intrusions of batholiths of a grey quartz diorite, followed by a pink-white granodiorite. The latter was accompanied, or followed, by extensive intrusions of quartz porphyries and porphyrites. These two plutonic rock types seem to be in series with the first diorite intrusion. They have, however, not been metamorphosed to the same extent and lie in large masses easily separable from the older group.

The quartz diorite is a grey, medium-grained, and even-textured rock. It consists essentially of plagioclase feldspar, hornblende, biotite, and quartz, the latter in varying amounts. The feldspar ranges, from oligoclase to labradorite.

The granodiorite varies from pink to white, and is very often porphyritic, with large crystals of pink orthoclase. The orthoclase lies in a coarsely crystalline groundmass of quartz and orthoclase with some plagioclase and biotite. These two intrusive masses together occupy nearly two-thirds of the area mapped, and the granodiorite extensive areas outside of it.

TERTIARY.

Oligocene?

The Tertiary sediments consist of beds of coarse agglomerate or conglomerate, overlain by coarse sandstone and dense white tuff. The conglomerate at the base contains pebbles of practically all the rocks of the older series. The tuff contains remains of land plants. There is probably 500 feet of these sediments in places. They lie unconformably on the older formations. There are about 4 square miles of this within the mapped area around Goat peak, and a small patch in the southeast corner near the Kettle river.

Miocene?

Basalts and andesites are the prevailing types of lavas. Basalt without olivine is often the latest flow, while a white andesite or dacite is very frequently the earliest. Intermediate in age is a series of dark grey and reddish andesites. Olivine basalt is more frequently found in small patches by itself. These Tertiary lavas occupy about 7 square miles in the northwestern corner of the map and occur as small patches in other parts of the area. They overlie the Oligocene? sediments unconformably at Goat peak and to the northwest of it.

RECENT.

Glacial Deposits.

Glacial debris evidently at one time covered the whole of this area. It has since been considerably modified and cut away by erosion. Typical glacial deposits are not often seen, and then only in places where erosion has been exceptionally retarded.

River Deposit.

The material deposited by the rivers is relatively coarse throughout the Upper West Fork valley. Fine alluvial material occurs only in small patches, generally near the river bed. A great part of the present river plain is made up of modified glacial drift. A series of river terraces are found along the sides of all the larger valleys. They indicate frequent changes in the rate of erosion, due perhaps to successive slight uplifts.

Economic Geology.

During the field season an attempt was made to examine all the more important deposits of ore in the district. A short description of each of these will be given in the final report. No ore has been shipped from the Beaverdell area since the beginning of 1910. Last summer a small shoot of silver-lead ore was opened by Mr. W. H. Rambo on the Rambler claim. About 30 sacks of ore were taken from a pit 6 by 3 feet and 6 feet deep. This is close to a rich shoot from which $10,000 worth of ore is said to have been taken some years ago. The ore sacked should run well over $100 to the ton, and that part of the vein exposed, at the time of our visit, looked very promising.

Another development of immediate interest is the building of the Kettle Valley railway, which will connect Midway with Merritt. Last October rails had been laid on this line to a point within 10 miles of Beaverdell, and contracts had been let for the construction of about 30 miles beyond that place. In another year or so this road should be available for the transportation of ore to the Boundary smelters.

FRANKLIN MINING CAMP, WEST KOOTENAY, B.C.

(*C. W. Drysdale.*)

Introduction.

The Franklin camp is situated on the east branch of the North Fork of Kettle river, about 43 miles by wagon road in a northerly direction from Grand Forks. The Kettle Valley branch of the Canadian Pacific railway terminates at present at Lynch creek, some 20 miles up the valley from Grand Forks.

During the past field season a detailed geological map on the scale of 1,500 feet to 1 inch was completed. The Franklin map embraces an area of some 16 square miles and includes the most important mineral deposits of the region. Previous work of a less detailed nature was done in this area by R. W. Brock in 1900 and 1906,[1] and the geology and topography of Franklin mining camp are shown on the West Kootenay sheet mapped on the scale of 4 miles to 1 inch.[2]

The first mining claims located in Franklin camp were the Banner and the McKinley, which were staked in the summer of 1896. The locator of the Banner claim was Frank McFarlane, after whom the camp was named. The Gloucester and adjoining claims were located by Thos. Newby in the summer of 1898. These were followed by the White Bear in 1899; the Maple Leaf in 1902; the Evening Star in 1903; the Buffalo in 1904; the IXL in 1904, and many others.

The year 1906 saw the greatest activity in Franklin, when considerable development was carried on. Since then comparatively little prospecting and mining have been done.

The past season's field work was carried on with a view to determining the probable extent, value, and geological relations of the mineralized areas opened up in this camp.

Messrs. C. A. Fox and F. J. Alcock rendered most efficient service as field assistants.

General Character of District.

The Franklin area falls within the Columbia Mountain system, which here has an elevation of 2,800 feet above sea-level in the valleys and 5,000 feet on the summits.

The district has a mature upland surface from 4,000 to 5,000 feet above the sea, and, except where lava cliffs occur, may be characterized as gently undulating with hills seldom rising over a few hundred feet above its general level. Many of the depressions on this old upland are occupied by stagnant ponds or "sloughs."

The main valleys which trench the upland have a north and south regional trend and vary in width from about 3,000 feet, as is the case in Franklin Creek valley, to over a mile in the main Kettle River valley. The valleys have steep, sloping sides converging to narrow bottoms with an average depth of over 1,500 feet.

The valley sides show the scouring and smoothing effects of glaciers, while their bottoms are largely filled with re-sorted glacial material which the rivers, since the retreat of the ice-sheet, have excavated in a series of step-like terraces. These river terraces of glacial outwash gravels have since then been deeply dissected by the

[1] Summary Report, 1900, Geol. Surv., Canada, p. 70 A.
Summary Report, 1906, Geol. Surv., Canada, pp. 62-65.
[2] Map sheet No. 792, Geol. Surv., Canada.

rivers which have entrenched box canyons and ravines, leaving in some places the tributary creeks and "draws" as hanging valleys high above the water level of the main stream. These "hanging valleys" and "draws" are characterized by the presence of ribbon-like waterfalls and cascades at their confluence with the main valley.

Those portions of the district underlain by the coarse heterogeneous phase of the Kettle River conglomerate, present striking land forms in the shape of many hummocky mounds with outstanding pinnacles or "hoodoos."

The fall of the North Fork of Kettle river between Franklin and Grand Forks amounts to about 1,100 feet, giving the river an average grade of about one-half of one per cent.

There is sufficient water-power available for ordinary mining purposes in Franklin and Gloucester creeks as well as in the main Kettle river.

The average rainfall amounts to about 20 inches per annum, a large part of which falls as snow in the winter months. The summers are moderately warm and dry with cool nights, while the winters are severe with heavy snowfall, particularly on the western slopes of the mountains.

This region was once heavily wooded with fir, tamarack, spruce, white cedar, cottonwood, white birch, and poplar; but forest fires have swept over a large portion of the district and only isolated groves of good timber remain.

Black-tail deer are numerous, and beaver, owing to protective game laws, have become very plentiful. Black and brown bear, mountain lion or "cougars," and coyotes are less frequently seen.

General Geology.

The rocks in this region are chiefly igneous, and, as no sections for microscopic study have been examined, only field terms are used in the following descriptions.

TABLE OF FORMATIONS.

System	Formation	Lithological character.
Quaternary	Superficial deposits	Gravel, sand, silt, boulder clay.
Miocene (?)	Midway Volcanic group	Pinkish pulaskite porphyry, dark basic dyke rocks—lamprophyres; quartz porphyry, and lavas ranging from basalt to andesite and rhyolite.
	Syenite	Pyroxenites (local term "Black Lead")—syenite.
Oligocene (?)	Kettle River formation	Conglomerate, grit, and tuff.
(?)	Monzonite	
Post-Jurassic (?)	Granodiorite	Massive igneous rocks from granite to diorite and in places sheared to gneiss.
Palæozoic (Upper ?)	Gloucester formation.	Crystalline limestone.
	Franklin group	Greenstone, altered tuff, jasperoid, and silicified argillite.

DESCRIPTION OF FORMATIONS.

The Franklin group includes the oldest rocks in the district. It has been subjected to the metamorphic action of intrusive magmas of Mesozoic and Tertiary ages and to so many mountain-making movements that its record of sedimentation and vulcanism has been greatly obscured.

The group consists of impure grey quartzites, jasperoids, altered tuffs, greenstones in places porphyritic, and brecciated and sheared volcanic and intrusive rocks indicating a complex of igneous and sedimentary rocks in their original state.

The rocks of this group have a general strike a few degrees east of north and dip steeply to the west. In places they exist as down-hanging portions of an ancient roof suspended in the underlying granodiorite batholith—termed by R. A. Daly, "roof-pendants."

The Gloucester formation consists of light to dark grey crystalline limestone which occurs as irregular masses interfolded with the Franklin group. The limestone usually grades off into jasperoid and in a few places it has been entirely replaced by silica. These limestones are possibly of the same age as those occurring farther south, which Daly included in his Atwood series of Carboniferous age, correlating them with the limestones in Rossland mountains.

The post-Jurassic (?) granodiorite varies in composition from a mica or a hornblende granite to more basic rock types. Foliated structure is frequently developed in it. It underlies all the other rocks of the region and possesses igneous contacts, proving its younger age. Its border contacts are irregular and steep in character, widening downwards.

The massive and underlying character of the igneous rocks composing it defines it as a batholith, and after the fashion of other batholiths its plunging contacts are evidences of a wider development below, so that at the time of its origin the overlying rocks were in the nature of a roof resting ou a molten magma.

Monzonite.—This is a medium to coarse-grained mottled rock. It is fresh looking, with dark pyroxene and dark brown mica with white and grey feldspar. It outcrops in two bosses, one at the base of Tenderloin mountain, and the other to the north of Franklin mountain. The monzonite is cut by dykes of pegmatite, and more rarely by others of the pinkish pulaskite porphyry type. In places it is sheared and brecciated, having magnetite and quartz developed along the planes of shear. The monzonite resembles closely the Rossland monzonite which R. W. Brock refers to the Mesozoic era.[1] Here, on account of its fresh appearance and lack of dynamic metamorphism as compared with the Mesozoic granodiorite, it has been tentatively referred to Tertiary time.

The Kettle River formation, which has a very strong development in this area, consists of a conglomerate with pebbles ranging from a few inches up to 2 feet and more in diameter. In places the conglomerate grades into well-stratified white to light grey grits and silts which display cross-bedding and current markings. In a few localities obscure plant remains were found in the shaly portions of this formation.

The zone of maximum deposition appears to have been near the junction of Franklin creek with the East Fork, where the conglomerate is very coarse and heterogeneous and is here exposed to a depth of 150 feet.

[1] Prelim. Rept. of Rossland, B.C. Mining Dist., No. 939, pp. 14-15.

This formation may possibly be correlated with the Coldwater group of Dr. G. M. Dawson lying to the south,[1] which occurs in several localities throughout the Boundary district, notably at Phoenix,[2] Baker mountain,[2] and west of Midway.

The age of this formation is Oligocene, as determined by the plant remains found in it.[3]

Syenite.—Intrusive into all the preceding formations is a syenitic rock characterized by elongated crystals of feldspar which lie usually parallel to each other. It occurs as an irregular mass ranging in character from a sill to a laccolith, and appears to be closely associated with the monzonite into which it is intruded.

The syenite varies in composition from the normal form to a phase rich in hornblende, black mica or biotite, and pyroxene crystals with which is associated copper sulphides. This phase or differentiation is consequently black in colour and is locally known as the "Black Lead." Where the syenite formation is narrowest, as in the northwest corner of the district, this differentiation is the best developed.

Midway Volcanic Group.—The Midway volcanic group here occurs as remnants of Tertiary lava flows, and is found chiefly on the hill tops. The rocks range from rhyolite to basalt and vary in thickness from 500 to 1,500 feet. Agglomerates, volcanic breccias, and vesicular, and amygdaloidal lavas are common. The borders of the exposures, as a rule, form prominent cliffs, at the bottoms of which caves occur in many places.

A prominent dyke rock, older than the above-mentioned lavas, is a pinkish porphyry (pulaskitet porphyry), locally known as "birds-eye porphyry," consisting largely of feldspar with biotite, hornblende, and pyroxene sparingly developed. In many places it becomes quite granitoid in texture and passes off into alkaline syenite. Similar pulaskite dyke rocks occur commonly throughout the Boundary district as at Phoenix and Deadwood, but in the latter localities are older than the local development of the lavas.[4]

The youngest dykes which, on McKinley mountain, cut through lavas, quartz porphyries, and conglomerates alike, are dark, soft, basic lamprophyres (minettes) made up largely of pyroxene and biotite. Some of the eruptives of this group appear to occur as sills along the upper border of the granodiorite batholith, between it and the rocks of the Franklin group, as exemplified in the quartz porphyry capping McKinley mountain.

Quaternary.—Superficial deposits. The recent deposits consist of glacial till grading from boulder to fine clay; scattered glacial erratics on hill tops; glaciofluviatile deposits in the form of terraces ("bench-lands") occurring at frequent intervals on valley sides from 5 feet to over 100 feet above the valley floors; and talus from cliffs and residual soil formed from the disintegration of rocks beneath.

Economic Geology.

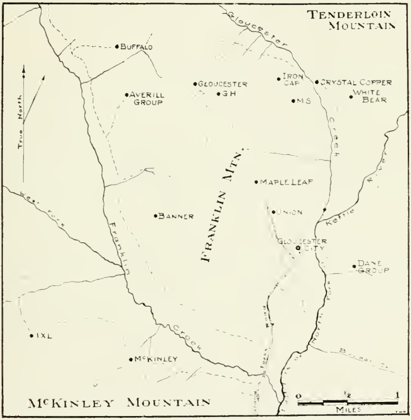
Development work was carried on this last summer on the McKinley property under bond by the British Columbia Copper Company. Besides this work done on the McKinley, assessment development work was carried on at the Dane group, Averill group, Union, Buffalo, and Royal Tinto claims.

[1] G. M. Dawson, Geol. Soc. Am., Vol. 12, 1901, p. 59.

[2] Summary Rept., 1908, Geol. Surv., Canada, pp. 65-66.
Geological and Topographical Map of Boundary Creek Mining district, B.C. Map 828. Geol. Surv., Canada.

[3] D. P. Penhallow, Trans. Royal Soc. of Canada, Geol. Surv., Canada, 1908, Report on Tertiary Plants of British Columbia, XIII, 1907, iv, No. 1013.

[4] Summary Rept., 1908, Geol. Surv., Canada, p. 66.



DIAG. 6. Location of principal mining properties, Franklin district, B.C.

The list of mining claims arranged in alphabetical order is as follows: Ajax, Aldie, Alert, Alpha, Alto Fr., Antelope, Athelstan, A.X.; Banner, Banner Fr., Big Cub, Black Bear, Blue Jay, Bryan, Buffalo, Bullion, Buttercup, Bystander; Columbia, Cottage, Crystal Copper; Doris Fr.; Eclipse, Eganville, Evening Star; Florence, Franklin; Gloucester, Gloucester Fr., G.H., Golden Age, Grande; Hanna, Hennekin, Hit-or-Miss, Homestake; Ida, Iron Cap, Iron Hill, IXL; Jumbo; Last Chance, Little Cub, Lucky Jock; Maple Leaf, May, McKinley, Montana, Montezuma, Mountain Lion, Munster, M.S.; Nakusp, Nellie, Newby Fr.; Old Dominion, Omar, Opher, Ottawa, Ouray; Pinto; Rio; San Francisco, Shelby, Standard; Thuot, Tiger, Tiger Fr.; Union; Verde, Violet Fr.; Wallace, Waverly, White Bear; Yellow Jacket; altogether 75 claims, all of which are Crown granted with the exception of the Blue Jay claim.

MCKINLEY.

The McKinley property is located on the north slope of the McKinley mountain, about 1¼ miles west by pack trail from the crossing of Franklin creek by the road to Gloucester City. There are three distinct types of ore deposits on this property: galena-blende, pyrite-chalcopyrite, and magnetite types. The galena-blende type follows predominantly the limy portions of the mineralized zone, while the pyrite-chalcopyrite and magnetite types follow the siliceous portions, as a rule.

The mineralized zone is irregularly distributed and is always close to the Gloucester limestone which is interfolded with the Franklin group rocks.

The gangue minerals include garnet, epidote, chlorite, quartz, calcite, and actinolite. The rock and ore associations here resemble in many ways those occurrences at Phoenix, Deadwood, and other copper camps throughout the Boundary district, where the ores appear to be of contact-metamorphic origin.[1]

MAPLE LEAF.

The Maple Leaf property, which has not been worked for four years, is situated on the east slope of Franklin mountain. The ore, consisting of copper sulphides and carbonates, is in the contact zone of the Tertiary syenite with the altered tuffs of the Franklin group, and the ore is chiefly confined to the syenite, in which it occurs as replacements along shear-zones. Work was carried on also in the basic differentiate from the syenite or "Black Lead" along the lower border of the syenite sill.

BUFFALO.

The Buffalo claim, which is situated in the northwest corner of the map area, is one of the "Black Lead" claims; and here the differentiate of the syenite has copper sulphides disseminated through it in small quantities. The ore is not far from a monzonite contact, and both syenite and monzonite are cut by a northeast and southwest system of pulaskite porphyry dykes.

Similar so-called "Black Leads" occur on the Averill group, situated on the same contact but farther to the southeast, where bornite is associated with the chalcopyrite, and also on the Blue Jay claim adjoining the Buffalo to the southeast.

BANNER.

On the Banner claim, one of the pioneer properties in the camp, no work has been done for some years. The ore is zinc-blende, galena, and chalcopyrite in a quartz gangue. The country rock is jasperoid and altered tuff of the Franklin group.

[1] Summary Rept., 1908, Geol. Surv., Canada, pp. 66-67.

GLOUCESTER.

The Gloucester property is situated on the Gloucester Creek slope of Franklin mountain. It was bonded by the Dominion Copper Company in 1906, and before that to the British Columbia Copper Company. No work has been done on it since 1906. The ore is chalcopyrite, pyrite, with a little molybdenite occurring in the contact zone between much brecciated grey granodiorite, which is largely calcified and silicified near the contact, and the Franklin Group greenstones.

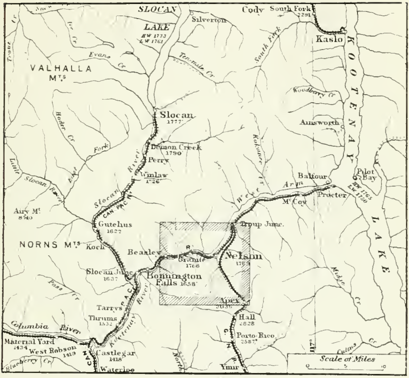
Adjoining the Gloucester to the southeast is the G.H. claim, on which is a magnetite and pyrite deposit. This occurrence also is similarly associated with the granodiorite which underlies it.

Other claims staked on this contact are the Iron Cap, M.S., and Crystal Copper, on which very little development work has been done.

COPPER AND RIVERSIDE CLAIMS.

These two claims, owned by A. Gelinas and J. Senter, are situated about 1 mile south of the map area and across the East Fork of the North Fork of Kettle river from Lower Franklin townsite. The property at present is under bond to the British Columbia Copper Company.

The ore is disseminated chalcopyrite and pyrite with some molybdenite in a quartz and calcite gangue. The country rock is sheared, calcified, and silicified granodiorite. The strike of the shear zone along which the mineralization has taken place is north 55° W., and can be traced for some hundreds of feet.



Diag. 7. Index map showing position of the Nelson map area.

GEOLOGY OF NELSON MAP-AREA.

(*O. E. LeRoy.*)

Introduction.

The area embraced by the Nelson map comprises about 106 square miles, with the city of Nelson lying a little to the north and east of its centre (Diag. 7.) It includes within its area the mines and prospects occurring on Toad and Morning mountains, and those along Cottonwood, Anderson, Fortynine, Bird, and Eagle creeks.

The city of Nelson is situated on the west arm of Kootenay lake, at an elevation of 1,769 feet above sea-level. The city, including the suburbs, has a population of about 7,000 (1911), and as a commercial centre occupies the foremost position in the interior of British Columbia. The city owes its initial growth to the development of the mining industry, which, however, has been subsequently supplemented by the lumbering and agricultural industries. In more recent years a manufacturing industry has been developed, which will in time assume a greater importance commensurate with the growth of the surrounding country. Railway and lake communication has made it the chief distributing point for East and West Kootenay and the Boundary district.

The Canadian Pacific railway reaches Nelson from the east via the Crows Nest line, and from Vancouver via Revelstoke and the Arrow lakes. A new line now under construction by the same Company will give Nelson a southern and more direct connexion with the Pacific coast via the Boundary and Similkameen districts. The Great Northern railway has a northern terminus in Nelson which gives a direct connexion with Spokane and all points to the south of the International Boundary.

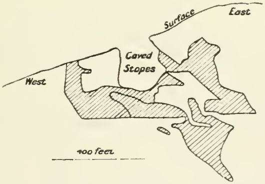


Fig. 1.—Vertical longitudinal section of the ore bodies of the Silver King mine.

The history of mining in the Nelson district dates back to 1886, in which year one of the pioneer mines, the Silver King, was staked on Toad mountain. Nelson at that time could be reached by two routes, either from the main line of the Canadian Pacific railway via Revelstoke and the Arrow lakes, or from the Northern Pacific railway via Bonners Ferry and Kootenay lake.

Geological work of a reconnaissance nature was carried on in this district under Dr. G. M. Dawson[1] in 1888, and Mr. R. G. McConnell[2] in 1894-6.

The history of mining development and production is to be found in the annual reports to the Minister of Mines of British Columbia from the year 1887. According to these reports the approximate total production of the Nelson division from 1895 to the end of 1910, a period of 16 years, amounted to 875,954 tons of ore and concentrates valued at $10,227,134. The area reported on last season only covers a portion of the division, and the above figures are given solely to show the importance of the district as a whole.

The field work in 1911 was done by the writer, assisted during the month of September by Mr. C. W. Drysdale and his party, the result being a geological sketch-map constructed on the scale of about 1 mile to the inch with a contour interval of 250 feet.

The writer wishes to acknowledge his indebtedness and express his thanks to the mine owners, managers, engineers, and others for the many courtesies extended to him during the course of his field work.

General Character of District.

TOPOGRAPHY.

The Nelson map-area lies within the Selkirk system of the Western Cordillera, and includes parts of two subdivisions known respectively as the Slocan mountains and the Pend d'Oreille mountains, the former lying north of the west arm of Kootenay lake and the latter to the south of it. In the vicinity of Nelson the country, though rugged, lacks to a certain extent the more alpine characteristics of the mountains to the north which culminate in the Kokanee massif. The peaks and ridges are more or less rounded and the slopes are usually covered with a varying thickness of glacial drift and "wash," the area of bare rock forming a comparatively small percentage of the whole. The mantle of rock waste, and the heavy forest growth over the more important mineralized areas, formed very serious obstacles to the pioneer prospector in his search for ore. Even at present the tracing of veins over any distance on the surface requires much cutting of timber and deep trenching, though occasionally streams may be deflected and ground sluicing carried on over limited areas.

The maximum range in altitude above Kootenay lake (1,760 feet above sea-level) is about 5,500 feet. The crests of the ridges are usually over 6,000 feet above sea-level, and culminate at intervals in peaks from 1,000 to 1,300 feet higher. The highest peak within the map-area is that of Toad mountain, which has an elevation of 7,334 feet above sea-level.

The minor drainage of the map-area is approximately at right angles to the west arm of Kootenay lake, and Kootenay river, its western continuation. The west arm and Kootenay river occupy one of the main transverse valleys of the Cordilleran belt and extend from Kootenay lake proper to and beyond the Columbia river at Robson, thus connecting the drainage systems of two of the chief longitudinal valleys of British Columbia. The west arm of Kootenay lake preserves its lake-like character as far as Nelson, a distance of 19 miles. From Nelson to Robson, some 27 miles west, the valley is occupied by the swift-flowing Kootenay river, with a grade of about 15 feet to the mile. The main falls are at Bonnington (Diag. 8), 11 miles west of Nelson, at which point two electric plants—the West Kootenay Light and Power and the Nelson Power plants—have been installed, which furnish various industrial and mining centres in West Kootenay and the Boundary districts with light and power.

[1] Ann. Rep. Geol. Surv., Can., Vol. IV. pp. 55-56 B.
[2] Ann. Rep. Geol. Surv., Can., Vol. VII, p. 35 A, Vol. IX, pp. 20 and 27 A. Geological Map of West Kootenay (No. 792).

This transverse valley is bounded by comparatively steep slopes and in places precipitous walls. The tributary streams flow in steep U or V-shaped valleys and partly in box canyons. Some of the larger streams, such as Grohman and Sproule, have, near their mouths, trenched themselves in narrow canyons, the bottoms of which are 20 or 30 feet below the general level of the valley.

The gradients vary from a fall of 250 feet per mile in Cottonwood creek to about 900 feet per mile in the east fork of that creek. The streams head in basins or cirques, whose steep walls have been much modified since the disappearance of the glaciers. The broader basins support grassy meadows, which in the early summer are covered with a variety of flowering plants. The larger streams have built up deltas which extend into the lake for considerable distances, and form limited, though suitable sites, for habitation. Nelson and the neighbouring town of Fairview are built upon the connected deltas of Cottonwood and Anderson creeks.

CLIMATE AND AGRICULTURE.

The climate on the whole is one of the finest in Canada. Warm summers and moderately cool winters prevail in the more habitable portions of the area. Excessive temperatures, either of heat or cold, are rare and of short duration. The following statistics have been kindly furnished by the Dominion Meteorological Bureau, based on the averages of four consecutive years at Nelson.

Temperature (Fahrenheit degrees).

—	Mean Highest.	Mean Lowest.	Mean.
February	32·7°	21·2°	27°
July	81·1°	51·9°	66·5°
Annual			46·2°

The average annual precipitation for the same period amounted to 29·27 inches. The snow fall is heavy on the hills, which, melting slowly, furnishes reserves for the streams for a considerable portion of the summer.

The mining industry was the first cause to attract the pioneers to form a settlement at Nelson, but in more recent years land has been cleared of the original dense forest growth, and a flourishing industry in fruits and vegetables has developed. From the point of view of demand this industry is capable of an expansion only limited by the land area suitable for such cultivation.

Lumbering in the vicinity of Nelson is at present confined to the valley of Sproule creek. The principal trees of the area are the fir, red and bull pine, spruce, cedar, hemlock, tamarack, balsam, larch, aspen, cottonwood, birch, juniper, and alder.

General Geology.

INTRODUCTION.

The Pend d'Oreille group, largely sedimentary, is the oldest rock series in the Nelson map-area. On the West Kootenay sheet (No. 792) this group was mapped under Niskonlith and tentatively referred to the lower Cambrian. More recently, Daly, in his section along the International Boundary, gave the name Pend d'Oreille to this group, and referred it to the Carboniferous period. It is thus provisionally placed until more detailed data are available.

The rocks of the Pend d'Oreille group are succeeded by those of the Rossland volcanic group, which are largely of igneous origin, and between which, so far as could be inferred from the field relations, there is an absence of any marked stratigraphical break or conformity. The age of the latter is tentatively placed as Carboniferous and post-Carboniferous. The rocks of both groups are intruded by the Nelson batholith of Jurassic or post-Jurassic age. The rocks composing the batholith range from granite to diorite, and its intrusion was probably closely associated with the mountain-building epoch of later Mesozoic. The rocks of the Rossland volcanic group and the Nelson batholith are the most important economically and contain practically all of the commercial deposits of ore.

Subsequent to the ore deposition, the country, generally, suffered from faulting and fissuring accompanied by the intrusion of a series of basic (lamprophyric) dykes which have in this area a wide-spread distribution. The Tertiary is apparently not represented in this area. The Quaternary deposits consist of some glacial clays, boulder drift, "wash," and the more modern alluvial deposits of the present day deltas.

TABLE OF FORMATIONS.

Quaternary.	Glacial and Recent.	Some boulder clay and drift 'wash' alluvial clay, sand, and gravel.
....	(?)	Basic mica, hornblende and pyroxene dykes (lamprophyree).
(?)	Period of Ore Deposition.	Gold-silver, silver-copper, copper-silver-gold deposits.
Mesozoic..........	Jurassic (?)	Nelson batholith intrusion (rocks range from granite to diorite).
Palæozoic..........	Carboniferous and post-Carboniferous.	Rossland volcanic group consisting of hornblende and pyroxene porphyrite, chlorite and mica schist, quartz porphyry, sericite schist, with a few beds or lenses of limestone and slate.
	Carboniferous (?)	Pend d'Oreille group sandstone, slate, phyllite, andalusite schist, quartzite, quartz schist.

THE PEND D'OREILLE GROUP.

The Pend d'Oreille group has only a small superficial distribution in the Nelson map-area, and occurs along the east border at the head-waters of Anderson creek and the east fork of Cottonwood. The rocks composing the group consist of interstratified grey sandstones, grey and black slates which along the contact with the granite have been altered to quartzites, quartz, and andalusite schists. The strike of the rocks generally conforms to the trend of the border of the granitic batholith, and varies from north to west, with dips from 60 to 90 degrees to the west and south.

The actual contact between this group and the Rossland volcanic is concealed[1] by drift. The outcrops of both groups when noted near the probable contact were practically vertical and coincided in strike. At one point the contact appeared to be

[1] No microscopic examinations have as yet been made of the rocks and the field terms solely are used in the following descriptions.

an igneous one, the intrusive from hand specimens resembling a deeper-seated phase of the augite porphyrite of the Rossland volcanic group.

THE ROSSLAND VOLCANIC GROUP.

The rocks of the Rossland volcanic group occupy the greater part of the southern half of the Nelson map-area. That they had a wider distribution in the past, is evidenced by the many isolated exposures in the area underlain by the granitic rocks of the Nelson batholith. The rocks are in the main of igneous origin and consist of interbanded porphyries and porphyrites and their brecciated, sheared, and altered (metamorphosed) equivalents, now porphyrite-breccia, chlorite, hornblende, quartz-biotite and quartz-sericite schists. There is a minor development of compact greenstones and quartzose rocks which may have been originally tuffs now silicified. Amygdaloidal rocks were noted in two instances and may represent original surface flows, being the extrusive equivalents of the main masses, which apparently occur in sills or sheets and indicate several periods of intrusion.

Interbedded with the above rocks are small bands or lenses of quartzite, slate, and crystalline limestone indicating rather brief periods favourable for the deposition of sediments. The basic igneous rocks are prevailingly green or dark green, weathering to a light greenish grey or to rusty brown, while the acid types are usually dark grey or light grey. Both types, especially the schistose phases, are more or less pyritic, and in some cases the pyrite carries gold values.[1]

The rocks throughout have been much folded and altered by dynamic as well as igneous action. The strike of the schistosity and of the bedding, in the case of the stratified rocks, conforms in general to the trend of the border of the Nelson batholith. From east to west across the map-area the strike gradually swings from northwest to west with south and southwest dips ranging from 30 to 90 degrees, the average dip being over 45 degrees.

THE NELSON BATHOLITH.

The enormous intrusion of granitoid rocks, termed the Nelson batholith, which underlies hundreds of square miles in the southern part of the West Kootenay district, occupies about three-fifths of the Nelson map-area, and underlies the whole of it at no great depth. These rocks are exposed almost continuously in the northern half of the area, especially north of the west arm of Kootenay lake. In the areas underlain by the rocks of the Pend d'Oreille and Rossland volcanic groups, this intrusion is represented by numerous dykes, and bosses of considerable size, which at moderate depths are no doubt connected with one another and also with the main body of the batholith. The age of this intrusion is tentatively referred to the Jurassic or post-Jurassic period.

The term Nelson granite, though widely used, is not applicable to any great portion of the rock mass, which is rather a granodiorite or a rock transitional between a granite and diorite. In mineralogical composition the rocks range from a true granite to a quartz diorite and to possibly more basic types. That portion of the batholith in the Nelson map-area is apparently a unit, though differentiation has played an important role, and assimilation to a minor extent, judging from field relations along certain contacts with the rocks of the Rossland volcanic group. Orthoclase and plagioclase feldspar, biotite, hornblende, and quartz are the essential constituent minerals. An analysis of the average type occurring on Kokanee mountain gave the following result which places the rock among the more acid of the Monzonites.[2]

[1] On the Starlight claim the pyritized schists are stated to carry $3 in gold.
[2] Geol. Surv., Can., Sum. Rep., 1902, p. 101 A.

SiO_2	66·46
TiO_2	0·27
Al_2O_3	15·34
Fe_2O_3	1·68
FeO	1·83
CaO	3·43
MgO	1·11
Na_2O	4·86
K_2O	4·58
H_2O	0·29
P_2O_5	0·08
	99·93

The texture ranges from coarsely porphyritic to fine granitoid. The colour varies from light to dark and brownish-grey weathering in lighter tones. Some of the more basic types readily disintegrate to a coarse sand. The most remarkable type is a granite porphyry which contains large-zoned crystals both single and in Carlsbad twins, varying in size from ½ to 1 inch in diameter and from 1 to 2 inches in length. This porphyry appears to be a differentiate in a rather coarse granite, and occurs in masses ranging from a few feet to hundreds or thousands of feet in diameter. The associated dykes cutting this granodiorite are light grey or pinkish aplite of two or more generations, coarse quartz-feldspar-biotite pegmatite, quartz porphyry, and quartz syenite porphyry. The aplite contains in rare instances small plates of molybdenite lying in minute fracture planes. The aplites and pegmatites are more numerous in the more basic phases of the granodiorite at or near its contact with the schists of the Pend d'Oreille and Rossland volcanic groups. These contact rocks are mainly quartz, quartz-biotite, and andalusite schists, and also occur as rounded and lens-like inclusions in the granodiorite mass, especially when the latter is foliated, in which case the longer axis of the inclusions coincides in trend with that of the foliation. A migration of material is also apparent, and phenocrysts of feldspar are found developed in the main body of the schists at or a few feet from the contact.

The granodiorite is much jointed throughout by broadly developed planes. Vertical planes in two directions almost at right angles, together with an almost horizontal plane, are the most prominent. An inclined plane (varying from 30 to 80 degrees in dip) passing into sheeted zones is locally common. Shearing occurs along the joint planes, especially in the vicinity of the basic lamprophyre dykes, and it probably marks the directions of later fissuring and faulting, though in the latter case criteria for its determination are usually lacking.

BASIC (LAMPROPHYRE) DYKES.

Basic dykes, with biotite, hornblende, or pyroxene as the chief phenocryst constituent, have a widespread development throughout the whole area. They are dark green to black in colour, weathering to greenish grey, and readily disintegrating to a coarse brownish sand. They are intrusive in all the older rocks, and they cut and sometimes fault the ore bodies in contra-distinction to lithologically similar dykes at Sheep creek and in the Slocan district which are older than the vein fissures. At Nelson the dykes are almost invariably steeply inclined or vertical, and when cutting the granodiorite, usually follow the main plane of jointing. They hold as inclusions, angular fragments of the wall rock which they have rifted off. In the bedded and schistose rocks they follow along the planes of stratification and foliation, and occasionally, though rarely, cut across the strike or dip. The dykes range from a fraction of an inch to over 20 feet in thickness, and in length from less than 100 to 1,000 or more feet. The wider dykes show at times a variation in texture, coarse-grained alternating with finer-grained, arranged in parallel bands. Being less resistant than the granodiorite they are easily eroded and leave small canyons with vertical walls. The gorge of Cottonwood creek just south of Nelson has been formed in this manner by the wearing down of a broad dyke leaving the vertical walls of granite.

GLACIAL AND RECENT DEPOSITS.

In the Glacial period the whole country was covered by the Cordilleran ice sheet, which, in this area, appeared to be moving S. 30° E., as evidenced by striæ and grooves on the higher slopes and ridges. At a latter period when the sheet was broken up into individual glaciers the trend of movement coincided with the present valleys. The highest erratics noted were on the slope of Toad mountain about 150 feet below the peak, at an elevation of 7,184 feet above sea-level, on Copper mountain 500 feet below the peak at 6,960 feet above sea-level, and on the ridge at the head of the east fork of Cottonwood creek 6,685 feet above sea-level. The highest outcrop of striated rock was noted on the east slope of Connor mountain 450 feet below the peak at an elevation of 6,600 feet above sea-level.

Boulder clays and sands, morainic in character, are common on the lower slopes of the ridges and in portions of the valleys. They are, however, much obscured by angular waste material or "wash." Morainic tongues evidently extended across the Kootenay valley at one or more points near Nelson, which were later cut through by the river, leaving bars and gravelly islands.

Stratified sands with some clays and gravels overlie the unassorted material, and have been noted up to an elevation of 3,000 feet above sea-level, or 1,240 feet above Kootenay lake. The highest terraces or bench lands noted were 460 feet above Kootenay lake.

ECONOMIC GEOLOGY.

INTRODUCTION.

The ore deposits in the vicinity of Nelson occur either in the granitic rocks of the Nelson batholith, or in the schists and limestones of the Rossland volcanic group. In the granitic rocks the veins occupy well-marked fissures, and the ore is essentially gold or gold-copper with a quartz gangue. The lodes or mineralized zones in the schists consist of elongated and parallel lenses of quartz alternating with bands of schist, both of which are mineralized. The ore bodies or shoots are lens-like in form, and in altitude approximately conform to the strike and dip of the schists. In a few instances distinct fissure veins occur across the strike or the dip of the schists. The ores in the schist are silver-cpper, gold-copper, and gold-silver. The ore bodies in the limestone are contact deposits, occurring at or near the border of the batholith, and are characterized by a gangue composed essentially of the lime silicates, garnet, epidote, and actinolite. They are similar to the low grade deposits of the Boundary district but are of much less importance.

The ore deposits have been arranged and are described under the following heads:—

(1.) Gold-silver.
(2.) Copper-gold-silver.
(3.) Silver-copper.
(4.) Non-metallic minerals.

The principal metallic minerals found in the Nelson map-area are native gold, silver, and copper; pyrargyrite (ruby silver), iron pyrite, chalcopyrite (yellow copper), bornite (peacock copper), tetrahedrite (grey copper), chrysocolla (silicate of copper), azurite (copper carbonate—blue), malachite (copper carbonate—green), stromeyerite[1] (sulphide of copper and silver), molybdenite, galena, zinc blende, pyrrhotite (magnetic iron pyrites), scheelite (calcium tungstate), magnetite, and limonite. The gangue minerals are quartz, calcite, siderite (spathic iron), barite, fluorite, garnet, actinolite, and epidote.

STATE OF MINING IN 1911.

The properties from which shipments were made during the past season (1911) were the Granite-Poorman, 380 tons (concentrates); Athabasca, 101 tons (concentrates); California, 33 tons; Royal Canadian (Nevada), 28 tons; Ophir, 5 tons, and a clean-up at the Silver King mine of 77 tons.

Minor development work was done on the Alma, Pingree, Perrier, and George V. During the summer there was considerable activity in prospecting for metals of the platinum group. Samples were taken from a few of the prospects, but the assays by the chemistry division of the Mines Branch gave negative results.

The profitable exploitaton of many of the smaller properties lies in the amalgamation of the several interests, in order to economize and secure the best results from systematic development. The owners also should be willing to permit their properties being developed under a practical working bond without any cash consideration. If the property is not sold the development work proves its value to a certain extent, and if the property is worthless the sooner that fact is discovered the better for the owner. There are so many cases throughout the country generally where the owner is spending his money in desultory development which is oftentimes valueless. The majority of mineral deposits are not easily exploited, but call for the employment of strict technical and business methods beyond the resources of the small holder. If reputable people could be secured to interest themselves every facility should be given to encourage them. Such a policy if generally adopted would undoubtedly yield results beneficial both to the individual and the community.

DESCRIPTIONS OF MINES.

Gold-Silver Deposits.

The Kootenay Gold Mines, Limited.—The Kootenay Gold Mines, Limited, own the Granite-Poorman group, situated about 5 miles west of Nelson at an altitude of from 1,200 to 2,400 feet above Kootenay lake. The group consists of fifteen claims and fractions, on which five main veins have been partially developed (Fig. 2).

The mill, situated about 1 mile west of Granite station on the Canadian Pacific railway, is equipped with twenty stamps, amalgam plates, and four Wilfley tables. An 8-drill Rand compressor is also situated in the mill building. Both water and electric power are used. A Riblet aerial tram about 5,000 feet long with a drop of about 1,200 feet connects the Granite shaft with the mill. Loading stations at convenient points along the line are connected with the several lower levels of the workings. The production from 1899 to January, 1912, amounted to about 83,175 tons. About 80 per cent of the gold is collected on the plates and about 10 per cent is recovered in the concentrates. The latter average about 1½ ounces of gold and 1½ per cent of copper per ton. The milling ore ranges in gold values (recovered) from $6.50 to $12 per ton with a very low silver content.

[1] A specimen of stromeyerite from the Silver King gave the following analysis: silver, 52·27%, copper, 31·60%, sulphur, 15·74%, iron, 0·17%. See Geol. Surv., Can., Vol. VIII, 1895, p. 12 R.

The veins are of the fissure type and occur in a medium or coarse-grained quartz hornblende diorite. They vary in thickness from an inch or so to over 6 feet, and the length so far as developed ranges from 500 to 2,500 feet. Usually a certain width of the country rock, either on the hanging or the foot-wall side, is sufficiently mineralized to stope. The predominant and almost exclusive gangue mineral is quartz. The chief metallic mineral is pyrite, with which is locally associated small quantities of galena, chalcopyrite, and in rare instances in the Poorman mine, scheelite. The galena is always an indicator of high gold values. Limonite is present in the oxidized portions of the veins in which visible free gold may occasionally be seen. The veins are cut by basic mica dykes (minettes), and are faulted, but usually with small displacements. The main fault cutting the Granite and Beelzebub veins has a throw of at least 180 feet.

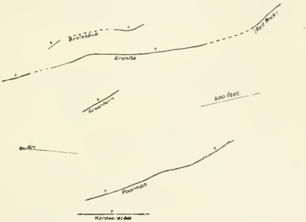


FIG. 2.—Vein system on the property of the Kootenay Gold Mines, Limited.

The five veins, going from west to east (Fig. 2), are the Hardscrabble, Poorman, Greenhorn, Granite, and Beelzebub. At the level of No. 4 cross-cut tunnel of the Poorman, and taking the Hardscrabble vein as the initial point, the other veins lie east of it at the following approximate distances, respectively: Poorman, 330 feet; Greenhorn, 1,300 feet; Granite, 1,900 feet; Beelzebub, 2,020 feet.

Hardscrabble Vein.—The Hardscrabble vein is intersected by No. 4 cross-cut tunnel of the Poorman, 60 feet from the portal. The vein is now being developed, and in recent drifting has shown an ore body at least 300 feet long with an average width of 2 feet. The vein strikes N. 10° W. with an average dip of about 45 degres to the northeast. Little stoping has been done so far; the ore stoped, however, is, on an average, of higher grade than is found in the other veins, and the gold is coarser.

Poorman Vein.—The Poorman vein has been developed by five levels, giving a depth on the vein of 700 feet. The bulk of the ore mined and milled by the Company in 1911 was derived from the Poorman, and stoped between the fourth and fifth levels. The main avenue is No. 4 cross-cut which intersects the vein about 480 feet from the portal. This level is connected to No. 5 by an incline shaft. The productive portion of the vein above 4 has in great part been stoped out. The vein strikes N. 22° W. and dips northeast from 30 to 4. degrees. The ore shoot is continuous from the surface, and on the fourth level was stoped for a length of over 1,000 feet. The shoot pitches rather flatly to the southeast. The thickness varies from a few inches to 8 feet, and the average stoping width is about 2 feet. The ore stoped during the last five years averaged $6.50 in recovered values. The average run of the ore in the vein proper is about $15, but the width of mineralized rock stoped below the foot-wall lowers the average to the former figures. The gold is "shotty" in character and easily recovered on the plates. Free gold in small but extremely rich pockets has been found at rare intervals down to the present lowest level. Scheelite also is found but is of rare occurrence. It occurs in small grains, pale brown in colour, in massive white quartz. The zone of oxidation is shallow in the Poorman and does not exceed 50 feet in depth.

Greenhorn Vein.—The Greenhorn vein has been opened by two drifts giving a vertical depth of 150 feet. The vein strikes N. 33° W. and dips northeast at 45 degrees. Stoping has been carried on from the surface to within 30 feet of the lower level. The shoot was about 300 feet long with an average thickness of 3 feet. Above the sill of the first level (Greenhorn tunnel), which represents the limit of oxidation, the ore averaged $12 per ton in gold (recovered values).

Granite Vein.—The Granite vein has been developed by seven levels, giving a vertical depth of 450 feet. The several levels in ascending order are, the lower tunnel 230 feet above No. 4 level of the Poorman, the Davenport, the Granite shaft with four levels, the lower being the White tunnel, and the Red Rock tunnel.

The vein varies in strike from N. 12° W. to N. 50° W. with an average dip to the northeast of 45 degrees. The stoping width averages 2½ feet.

In the absence of through connexions with all the workings it is impossible to outline with accuracy the limits of pay-ore. There appears, however, to be four shoots: the Red Rock; the Granite shoot, 285 feet long on the level of the White drift, and extending to the surface at the Granite shaft, 280 feet high on the dip; the White shoot, 230 feet long; and the shoot in the lower tunnel, 200 feet long with a maximum height of 80 feet. A fault cuts this latter shoot off to the south, on a strike of N. 85° E. and a north dip of 50 degrees, the vein at this point striking N. 30° W. and dipping northeast at 55 degrees. The fault zone, from 1 to 17 feet thick, consists of crushed country rock, gouge, and dragged ore. The throw along the horizontal plane is not less than 180 feet. Sufficient work has not yet been done to definitely locate the vein south of the fault.

The ore is largely oxidized, and the gold is flaky in character. The recovered values in gold averaged $8 per ton. In the Red Rock shoot crude ore ran $45 per ton in carload lots, and the milling ore averaged $11 per ton.

Beelzebub Vein.— The Beelzebub vein has been opened up on two levels giving a vertical depth of 175 feet between them. The vein varies in strike from N. 30° W. to N. 40° W. and dips northeast at from 30 to 50 degrees. The eastward continuation of the fault displacing the Granite vein was encountered, and until the throw is definitely determined in the Granite workings no further work will be done on this vein. The stoped width varies from 14 to 22 inches. One thousand tons stoped above No. 2 level yielded $9 in gold (recovered) per ton. One rich pocket of oxidized ore gave a return of $7,000 from a barrow load.

Athabasca Mine.—The Athabasca mine, controlled and operated by the Athabasca Syndicate of Vancouver, is situated on the east slope of Morning mountain, about 3 miles in a direct line from Nelson, and about 2,200 feet above Kootenay lake. A branch from the Hall Mines road leads to the Athabasca mill. The property originally consisted of four claims, to which was added the Venus group in 1903. The Athabasca mine is connected with the mill by a surface gravity tram and the Venus by Riblet aerial tram 7,300 feet long. The mill, situated on Giveout creek, about

1,000 feet below the former mine, is equipped with ten stamps, amalgam plates, Frue vanners, and cyanide tanks.

The Athabasca mine[1] has been operated since 1897, though not continuously. During the past two years development has been steadily advanced and a limited amount of ore stoped. There are several ledges on the property, only one of which has been developed. This well-defined vein occurs near a granite-schist contact and the fissure traverses both rocks (Fig. 3).

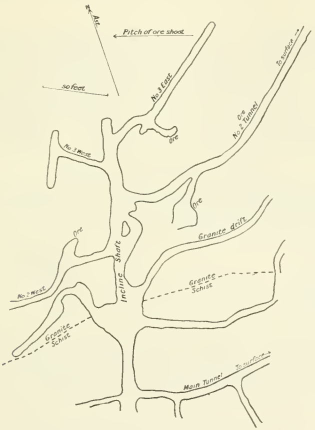


FIG. 3.—Plan of a portion of the Athabasca mine.

The vein, in passing from the granite to the schist, rolls over and flattens (Fig. 4). In the schist the vein is disturbed by numerous normal faults running in various directions, with throws from a few inches to over 100 feet. In the granite the vein is more regular and when faulted is but slightly displaced. The faulting is associated with the intrusion of a series of basic dykes which cut the vein. In its normal course the vein strikes N. 40° E. and dips northwest, the angle varying from 30 to 50 degrees. The vein has been developed by two main (adit) levels, and intermediate drifts connected by an incline shaft. The more recent development consisted in prospecting above No. 2, and opening a third level to explore the downward continuation of the ore shoot to the northwest (Fig. 3).

[1] Fell, E. N. Notes on the Athabasca Mine, Jour. Can. Min. Inst., Vol. V, 1902, pp. 15-20.

Stoping was general on and south of the main level for nearly 600 feet along the strike. The paystreak varies in thickness from about 2 inches to 3 and even 4 feet, the general average being about 1 foot. The ore is a mixture of galena, zinc blende, and pyrite with occasionally free gold either in the quartz gangue or in the solid sulphides. The values are less regular in the granite than in the schist belt. A remarkable concentration of values was noted along the contact, especially on the schist side. The recovered values in 1900 averaged $33.66 per ton in gold and silver.

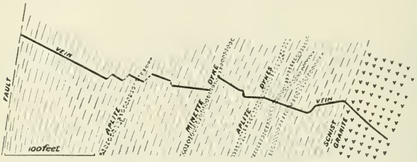


Fig. 4 —Section across the Athabasca vein.

The latter is in small amount and never exceeds 6 ounces per ton. An assay of the pulps of the mill-runs of 14 days (December, 1900) gave the following values, the ore being classed as medium low grade[1]:—

Gold	1·35 ounces per ton.
Silver	0·45 " "
Zinc	2·20 per cent.
Lead	1·60 "
Iron	10·70 "
Sulphur	6·00 "
Silica	68·80 "
Lime	1·90 "
Alumina	6·00 "

The Venus mine has been idle for some years and was not visited. The vein is stated to occur in the schist belt (Rossland volcanic group). It has a northerly strike and is stated to vary from 2 to 4 feet in thickness. The vein has been developed by four tunnels and the workings are connected with the neighbouring Juno mine. The ore is of lower grade than that of the Athabasca.

California Mine.—The California mine is owned by Mackenzie and Mann and at present is being worked under bond by Messrs. Bell and Hudson. The mine is situated above and to the south of Giveout creek at an elevation of about 2,000 feet above Kootenay lake. A branch of the Hall Mines road leads to the lower tunnel and ore bunkers.

The vein or lode has been traced by stripping and open-cuts for about 800 feet; it occurs in a band of schist near a granite contact and has a westerly strike with a dip to the south of between 50 and 60 degrees. On the California ground the main development is a drift tunnel about 250 feet long, which has opened up two ore shoots, one 37 feet long and from 10 inches to 2 feet thick, while the other is at least 150 feet long and varies in thickness from 3 inches to 2½ feet. Shipments from the former ran $40 and from the latter $30 per ton. The value is mainly in gold, as the silver content never exceeds 8 ounces per ton. The ore is similar to that of the

[1] Jour. Can. Min. Inst., Vol. IV, 1901-2, p. 83.

Athabasca and consists of pyrite, galena, and blende in a quartz gangue, occurring as a series of parallel bands or long attenuated lenses in the schist. The values are rather spotty and are best when there is an intermixture of the sulphides. The foot-wall streaks usually carry the richest ore.

The Exchequer adjoins the California to the west and is on the same lode, which has been developed by a shallow shaft connected with a short cross-cut tunnel. At the intersection of shaft and tunnel the lode is from 10 to 15 feet thick and consists of interbands of quartz and schist. In 1899, a trial shipment of 50 tons gave $20 per ton in gold.

Perrier Group.—The Perrier group, owned by Messrs. Hinton, Crossley, and associates, consists of seven claims situated on the Great Northern railway about 4 miles south of Nelson, at an elevation of 1,200 feet above Kootenay lake. The mine is equipped with a boiler, Akron-Chilian mill, plates, and a one-drill compressor.

The main vein has been traced on the surface for over 700 feet by small cuts and tunnels, and an incline shaft, at present 60 feet deep, is being sunk on the dip. The strike varies from N. 5° E. to N. 20° E. and dips east from 35 to 60 degrees. The fissure cuts across the foliation of the chlorite schists (Rossland volcanic group). The thickness of the vein varies from 10 to 22 inches and consists of quartz, zinc blende, galena, chalcopyrite, and occasionally a little free gold. A nine ton shipment to Trail gave $23 in gold and from 4 to 5 ounces of silver per ton.

About 200 feet southeast of the shaft a vertical lode outcrops, striking N. 30° W., or with the trend of the schists. It consists of bands of quartz, with an aggregate thickness varying from 7 to 15 inches, interbanded with the schists. The mineral content is the same as that of the main vein, but in addition minute quantities of ruby and native silver have been found in small fissures associated with calcite. It is probable that this vein is a branch of the main one, but development work is not yet sufficiently advanced to prove it.

Royal Canadian Group.—The Royal Canadian, owned by a Victoria syndicate, consists of five claims and fractions situated on the Nelson-Bonnington road at the junction of the road to Fortynine creek, about 7 miles west of Nelson. There are two veins on the property, named the Royal Canadian and Nevada, respectively. The Royal Canadian vein has been developed by three short drift tunnels, giving a vertical depth of about 125 feet. A limited amount of stoping has been done, and it is stated that some years ago 300 tons put through the Granite mill gave appropriate returns of $4.75 per ton in gold. The vein occurs in a grey granodiorite and has a strike N. 15° W. with a dip of between 60 and 70 degrees to the northeast. In the lower tunnel the vein has been cut and slightly faulted by a basic mica dyke. The ore consists mainly of pyrite with very slight amounts of chalcopyrite in a quartz gangue and varies in thickness from 2 to 33 inches.

The Nevada vein lies to the south and higher up the hill. A cross-cut tunnel intersected the vein about 70 feet from the portal, and from that point a drift was driven about 70 feet to the east and connexion made with a shallow shaft sunk from the surface. The vein occurs along a contact of granodiorite and schist, the former being the hanging-wall and the latter the foot-wall. The strike is N. 78° E. with a dip to the south of 53 degrees. The thickness varies from 8 inches to 3 feet. A shipment (1911) of 28 tons was made from an underhand stope in the east end of the drift which averaged $20 per ton in gold. The mineral content of the vein is similar to that of the Royal Canadian.

The Ophir and George V.—These properties adjoin one another and are situated on Bird creek, about 10 miles from Nelson by wagon road. The Ophir is owned by John Baxter and the George V by John Smallwood, both of Nelson.

The lode crosses both claims and occurs in quartz-mica and chlorite schists, with which it coincides in the main, both in strike and dip. The strike is N. 85° E. and the dip is south, varying from 30 to 45 degrees.

The lode consists of bands and lenses of quartz with interbands of pyritic and siliceous schist having a maximum aggregate thickness of about 3 feet. Pyrite was the only ore mineral noted, but it is stated that visible free gold occurs in the oxidized portions. A trial shipment of 5 tons has been sent to Trail but the results are not yet to hand. The lode has been exposed at several points by short tunnels, open-cuts, and a shallow incline shaft. A main cross-cut is now being driven which will give a depth of about 90 feet on the dip. The George V has been developed by a short and shallow cross-cut tunnel and an open-cut.

The Juno.—The Juno mine, owned by the Juno Mines, Limited, Montreal, is situated on Morning mountain, adjoining and above the Venus mine. The property has been idle for several years and was not visited last season. The vein is exposed by some open-cuts on the surface. The underground development consists of a shaft 300 feet deep with levels at 100 foot intervals. No. 2 tunnel of the Venus is connected with the lowest level by a 550 foot raise.

The vein strikes at about N. 50° E. and dips southeast at about 60 degrees. The vein is quartz varying in thickness from 15 inches to 2 and 3 feet on the first and second levels. It is stated that some years ago the Athabasca mill was leased and about 2,000 tons of ore was milled. It is not known what values were recovered.

The Venus vein extends into the Juno ground, but has not been developed beyond driving the tunnel and making the raise connexion.

The May and Jennie Group.—This group, consisting of four claims and owned by the Reliance Gold Mining Company of Nelson, is situated on the east side of Fortynine creek, about 9 miles west of Nelson by wagon road.

The mine is connected to the mill by a Riblet aerial tram 1,750 feet long with a drop of about 550 feet. The mill is equipped with a 50 ton Akron-Chilian mill, plates, and cyanide tanks. No work has been done ou the property for several years.

There are two lodes, of which the main one has been developed by two cross-cut tunnels with drifts connected by a raise of 112 feet. Nos. 3 and 4 tunnels have been run only short distance sand have not reached the vein. The aggregate footage amounts to rather more than 2,500 feet. In No. 2 tunnel, driven about 235 feet below the outcrop, the lode has a general strike of N. 30° W. with a dip to the southwest of 75 degrees, northeast or to the north at from 60 to 85 degrees. In general the lode coincides in strike and dip with the hornblende and chlorite schists forming the country rock. The lode consists of interbands of pyritic quartz and schist, the latter being much crushed and oxidized in places, with lenses and masses of fairly clean pyrite. The thickness varies up to a maximum of 2½ feet with bands of massive pyrite up to 18 inches thick. The ore is low grade and is stated to run about $4 per ton in gold.[1]

In the same tunnel the cross-cut intersected another lode about 230 feet from the portal on which a little work has been done. It occurs as a shear zone in basic porphyrite, and consists of a filling of crushed rock, quartz, and pyrite.

Anderson Creek.—An interesting occurrence of a vein showing crustified and comb structure is to be seen on the east fork of Anderson creek, about half a mile above the Great Northern railway. The vein occupies a fissure in a light grey medium-grained granodiorite and is exposed by a drift tunnel about 200 feet long. It strikes N. 20° W. and dips northeast from 85 degrees to vertical. The vein con-

[1] Ann. Rep. Min. of Mines, B.C., 1904, pp. 138-139.

sists of heavy gouge and quartz up to 4 feet in thickness, the quartz having a maximum thickness of 18 inches. The ore consists of alternate bands of galena, zinc blende, chalcopyrite, pyrite, siderite, calcite, and quartz. These, in its best development, correspond on each side of the central drusy zone. The centre is marked by quartz crystals with well-developed terminal faces and strong zonal structure. The crystals either interlock or are separated by open spaces from a fraction of an inch to 2 or 3 inches across. In certain places the lower three faces of the pyramids are coated by small cubes of pyrite indicating that vapours carrying sulphide of iron passed upwards and deposited their metallic content on the planes facing the direction of movement.

Copper-Gold-Silver Deposits.

The Eureka Mine.—The Eureka mine, owned by the Eureka Copper Mines, Limited, of Nelson, is situated on Eagle creek, about 8 miles by wagon road from Nelson, at an altitude of about 2,700 feet above Kootenay lake. The group consists of seven claims and fractions. The mine workings consist of an incline shaft 200 feet deep with drift at the 100, 150, and 200 foot levels, and a cross-cut tunnel which gives an additional depth of 82 feet. In all about 3,000 feet of work has been done exclusive of open-cuts and trenching.

The mine has shipped to date 2,660 tons of ore, which averaged 5·5 per cent copper, 0·21 ounce of gold, and 2·5 ounces of silver per ton.

The country rock is a dark grey quartz diorite cut by several basic mica dykes, which also cut, and in cases, fault the vein. There appear to be at least two vein fissures (Fig. 5), which may be connected, though development work is not sufficiently

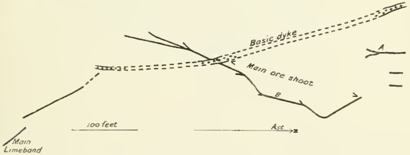


Fig. 5.—Vein system of the Eureka mine.

advanced to prove it. In the old workings at the shaft the main vein strikes N. 52° W. and dips northeast from 85 degrees to vertical. The main fissure in the cross-cut tunnel strikes N. 17° E. with a high dip to the east. A fault near the north end changes the trend to the northwest, or practically parallel to the main vein in the old workings. Both are intimately associated with bands of crystalline limestone which have apparently been engulfed in the diorite when it was in a molten condition. These bands probably served as suitable directions for fissuring at a later period. The principal gangue is quartz which has apparently replaced the limestone to a greater or less extent, and the latter in many places is sufficiently mineralized to constitute ore. The ore was primarily a sulphide, but has been extensively oxidized to the lowest level now exploited; the minerals are azurite, malachite, chrysocolla, and chalcopyrite in a gangue of quartz and calcite. There are four main shoots which have been partially developed.[1]

[1] Personal communication from Mr. L. B. Reynolds.

In the shaft workings the north shoot (Fig. 6) is 60 feet long and over 140 feet high. It commences 60 feet below the shaft collar and extends below the 200 foot level. It varies in thickness from 1 inch to 4 feet. On and below the 150 foot level a band of crystalline limestone from 2 to 10 feet thick forms the hanging-wall. The ore is all oxidized and shipments gave 5½ per cent of copper, 0·21 ounces of gold, and 2·1 ounces of silver per ton. The south shoot has been opened on all levels and sulphide ore begins to appear on the 200 foot level. On the 150 foot level the shoot is 50 feet long and 2 feet thick, and averages 6 per cent copper, 0·2 ounce of gold, and 2 ounces of silver per ton.

On the level of the tunnel the first shoot occurs at the junction of the cross-cut and drift (Fig. 5A). It has been developed in two sections, the one north of the cave being 30 feet long and up to 13 feet in thickness, while south of the cave it is 20 feet long and 3 feet thick. The ore averages 5 per cent copper, $2 in gold, and $1.50 in silver per ton. The main shoot on the tunnel level (Fig. 5B) is 300 feet long and averages 25 inches in thickness. The ore occurs in mineralized limestone and in quartz, and, therefore, both calcareous and siliceous types are present. The oxidized calcareous ore ranges from 5½ to 6 per cent of copper, $2 to $3 in gold, and from 2 to 9 ounces of silver per ton. The siliceous ore, partially oxidized but containing some sulphide ore, gives 2½ per cent of copper, $1 in gold, and 13 ounces of silver per ton.

The Queen Victoria Mine.—The Queen Victoria mine, owned by John Swedberg, is situated at Beasley on the Canadian Pacific railway, 7 miles west of Nelson, at an altitude of 1,050 feet above the track.

The mine is connected with the ore bunkers at the track by an aerial tram about 2,800 feet long. The development consists of a series of open quarries and three short tunnels cross-cutting the mineral zone. The zone is composed of bands of garnet and epidote alternating with bands of quartz mica and chlorite schists. The bands vary in thickness from a few inches to 50 or more feet, and have been developed along their strike for about 500 feet. The general strike is N. 82° E., but in its western extension curves and strikes N. 65° W. The dips are respectively north and northeast, varying from 25 to 60 degrees. Faulting with small vertical throws occurs along planes varying in direction from N. 15° W. to N. 25° W., and is accompanied by shearing and slickensiding. The bands of epidote, garnet, etc., represent a replacement of limestone near a contact with the granodiorite and are similar in origin to the mineralized zones containing low grade ores which occur in the Boundary district. The mineralized zone here represents a lens-like patch probably 2,000 feet long and a few hundred feet wide composed primarily and chiefly of calcareous rocks of the Rossland volcanic group. The zone is cut by basic hornblende dykes. The ore is low grade, too low for shipping at present prices of copper. It consists of pyrite, chalcopyrite, small amounts of magnetite and pyrrhotite in a gangue composed of garnet (andradite), epidote, actinolite, quartz, and calcite. The ore also contains nickel and cobalt, an analysis giving 0·41 per cent of nickel and a trace of cobalt.[1]

The production to date amounts to 6,189 tons, the metal content being: gold 49 ounces, silver 3,947 ounces, copper 263,409 pounds, with a total gross value of $49,771.

Silver-Copper Deposits.

The Kootenay Bonanza Mines, Limited.—The above Company owns a group of about 40 claims situated on the slopes of Toad mountain. It includes the Hall Mining and Smelting Company, the Dandy and Ollie Consolidated, the Starlight

[1]Geol. Sur., Can., Vol. ix, 1896, p. 39 R.

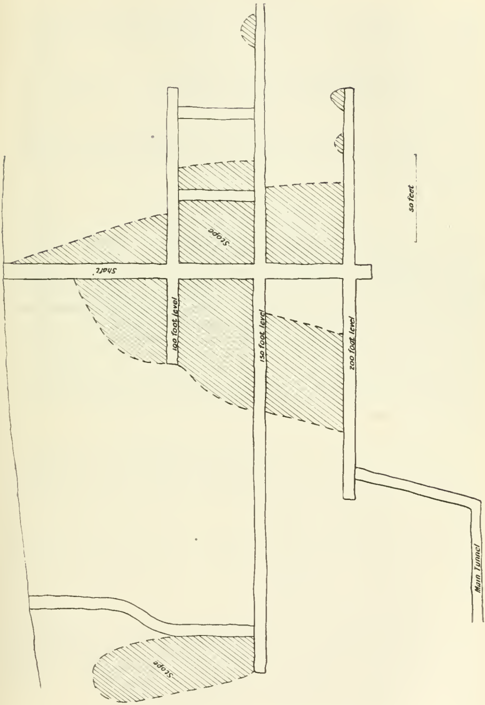


Fig. 6.—Eureka mine. Stope plan.

mines, the Kootenay Development Syndicate, and several smaller groups. This consolidation was effected by Mr. R. S. Lennie in 1910. The Silver King mine is the oldest and best known of the whole group. It is situated on Toad mountain, about 8 miles by wagon road from Nelson, and at an altitude of about 4,200 feet above Kootenay lake.

The Provincial Mineralogist has kindly furnished the following information taken from the annual official returns which show that the production to the end of 1910 amounts to 198,650 tons, containing 3,614,762 ounces of silver and 13,140,005 pounds of copper.

The mine has been developed by open-cuts, four tunnels (Nos. 1, 3, 4, and 5), with a main shaft from the level of No. 5 to the 10th level, giving a total vertical depth on the lode of 927 feet. From No. 8 level to the surface the several levels are connected by stopes and raises. As the mine was idle last season only the surface openings were examined.

There are two approximately parallel lodes, named, respectively, the main and the south vein, with a cross-vein between the 5th and 6th levels. The latter is higher in silver and lower in copper than the main lode. The country rocks consist of chlorite and sericite schists, being the sheared equivalents of hornblende porphyrite and quartz porphyry, cut by later hornblende and mica dykes. The lodes practically coincide with the schists in strike and dip. The strike of the main lode is N. 65° W. with a southwest dip varying from 55 to 70 degrees. The lodes are mineralized portions of the above schists, caused by a very complete system of cross-fissures now filled with quartz and ore. From examples seen last season the ore appears more concentrated along the fissures and gradually diminishes on passing away from them. They occur at such short intervals, however, that the metallics are sufficiently disseminated throughout to form continuous stoping ground over considerable distances. The importance of the cross-fissures was noted in the early development, as evidenced by a statement that the ore shoots crossed the lode at right angles.

The stope plan of the mine shows that the main lode has been stoped from the surface to the sill of No. 5 level (Fig. 1), and the south lode from No. 5 to the level of No. 8.

The length of the ore bodies along the pitch of 40 degrees to the east is about 730 feet, and they were stated to average 12 feet in thickness in the upper levels.

The ore consists of tetrahedrite (grey copper), chalcopyrite, pyrite, and galena disseminated through the schists and associated with quartz and calcite. The concentration of tetrahedrite at several points in the main ore-body furnished very high grade and profitable stoping ground. Bornite and occasionally stromeyerite occurred in the superficial portions.

Ore from the south lode is now being subjected to experimental tests in England. If a satisfactory solution is evolved there appears to be every indication of a large tonnage of low grade ore available for stoping. In the further development and prospecting of these low grade ore-bodies, it is by no means improbable that smaller shoots of high grade ore will be discovered.

The Dandy belongs to the same group and the claim covers the western extension of the Silver King's lode. The lowest tunnel of the Dandy is about 240 feet below the level of No. 5 of the Silver King. A limited amount of stoping has been done above the level at and east of the intersection of the cross-cut and drift. The lode averages 4½ feet in thickness and is no doubt the continuation of one of the lodes of the King. The ore consisted of chalcopyrite, pyrite, galena, some zinc blende with a gangue of schist, quartz, calcite, and some siderite.

Non-Metallic Deposits.

Fluorite.—A deposit of fluorite occurs at Fivemile point just east of Troup junction, and has been opened up by a drift tunnel about 80 feet long. The country rock is granite porphyry, the vein occupying a fissure in the sheared rock. It strikes N. 60° W. and with a dip to the northeast varying from 55 to 90 degrees. The filling is largely crushed granite and gouge, having a maximum thickness of 43 inches.

A band of bluish and purplish fluorite, with a maximum thickness of 14 inches, occurs along and near the foot-wall, and smaller parallel streaks lie in the central and hanging-wall portions of the vein. Other streaks of a light grey dense siliceous material have a similar occurrence. An analysis of the latter by Mr. R. A. A. Johnston gave silica 91·28, alumina 6·16, and water 2·26. These streaks are apparently quartz containing a little kaolin from the crushed granite. Vuggs up to a foot or more in diameter with concentric banded borders are common in the fluorite bands. Barite in minute crystals and aggregates is found in some of the vuggs deposited on the fluorite.

Quarries.

Two quarries are being operated at present by the Canadian Pacific railway, one 2 miles west of Nelson and one 2½ miles east of Nelson, both being adjacent to the railway tracks. The rock is a light grey to almost white granite or granodiorite, medium to coarse-grained with approximately vertical and horizontal joint planes permitting large blocks to be quarried. The stone is used entirely by the railway for culverts and bridges.

RECONNAISSANCE IN EAST KOOTENAY.

(*S. J. Schofield.*)

Introduction.

During the field season of 1911, geological investigation was pursued in an area to the southwest of Cranbrook, B.C., enclosed by 49° 18′ and 49° 30′ north latitude and 115° 45′ and 116° 30′ west longitude. In addition, a geological examination was made of the section across the Purcell range along the Crows Nest branch of the Canadian Pacific railway from Wardner to Sirdar. McEvoy's topographical map of East Kootenay was used as a base in detailing the geological boundaries. Mr. L. E. Wright again ably assisted in the work.

Summary and Conclusions.

The region is underlain by a huge thickness of sedimentary rocks, the Purcell series of Cambrian or Pre-Cambrian age, intruded by numerous sills of diorite and small cross-cutting bodies of granite and granite porphyry. Mountain building forces, acting probably in post-Jurassic time, folded the sediments into a series of anticlines and synclines trending for the most part in a northerly direction. Normal faulting followed, the faults having a northeast-southwest strike. Thus the strike of the fault blocks in the Purcell range is at right angles to that of the Rocky mountains to the east, which have a northwest-southeast trend. An area of Carboniferous limestones occupies the Kootenay River valley or Rocky Mountain trench in the neighbourhood of Wardner. This is interpreted as a down-faulted block of Mississippian limestone in contact on the east and west with the Purcell series which is Cambrian or Pre-Cambrian in age. Hence the Kootenay valley in this region is a "graben." The presence of this limestone supports the idea that Carboniferous rocks once were present in the Purcell range and have since been removed by erosion.

The silver lead deposits of commercial importance were found, as was the case last year, to be confined to the younger members of a formation, which in previous reports on this area, has been called the Kitchener formation. In these ore deposits the pay-chutes are, in general, restricted to the massive and purer quartzites. Where the vein traverses the thinner, more argillaceous members, it is barren or filled with quartz containing small quantities of iron and copper sulphides. The members of the above sedimentary formation favourable for the deposition of silver-lead ores occur in greater abundance near the top of the formation, but are also present to some extent throughout its whole thickness.

General Geology.

The great thickness and the homogeneous character of the sediments of the Purcell series have rendered difficult the attempt to correlate this series in East Kootenay with the apparently analagous series of the Boundary belt, although the two regions are in close proximity.

TABULAR DESCRIPTION OF FORMATIONS.

Pleistocene and Recent	Unconsolidated gravels and sands.
Jurassic ?	Dyke intrusion ; aplite, lamprophyre and granite porphyry. Granite intrusion ; granite, granite porphyry.
Carboniferous— Mississippic	Wardner limestone.
Cambrian ? Purcell Series	(c) Thin-bedded grey to chocolate brown argillites and sandy shales with some quartzites and conglomerates. Thin bedded lava flows occur at various horizons. Estimated thickness 10,000 feet. (b) Light grey argillaceous quartzites and purer quartzites, estimated thickness 9,000 feet. (a) Rusty weathering heavy and thin bedded argillaceous quartzites, purer quartzites and slates. Numerous sills of gabbro occur at various horizons. Estimated thickness, 6,000 feet.

PURCELL SERIES.

The oldest member of the Purcell series in East Kootenay consists of an alternating series of heavy-bedded and thin-bedded argillaceous quartzites and purer quartzites. The massive members are coarser in texture and grey to black on fresh fracture, and weather for the most part in grey tones, while the thinner-bedded, more argillaceous members, are a very dark grey on fresh fracture and weather a rusty brown, and being in great abundance, give the formation its typical rusty-red colour as a whole. This formation also contains the greater number of diorite sills and is the most favourable for ore deposition.

In the previous summary reports for 1909 and 1910,[1] the oldest member, as described this year, was correlated with the Kitchener, the succeeding member with the Creston, and the youngest member with the Moyie. This correlation was based solely on lithological characters, for the stratigraphic relations were obscured by heavy faulting and folding of the strata. In the lack of direct evidence to the contrary, the stratigraphical succession was supposed to be the same as found by R. A. Daly[2] along the International Boundary, *i.e.*, in ascending order, Creston, Kitchener, Moyie. This year a favourable section was found in which the strata were seen in their true relations. At this locality, the section, if the assumed correlation held true, was determined to be in ascending order, Kitchener, Creston, and Moyie.

As the stratigraphic succession in the Cranbrook map-area apparently does not correspond with that of Daly along the International Boundary, the term Kitchener has, therefore, been dropped from that pre-Creston formation in the former area. The Creston formation, however, appears to be identical in both areas, and there are no data yet available that would change the position of the Moyie. The three formations of the Cranbrook sheet in ascending order are pre-Creston, Creston, Moyie.

Lying conformably on the above series of rusty-weathering argillaceous quartzites, and passing into it by gradual transition, occurs a series of light grey argillaceous quartzites and purer quartzites, which is, on the whole, more massive than the older formation. The heavy massive beds are often separated by thin bands of argillite. The staple rock in this series is generally light grey on fresh fracture, and because it weathers grey it gives the whole formation a greyish-white appearance which is very distinctive in the field. This formation is correlated with the Creston formation of the Boundary Survey.

This series of grey weathering quartzites gradually passes upwards into a series of thin-bedded argillites and sandy shales with a few interbedded argillaceous quartzites and conglomerates. The shales are grey to chocolate-brown in colour, and hold abundant shallow water indications such as mud-cracks and ripple-marks. Litho-

[1] G.S.C. Summary Report, 1909, pp. 135-138.
G.S.C. " " 1910, pp. 130-134.
[2] Summary Report, Geol. Surv., Canada, 1904, pp. 91 A-100 A.

logically this group resembles the Moyie formation of the Boundary Survey, but does not correspond to it in stratigraphical position, since along the International Boundary the Kitchener formation intervenes between the Creston and Moyie.

Purcell Sill Intrusion.

The Purcell sills occur as tabular intrusive masses in the Purcell series, and are particularly numerous in the oldest subdivision of the series. They vary from a few feet in thickness in the area examined. The rock types vary from a very acid granite to a hypersthene gabbro, and the relations of these types are now under investigation.

Dyke Intrusives.

Small aplitic and lamprophyric dykes are associated with the Purcell sills.

WARDNER LIMESTONE.

Down-faulted against the Purcell series in the Kootenay valley, in the neighbourhood of Wardner, is a block of limestone, Mississippian in age. It is mostly grey in colour, weathers a greyish-white and contains the following fossils, identified by Dr. E. Raymond.

Camarophoria explanata, (McChesney),
Leiorhynchus, sp. ind.
Camarotœchia cf. *C. metallica*, (White).
Composita madisonensis, (Girty),
Cleiothyndina crassicardinalis, (White),
Spirifer cf. *S. centronatus*, (Winchell),
Productella cooperensis, (Swallow).

Granite Intrusion.

Numerous small bodies of granite cut the Purcell series, but in no place was the granite found in contact with the Wardner limestone. The granite is lithologically similar to the Nelson granite and can probably be correlated with it.

Dyke Intrusives.

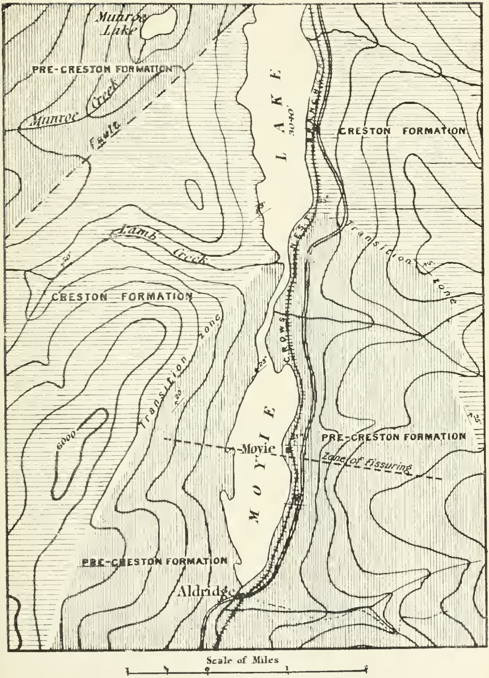
Cutting the granite and occurring as apophyses in the sediments are numerous small dykes of aplite and granite porphyry.

PLEISTOCENE DEPOSITS.

Covering the valley floors of all the master streams are deep deposits of stratified clays, sands, and gravels into which the rivers have entrenched themselves, leaving well-marked terraces along their courses.

ECONOMIC GEOLOGY.

The principal ore-bearing formation in East Kootenay is the oldest member of the Purcell series, called the Kitchener formation in previous reports of East Kootenay. The principal ore-bearing horizon is the upper part of this formation where the heavy-bedded quartzites occur in greater abundance. At this horizon are the Sullivan, North Star, Stemwinder, St. Eugene, Aurora, and Society Girl mines. There are two areas in the region examined which are of special importance, the Moyie and Kimberly districts.



DIAG. 8. Geological and structural relations of two formations of the Purcell series, near Moyie, B.C. Topography by J. McEvoy, 1912. Geology by S. J. Schofield, 1911.

THE MOYIE AREA.

The Moyie area embraces the region around Lower Moyie lake. It is underlain by the Purcell series, which is here folded into a northerly-plunging anticline, whose axial part is made up of the oldest member of the Purcell series, while the radial parts consist of the grey-weathering argillaceous quartzites which lie conformably on the older formation. The field relations of these series and their distribution is shown on the accompanying cut. Crossing this anticline in an easterly direction is a very extensive zone of fissuring which dips about 70 degrees to the south.

There are two main fissures on both the east and west side of Lower Moyie lake, and it is probable that they occur underneath the lake. The general trend of the fissures is shown on the accompanying zinc cut. The walls bounding the main fissures show very little evidence of relative displacement, the greatest movement observed being 18 inches, although in such a homogeneous series of quartzites the detection of such movement might be difficult. In general, the pay-shoots are associated with the massive, purer quartzites which are less aluminous and more capable of forming an open fissure. The purer quartzites are also more easily replaced by the ore solution.

The Aurora Group of Claims.

The Aurora group, operated by the Aurora Mining and Milling Company of Moyie, B.C., consists of five Crown-granted claims—the Aurora, Horse Shoe, Durang, Etna, and Portland, situated on the west side of Lower Moyie lake, opposite Moyie, B.C. The vein occurs on the east and west system of fissuring described in the general description of the district, and possibly on the southern of the two main fissures, which here has a general strike east and west, but varies as much as 15 degrees from this direction. The dip of the vein is 60 degrees to the south. The vein cuts across the oldest subdivision of the Purcell series, which here strikes northeast with a dip of 50° to the northwest.

The formation is made up of thin-bedded argillaceous quartzites (locally called slate) and massive purer quartzites, which here form the western limb of the northerly-plunging anticline described above. The vein has a maximum observed width of 6 feet, and consists of zinc blende and galena with very little gangue. Occasionally fragments of wall-rock are enclosed by the ore. In the report on the zinc resources of British Columbia, the following assay of the ore is quoted: gold. 0·02 ounce; silver, 7·3 ounce; lead, 21·5 per cent; zinc, 33 per cent. The ore, represented in the Aurora is also considered by the same commission to be the simplest to treat of any of the ores examined in their series of experiments.

Development on the property consists of about 1,500 feet of workings, mostly in the form of tunnels. Operations on this property are suspended, for at present there is no demand for zinc ore in British Columbia.

The Guindon Group of Claims.

This group, consisting of the Guindon, Fereole, Alica, and St. Joseph fractions, is located in the territory adjoining the Aurora group to the north. The vein on which these claims are located is about 700 feet north of the Aurora vein and has an east and west strike with a dip of 60° to the south. The formation which the vein traverses is the oldest subdivision of the Purcell series, which here strikes northeast and dips 20° to the south. The vein is from 4 to 5 feet wide, and in one tunnel the ore was 18 inches in width and consisted of galena, zinc blende, and some pyrite. Development work consisted of a few short tunnels.

The Cambrian and Mabelle Claims.

The Cambrian and Mabelle Crown-granted claims, operated by the Cambrian Mining Company, Limited, of Moyie, B.C., embrace the territory between the St. Eugene Consolidated and the Aurora, and thus lie for the most part under the waters of Lower Moyie lake. The extensive zone of fissuring described in the general statement, and which occurs on both sides of the lake, is to be expected to occur in the intervening territory, and as the veins are mineralized in the St. Eugene Consolidated and in the Aurora, it is logical to expect that the Cambrian and Mabelle claims will also be productive. The sounding of the lake on the Cambrian and Mabelle claims revealed the maximum depth of water to be 140 feet, and in addition 90 feet of blue clay and hard-pan covers the bottom of the lake. This last information was supplied by Chas. A. MacKay, of Moyie, B.C., one of the directors of the Company.

St. Eugene Consolidated Mining Company.

The claims operated by this Company comprise an area of 520 acres, situated on the east side of Lower Moyie lake. The property contains two veins, having a general strike east and west with a dip of 70° to the south. The two veins are 600 feet apart on the 1,000 foot level, which is 1,000 feet above the level of the lake. They apparently converge downwards and to the west. Connecting the two main veins, at variable distances apart, is a series of important cross-veins, which meet the main veins, in general, at a small angle. Locally these cross-fissures are termed "avenues." The ore bodies are mainly confined to the fractured and folded area between the main veins, and in places large ore-chutes occur where the avenues meet the main veins, or close to this junction. Very little displacement was noticed along the main fissures, although slight folding or bending of the strata occurs in close proximity to these fissures. The country rocks consist of argillaceous quartzites, and purer heavy-bedded quartzites of the pre-Creston, the oldest subdivision of the Purcell series, which here form the axis and eastern limb of the anticline described above. The ore-bodies are associated with the massive purer quartzites of the above formation. The ore consists of galena, both fine and coarse-grained, associated in places with zinc blende. The gangue, which is small in amount, consists of garnet, anthophyllite (a variety of amphibole), and a little quartz, the latter mineral being very prominent where the vein pinches in the argillaceous quartzites. Locally the wall-rock in the immediate vicinity of the ore-bodies shows strong metamorphism in the development of garnet and anthophyllite.

The Society Girl.

This group comprises seven Crown-granted claims operated by the Society Girl Mining Company, Limited. They are situated about 2 miles east of Moyie at an elevation of about 5,000 feet, and adjoin the eastern boundary of the St. Eugene Consolidated. The formation, in which the deposit occurs, is the oldest known subdivision of the Purcell series, which here strikes north and south with a dip of 25° to the east and forms the eastern limb of the anticline described above. The vein, where examined, strikes N. 60° W. with a dip of 60° to the south, and appears to be in the great zone of fissuring which traverses the Moyie area. The vein is narrow where it traverses the thin-bedded argillaceous quartzites and widens out in the heavier-bedded quartzites.

The upper workings expose an oxidized ore-body consisting of cerussite and pyromorphite, both massive and in beautiful crystals. The pyromorphite is a yellowish green in colour and has been described both crystallographically and chemically by Bowles.[1] He gives the composition as $Pb_5\,Cl\,(PO_4)_3$.

The cerussite is white to colourless and occurs in tabular orthorhombic crystals either singly or as penetration twins. Massive cerussite is also present. The cerussite is often embedded in dense masses of limonite. The oxidized ore-zone is a rare occurrence in East Kootenay. The unoxidized or primary ore, consisting of galena and zinc blende with little or no gangue, is exposed in the lower tunnel which penetrates the ore-body 250 feet below the surface. At present the ore is hand-sorted and then sent to the smelter at Trail for treatment. For the year 1911 up to the end of September, the total output of the mine amounted to about 400 tons. The galena carries 1 ounce of silver to 4 per cent lead, while the oxidized ores carry 1 ounce silver to 5½ per cent of lead.

THE KIMBERLEY AREA.

The area is situated near Kimberley, the terminus of the Canadian Pacific Railway branch line from Cranbrook to Kimberley, and includes the Sullivan, Stemwinder, North Star, and several minor properties. It is underlain by a series of argillaceous quartzites and purer heavy-bedded quartzites, which are identical in lithological and physical characters with those described in the Moyie district, and hence belong to the lowest known subdivision of the Purcell series. About one-half mile above Kimberley, on Mark creek, a few diorite sills are exposed in the valley walls.

Sullivan Group.

This group was discovered in 1895, and is located on Sullivan hill about 2½ miles by road north of Kimberley, at an elevation of about 4,600 feet above sea-level. The deposit lies in the lowest known subdivision of the Purcell series, which here strike about north and dip from 10° to 60° to the east. The country rocks consist of thin-bedded argillaceous quartzites and heavy-bedded, purer quartzites. The ore-body conforms in dip and strike with the quartzites and cannot be called a true fissure vein, but a replacement deposit in which the sulphides have replaced the fine-grained quartzites. The hanging and foot-walls are, in general, not well defined, but the ore gradually passes into the normal country rocks so that the distinction between country rock and ore is commercial rather than structural. Exceptions to this occur where the walls consist of the thin-bedded slaty quartzites which are evidently difficult to replace. In the upper workings, close-folding later than the ore deposition increases the apparent width of the deposit. On the 60 foot level the dip of the ore-body in places approximates 25°, and on the 100 foot level the dip increases to 70°, which is also the dip of the surrounding quartzites. As far as exploited, the maximum stope width is 120 feet and the maximum stope length 325 feet. There are nine levels, the deepest being 100 feet below the surface. The deposit is a lens-shaped mass striking about north and south with a dip to the east.

The ore-body is arranged in distinct zones which grade imperceptibly into each other. The centre of the body is occupied by a fine-grained mixture of galena and zinc blende in which masses of purer galena occur as lenses. The gangue in this inner zone is absent, except for a few well-formed crystals of pink garnets. This inner portion gradually passes exteriorly into a fine-grained mixture of pyrite, pyrrhotite, and zinc blende which contains as a gangue numerous crystals of a clear colourless garnet with some grains of anthophyllite and possibly diopside. The sulphides gradually diminish in amount and finally give way to a fine-grained chert which is present where the country rock is a heavy-bedded, purer quartzite, and is absent where a more argillaceous slaty member constitutes the wall-rock. No garnets

[1] Am. Jour. Sci., 4th Series, Vol. XXVIII, p. 40.

or anthophyllite are present in this zone. The chert gradually passes into the normal quartzite. The contact minerals occur only in the ore-body and are entirely lacking in the country rock surrounding the deposit. The presence of the minerals, garnet, and diopside, so characteristic of contact deposits, is not due to any intrusion of igneous material at present visible, for the nearest outcrop of granite is 4 miles away, near Wycliffe, on the St. Mary prairie. The presence of the minerals, garnet, pyroxene, and pyrrhotite warrants the conclusion that the Sullivan ore-body was formed under conditions of high temperature and pressure, and in origin was connected with some deep-seated intrusion of granite which has not yet been exposed by erosion in the neighbourhood of the Sullivan mine. The Stemwinder property, occurring in Mark creek and apparently in a lower horizon than the Sullivan, indicates that ore-bodies might be expected below the Sullivan deposit.

The ore is shipped to Trail for treatment and is melted without any preliminary concentration.

Development and constructional work is being rapidly pursued and a force of 100 men is employed.

The Stemwinder.

The Stemwinder is situated about 1 mile northwest of Kimberley on Mark creek. The country rocks consist of argillaceous quartzites intruded by several sills of diorite. The ore-body is enclosed entirely by the quartzites and closely resembles the Sullivan deposit in its occurrence and mineralogy. The interior of the ore-body consists of a fine-grained mixture of galena and zinc blende passing exteriorly into a fine-grained mixture of pyrrhotite, pyrite, and zinc blende. This is succeeded by a cherty layer which in turn passes into normal quartzite. The amount of development so far accomplished was not sufficient to expose the relation of the ore-body, but it is evidently of large size. Three short tunnels and a shaft 75 feet deep open up the deposit. Experiments are in progress to determine the best methods for the treatment of this refractory ore.

RECONNAISSANCE OF THE SHUSWAP LAKES AND VICINITY (SOUTH-CENTRAL BRITISH COLUMBIA).

(*Reginald A. Daly.*)

Introduction.

The writer spent most of the season in a partial reconnaissance of the area (6,400 square miles) covered by the Shuswap sheet, which was engraved for the Survey in 1898 (Publication No. 604). That sheet was geologically coloured by George M. Dawson, who had combined the results of his own field work with that performed by McEvoy in his many arduous traverses of this district. No detailed report to accompany the map-sheet has been published. One object of the 1911 season was to collect facts which can be used in the future preparation of such a report.

The work was also planned to be part of that required in the development of a geological map and section, which is to extend along the main line of the Canadian Pacific railway from the Great Plains to the Pacific ocean. In connexion with the latter project the writer made traverses along the railway eastward and westward from the respective limits of the Shuswap sheet. The total length of the railway section traversed is 200 miles, extending from the summit of the Selkirks to the western end of Kamloops lake. Additional field work is required in the stretch from Revelstoke eastward; the structure section actually completed is 150 miles long, and lies between Revelstoke on the Columbia river and Savona on Kamloops lake.

The most important problems of the region concern the composition, structure, and stratigraphic relations of the Pre-Cambrian rocks, which cover a large part of the area mapped in the Shuswap sheet. A considerable part of the season was spent in an examination of the shores of the Shuswap lakes and of Adams lake, which occupy deep valleys sunk in the Pre-Cambrian terrane. Rock outcrops are there much more abundant than on the adjacent, densely-wooded mountains. Outside the railway section, about 200 miles of lake-shore traverse were run.

In the field the writer was efficiently assisted by Mr. N. L. Bowen.

Synopsis of Conclusions.

The results which seem to be established are the following:—

(1.) Dawson's "Niskonlith series," outcropping in his original section across the Selkirk mountains, is not of Cambrian age as now defined, but represents the northern continuation of the "Beltian"[1] (pre-Olenellus part of the Belt terrane) rocks at the International Boundary. As suggested by Dawson, these rocks are to be correlated with the pre-Olenellus portion of the Bow River series of the Rocky mountains.

(2.) The "Niskonlith series," mapped in the Shuswap sheet area, is an entirely different, pre-Beltian as well as pre-Cambrian, group of sediments, which unconformably underlie the "Niskonlith series" of the Selkirk section.

(3.) The "Adams Lake series (volcanic)" which conformably overlies the thick limestones of Dawson's "Niskonlith series" of the Shuswap Lakes area, is also of pre-Beltian age.

(4.) The "Shuswap series" of the Shuswap lakes is not a distinct gneissic group unconformably underlying the "Niskonlith" sediments, but is the facies of those

[1] Systemic name suggested by C. D. Walcott in Smithsonian Miscellaneous Collections, Vol. 53, 1908, p. 169.

sediments where thermally metamorphosed and injected by pre-Beltian granites.

(5.) Since the sediments of the "Shuswap series" and "Niskonlith series" and the basic volcanics of the "Adams Lake series" (as mapped by Dawson) are conformable throughout, it is proposed that the definition of "Shuswap series" be so enlarged that it shall include all these pre-Beltian rocks.

(6.) Though this Shuswap series is everywhere composed of typical crystalline schists (with crystalline limestones and quartzites), their regional metamorphism was not due to dynamic action. The writer agrees with Dawson in holding that this metamorphism was "static"; the stress directing the recrystallization was induced by deep burial and dead-weight.

(7.) The Pre-Cambrian rocks are much less deformed (upturned) than the overlying Carboniferous or Triassic rocks. This fact illustrates the small depth of the earth-shell which underwent strong folding in post-Cambrian time.

(8.) The petrography of the pre-Beltian terrane (Shuswap series and granitic intrusions) strongly suggests that it furnished the greater part of the clastic material in the Rocky Mountain geosynclinal prism.

(9.) The observations regarding the post-Cambrian formations of the region studied, tend to confirm Dawson's conclusions, except that the Tertiary lavas and interbedded fresh-water sediments are believed to be of Oligocene age, rather than Miocene, as indicated on the engraved Shuswap and Kamloops sheets.

TABLE OF FORMATIONS.

The principal object of the summer's work was to collect facts bearing on the stratigraphy of the region. The results are definite as to the general succession of the rock formations. The following table, which bears some provisional names, gives the sequence actually determined.

Pleistocene	Thompson River silts. Glacial drift.	
	—Unconformity—	
Oligocene	Basic lava sand fresh-water sediments.	
	—Unconformity—	
Probably late Jurassic	Granite batholiths cutting the Nicola series.	
Triassic (and Jurassic?)	Nicola series: basic lavas, with ash-beds, sandstones, argillites, and rare limestone lenses.	
	—Unconformity—	
Carboniferous	Limestones, cherty quartzites, argillites, and basic volcanics.	
	—Unconformity—	
Cambrian (?)	Glacier quartzite division.	Selkirk series.
"Beltian" (Pre-Cambrian)	Albert Canyon division: argillities, carbonaceous limestones and quartzites.	
	—Unconformity—	
Pre-"Beltian" (Pre-Cambrian)	Granite batholiths, sills, and dykes, cutting the Shuswap series. Shuswap series: limestones, metargillites (phyllites), mica schists, paragneisses, green schists, and greenstone.	

SHUSWAP SERIES.

COMPOSITION.

The oldest rocks form a composite mass, which is known to be of very great thickness, though neither base nor top has been discovered. On the shores of Shuswap lake, from Sicamous to Cinnemousun narrows, a section was run, the statement of which will give an idea of the magnitude of this most ancient terrane yet recognized in British Columbia.

		Approximate thickness in feet.
	Top of series not exposed.	
	Green schists	2,000+
	Cinnemousun limestone	600
	Green schists	1,000
	Phyllites	800
	Limestone with phyllitic interbeds	1,000
	Phyllites	600
	Green schists	6,000±
	Phyllitic schists	6,500+
	Sicamous limestone (phyllitic and carbonaceous)	3,200
	Phyllite	300
Thermally metamorphosed	Coarse mica schists	1,500+
	Massive calcareous quartzites with interbeds of mica schists	3,000+
	Base concealed.	
	Total	26,500+

On Adams lake, green schists, corresponding in general horizon to those noted at the top of this column, are overlain by at least 2,000 feet of phyllitic schists. These are overlain, in ascending order, by 1,600 feet of massive limestone (marble), 800 feet of phyllite, 1,500 feet of phyllitic limestone, and an enormous mass of greenstone, with an apparent thickness of at least 10,000 feet. This greenstone is truncated by a large Pre-Cambrian batholith. The schistose rocks on Adams lake may be largely the same as those on Shuswap lake, being repeated in outcrop by normal faulting.

RE-DEFINITION OF "SHUSWAP SERIES."

With the exception of the Sicamous limestone and the underlying formations, all of these rocks on both Shuswap and Adams lakes were mapped by Dawson as belonging to his (Cambrian) "Adams Lake series." He mapped the Sicamous limestone under the name, "Niskonlith series," and regarded it as likewise Cambrian in age.

The writer has been forced to different conclusions, which are based on studies more detailed than Dawson could make during his reconnaissance. Many other sections, besides those above noted, show that there is apparently perfect conformity throughout the whole series, from the lowest schists and quartzites to the top of the thick greenstone on Adams lake. All these rocks are not only Pre-Cambrian, but are also pre-"Beltian," to adopt Walcott's suggestion of a period name covering the time occupied in the deposition of the "Belt Terrane" sediments, of pre-Olenellus age.

Wherever exposed, the lower beds of this great series are intensely metamorphosed by batholiths of biotite granite or hornblende-biotite granite. At the roof or walls of each batholith the magma was forced into the highly fissile sediments, forming sills in such number and of such persistence as had never before been encountered in the writer's experience. The sills are often composed of the normal batholithic granite, but vast numbers of them are aplitic or pegmatitic. Very numerous dykes of similarly varying composition are likewise apophysal from the great magma chambers.

The thermal metamorphism of the sediments is roughly proportional to the number of these satellitic injections. The metargillites or phyllites have been converted into coarse, glittering muscovite-biotite schists or paragneisses; the calcareous beds into marbles, coarse crystalline limestones, or masses of lime-silicates. It was to these coarsely crystalline phases of the sediments, together with the intrusive sills, that Dawson originally gave the name "Shuswap series." At first he regarded the granite as in part the fused equivalent of these same sediments, but later became more and more convinced of its eruptive nature.

In view of the perfect conformity which seems to exist throughout the sediments and greenstones, the writer proposes that the name "Shuswap series" be extended to cover this whole group, together with any additional rocks which, in the future, may be found conformably below or above the formations here described. The "Adams Lake series" may accordingly be called the "Adams Lake greenstone," a member of the Shuswap series. The "Niskonlith series" of the Shuswap Lake region is the Sicamous limestone, another important member.

ORIGIN OF THE GREENSTONES AND GREEN SCHISTS.

Dawson described the "Adams Lake series" as of volcanic origin. The description may be quite correct, but it is a remarkable fact that the present writer has found no clear evidence of an extrusive origin for greenstone or green schist, either in the field or in the study of many microscopic sections. Traces of porphyritic and granular structure have been found, but not one undoubted relic of pyroclastic, amygdaloid, or lava flow. It is certain only that the greenstones and green schists have been derived from highly uniform masses of basic eruptive rock, of basaltic, diabasic, or gabbroid composition. So far as the study has progressed, the writer is inclined to believe that some, perhaps much, of the greenstone is intrusive, as sills or irregular masses. Probably, however, the larger part is of extrusive origin.

STATIC METAMORPHISM.

The difficulty in finding the exact origin of the green rocks is explained by their unsually thorough metamorphism; they are now chloritic and talc schists. Their fissility is usually extreme, so that it was often hard to secure a convenient specimen thick enough for thin-sectioning. Drastic recrystallization has also affected the sediments at every observed horizon. The effect has been to develop typical crystalline schists, indistinguishable from those so often produced in zones of intense deformation.

Yet it is clear that the general or regional metamorphism of the Shuswap series is not of dynamic origin. The full proof of this conclusion cannot be given in a summary report, but a few pertinent facts may be stated. With rare exceptions, bedding and schistosity are parallel in the Shuswap sediments. The average dip for an area of at least 800 square miles is very probably less than 45°. For several miles together, in well exposed areas, the dip ranges from 10° to 25°, while elsewhere the schistose sediments may be practically horizontal for considerable areas. In this case it is not possible to explain the low dips as those expected in a series of blocks dynamically metamorphosed by tangential thrust and then overthrown to recumbent positions. The crystallinity of the rock generally bears no relation to the angle of dip. The writer finds most satisfaction in adopting Dawson's view that the regional metamorphism is here simply due to deep burial under Pre-Cambrian sediments or volcanics. Deep burial of a surface rock means a raising of its temperature and, so long as the rock remains solid, it must undergo gravitational "stress." Recrystallization with the development of schistosity is hastened by the presence of water or other solvents. Since the lower beds of a great geosynclinal prism are nearly or quite horizontal, the dead-weight "stress" must produce schistosity sensibly parallel to the planes of stratification. This recrystallization is regional but is not connected with rock shearing as in the well-recognized type of dynamic metamorphism. Milch has given the name "*Belastungsmetamorphismus*" to such recrystallization under dead-weight stress. Probably Judd's word "static" is the best descriptive term in English.

Metamorphism of this kind is recorded in the flat schistosity of great areas of Pre-Cambrian rocks in the International Boundary section, in eastern Canada, in Greenland, in the German Grundgebirge, etc. The fact that it is not prominent anywhere in the relatively young Mesozoic geosynclinals, even 5 or 6 miles deep, suggests that possibly the earth's temperature gradient was steeper in the Pre-Cambrian than it has been in more recent time.

Locally superposed on the schistosity due to static metamorphism is that later produced, in certain zones, by dynamic metamorphism. The two are often easily distinguished in the field, and both can generally be distinguished from the primarily thermal metamorphism near the batholith contacts. In this field static metamorphism clearly dominates over the other two kinds.

STRUCTURE OF THE SHUSWAP TERRANE.

Apart from local crumplings, systematic folding is extremely rare in this older Pre-Cambrian complex. The mass seems to have been deformed chiefly by normal faulting. Some of this deformation was already accomplished before the Beltian (Belt series of) sediments were deposited. The average strike of the Shuswap schists runs E.N.E.-W.S.W., that is, nearly at right angles to the N.W.-S.E. trend of the post-Triassic Cordillera. Only quite locally was the rock of the oldest visible terrane upturned so as to exhibit the typical Cordilleran strike.

A second important contrast to the younger formations of the region is implied in a foregoing paragraph. Unlike the Shuswap sediments, the Carboniferous and Triassic rocks almost always dip at high angles. For comparison an estimate was made of the average dips in three typical areas of about 100 square miles each, respectively underlain by Shuswap, Carboniferous, and Triassic rocks. The result is:—

Terrane.	Average Dip.
Shuswap..	20°
Carboniferous..	75°
Triassic..	60°

The conclusion seems to be that the deepest-lying terrane has been the least disturbed of the three; that the late Jurassic, Laramide, and mid-Tertiary folding took place in a relatively thin shell of the earth's crust. There is no evidence that the Pre-Cambrian terrane of the Shuswap area has ever been subjected to intense tangential stress. A similar condition is represented in the structure of the European Alps. Its repeated occurrence enforces belief in the importance of the fact for the general theory of mountain building. The earth-shell here subjected to orogenic folding is only a few miles in depth.

SELKIRK SERIES.

RELATION TO SHUSWAP SERIES.

The basal complex, including the Shuswap sediments and green schists, together with the numerous Pre-Cambrian sills, dykes, and batholiths, became moderately deformed and eroded. East of the Columbia river, at Revelstoke, its eroded surface was depressed and an enormous thickness of stratified rocks was piled upon it. These rocks compose most of the high Selkirks of the present day. Dawson divided them into an older "Niskonlith series" and a younger "Selkirk series," but recognized perfect conformity between the two series.[1] He regarded both series as of Cambrian age, having found unconformity between the "Niskonlith series" and the orthogneisses of the "Shuswap series" at Albert Canyon.

The writer has confirmed Dawson's discovery of that unconformity. Though the exposures of the "Niskonlith series" in the Selkirk range are unusually complete, not a single dyke or sill of aplite or granite could be found in those rocks either at or above the basal unconformity at Albert Canyon. The orthogneiss west of Albert Canyon and immediately below the plane of unconformity, is penetrated by such dykes and sills in great abundance. The Sicamous limestone, described and mapped by

[1] G. M. Dawson. Bulletin, Geological Society of America, Vol. ii, 1891, p. 168; Vol. xii, 1901, p. 66.

Dawson as the typical "Niskonlith" of the Shuswap lakes, is often traversed by sills and dykes of aplite, pegmatite, and granite (orthogneiss). That fact was apparently overlooked by Dawson in correlating these sediments of the Selkirks with the Sicamous limestone. As already implied, the "Niskonlith series" of the Selkirk range is a younger and quite different group of rocks from that of the "Niskonlith series" mapped in the Shuswap sheet area. This conclusion is sustained by the great lithological contrast of the two series, as well as by their structural relations.

Further, it was found, on the ground, that the name "Niskonlith" cannot be used appropriately for either of the groups of rock to which Dawson attached it. The belt of "Niskonlith" rocks, mapped by Dawson at Niskonlith lake, is narrow and poorly exposed, but it is almost certainly post-Cambrian in age. In fact, it probably represents the upper part of the Nicola series, and is thus of either Triassic or Jurassic date.

The writer believes it advisable to drop the name "Niskonlith series" as a designation for any of the rocks so named by Dawson.

RE-DEFINITION OF SELKIRK SERIES.

On the other hand, Dawson's "Selkirk series" should also include all the sediments extending from the basal unconformity at Albert canyon to the base of the thick quartzites, which he originally includes in that series. For clearness in the present report, the Selkirk series, as exposed between Albert canyon and Rogers pass at the summit of the Selkirk range, is divided into two parts: the Glacier quartzite division (Dawson's original "Selkirk series") and the underlying Albert Canyon division (Dawson's "Niskonlith series").

A preliminary estimate of the thickness of the Albert Canyon division is 18,000-20,000 feet, or more than the 15,000 feet which Dawson attributed to the "Niskonlith series." The basal member is not a conglomerate, but a quartzitic sandstone or arkose. This member is known to be more than 200 feet thick. Above it lies a vast thickness of argillaceous rock with subordinate interbeds of carbonaceous limestone and quartzite. These rocks have been statically metamorphosed and are now micaceous or phyllitic in largest part (metargillites, micaceous quartzites and limestones). They form a gigantic monocline of dark grey beds, dipping conformably under the white to light grey quartzites so wonderfully exposed around Glacier House.

The writer believes that Dawson's estimate of 25,000 feet for the thickness of those quartzites is justified as to order of magnitude, though the youngest beds were seen, this season, only at a distance.

CORRELATION.

No fossils have yet been reported from either division of the Selkirk series. Many lithological and stratigraphical features agree in suggesting that the Albert Canyon division and the lower part of the Glacier division together represent the Pre-Cambrian "belt terrane" of the 49th Parallel section. There is no reason to doubt Dawson's correlation of the upper quartzites of the Selkirk series with the fossiliferous Cambrian rocks of the Rockies; following Dawson, the sediments now grouped as the Albert Canyon division are, for the present, best correlated with the pre-Olenellus portion of the Bow River series.

The new and old correlations of the Pre-Cambrian rocks are shown in the following table.

	Shuswap Lakes Region (Columbia Mountain Range and Interior Plateaus).	Selkirk Range.
	CORRELATION BY DAWSON.	
Cambrian	Adams Lake series	Selkirk series.
Cambrian	Niskonlith series	Niskonlith series.
	—Unconformity—	*—Unconformity—*
Pre-Cambrian (Archæan)	Intrusive granites / Shuswap series	Intrusive granites. / Shuswap series.
	NEW CORRELATION.	
Cambrian (chiefly)	Not known	Glacier division. } Selkirk series
"Beltian"	"	Albert Canyon division ("Niskonlith" of Dawson's Selkirk section). } Selkirk series
	—	*—Unconformity—*
Pre-"Beltian"	Intrusive granites (orthogneisses)	Intrusive granites (orthogneisses).
Pre-"Beltian"	Shuswap series (includes rocks mapped on the Shuswap sheet as "Niskonlith" and "Adams Lake" series)	Shuswap series.

Use of the Term "Algonkian."

Once again the question arises as to the validity of the name "Algonkian." Though the Shuswap series and pre-"Beltian" intrusives form the Pre-Cambrian "Basement Complex" of British Columbia, it is clear that this complex is dominantly sedimentary and that "ordinary stratigraphic methods" can be applied to its elucidation. According to the vague criteria now employed for the separation of "Algonkian" and "Archæan," it becomes necessary to put the exceedingly thick Albert Canyon sediments and the exceedingly thick Shuswap series all in the "Algonkian." The "Algonkian period" thus comes to include the long interval represented in the unconformity at the base of the Albert Canyon strata. Yet this unconformity represents one of the most signal breaks in sedimentation which are registered in the Cordillera. The case is analogous to that in the east, where the "Algonkian" is made to include Keweenawan and Animikie and the underlying, spectacularly unconformable (lower) Huronian. Several influential authors have already placed the "Beltian" in the Algonkian; they must logically include in it also the huge Shuswap series. Is there any essential gain in thus throwing overboard "ordinary stratigraphic methods" in making stratigraphic classification? The writer believes that there is no gain in such procedure, but, on the other hand, that it would entail the certainty of serious, quite unnecessary confusion for future workers in Cordilleran geology.

SOURCE OF CLASTIC MATERIAL IN THE ROCKY MOUNTAIN GEOSYNCLINAL.

During the survey of the Cordilleran belt along the International Boundary, the writer came to the conclusion that the very thick Beltian-Cambrian fragmental rocks (Rocky Mountain geosynclinal) of the Selkirk, Purcell, and Rocky Mountain systems were chiefly derived from a great land-area lying west of the Columbia river at the 49th parallel. During last summer, strong evidence was secured that this ancient terrane was the southern continuation of the actual basal complex (Shuswap sediments and granitic intrusives) of the Shuswap Lakes region. The abundant large grains of microcline and microperthite in the Rocky Mountain geosynclinal are identical in microscopic habit with the feldspars of the extremely numerous, thick sills and dykes of coarse pegmatites cutting the Shuswap series. Most of the quartzites of the geosynclinal are not true sandstones, for their average grain is incomparably smaller than even the finest-grained sand, strictly so called. The geosynclinal quartzites are really consolidated quartz muds, with which essential amounts of minute microperthite and other alkaline feldspars are often mixed. The original quartz grains of these quartzites can be traced to the weathering of just such metargillites, phyllites, and greenstone schists as form colossal masses in the basal complex at the Shuswap lakes. In the thorough weathering of such rocks, the more soluble, finely-divided chlorite, uralite, talc, etc., are carried away in solution, while the relatively insoluble quartz is concentrated and washed into the sea as a highly siliceous mud. The minute particles of alkaline feldspar, also comparatively stable and insoluble, may be considered as having been derived from the simultaneous weathering of sill, dyke, and batholith in the Shuswap-orthogneiss terrane.

Though additional microscopic study of this problem is planned, the writer finds the foregoing explanation of these hitherto puzzling quartzites to be the best yet suggested by the facts. The question is important, as it relates to the origin of at least 20,000 feet of quartzites in the Rocky Mountain geosynclinal. Great as their volume is, there seems to have been ample areal extent and thickness in the older terrane to furnish the requisite amount of siliceous mud.

Carboniferous Formations.

In the Shuswap Lakes area there seems to be no rock formation representative of the "Beltian," Cambrian, Ordovician, Silurian, or Devonian periods; that is, of the long interval during which the Rocky Mountain geosynclinal prism was being deposited. For most of that time the zone of shore-lines may have lain near the present divide of the Columbia Mountain range, west of Revelstoke. In that case, the absence of "Beltian" and older Palaeozoic sediments in the Shuswap region would be explained by failure of deposition. Yet it is quite possible that one or more of the periods mentioned saw deposition in the region and that erosion has since destroyed the sedimentary rocks so formed. Whatever the explanation, the Carboniferous (Pennsylvanian) is the next period known to be actually represented in the rocks of the Shuswap area, after the pre-Beltian granites were intruded into the Shuswap series.

The Carboniferous rocks have been described in detail by Dawson, especially in his Geological Survey report on the Kamloops sheet (1896). In 1911, the present writer began a revision of the complex structural geology of these rocks where mapped in the western part of the Shuswap sheet and the adjacent part of the Kamloops sheet area. Several collections of fossils were made from the thick limestones north of the Thompson river and east of Kamloops. The other chief rock-types of this rock series are noted in the foregoing general table of formations. The lithology and succession were found to be essentially as described by Dawson. The youngest member exposed (Marble Canyon limestone) is capped by an erosion surface, and the base of the Carboniferous is not exposed in any section traversed this season. Hence the whole thickness is unknown, but it is certainly great, and probably well over 10,000 feet.

Nicola Series.

In all, about 25 miles of the railway section was run through the strongly deformed basaltic lavas (porphyrites) and subordinate sediments which Dawson grouped under the name "Nicola series." His description of the general lithology was, here too, found to be admirable; the account given in the Kamloops Sheet report applies well to the Nicola as it outcrops in the area of the Shuswap sheet. The lavas are extraordinarily massive and it is extremely difficult to read out the structure. So far, the writer has been baffled in the attempt to determine the total thickness or the exact succession. It is known, however, that the maximum thickness is greater than 4,000 feet.

The Nicola lavas rest unconformably on the Carboniferous limestone. They are overlain by at least 1,000 feet of hard sandstones and argillites, which are unfossiliferous and are possibly of Jurassic date. Where observed on the South Thompson river, these sediments are truncated by a Mesozoic granite batholith, so that their whole thickness is unknown.

Where discoverable, the dips of the Nicola rocks vary from 30° to 90° and, in this region, probably average more than 50°. The series has been deformed almost as much as the Carboniferous beds.

The writer was much struck with the close similarity of the Nicola rocks to the great mass of the complex Rossland group to the south. It would not be surprising if at least a large part of the latter group should some day be definitely referable to the Triassic.

Mesozoic Batholiths.

Several large masses of biotite granite and hornblende-biotite granite cut the Triassic lavas or the Carboniferous sediments in the vicinity of the Shuswap lakes. These granites are generally somewhat strained but are seldom gneissic. Their field relations, field habit, and petrographic characters suggest that they were intruded at the same time as the great batholiths of the International Boundary belt, which are covered by lower Cretaceous sediments unconformably and are to be referred to the later Jurassic time of batholithic intrusion. It is possible that some of the granitic bodies cutting the Shuswap sediments are of the same age, but the evidence is clear as to the Pre-Cambrian date for nearly all of those intrusions where traversed last season.

Oligocene Formations.

A beginning has been made on the petrographic and structural geology of the Tertiary lavas and interbedded fresh-water sediments, which cover such large areas in the area of the Kamloops and Shuswap sheets. The reader is referred to Dawson's Kamloops report for details. However, it should be pointed out that both the "upper Volcanic group" and the "lower Volcanic group" of Dawson's Kamloops sheet are very probably not Miocene in age, as there coloured, but Oligocene. In the field, the writer came to suspect that these thick basaltic formations were pre-Miocene, the chief reason being the strong upturning which the lavas have suffered. On his return to the east he found corroboration for this view in the palæontological studies of Lambe and Penhallow, who had published material dealing with the Tranquille beds, separating the upper Volcanic and lower Volcanic groups. Their results agreed in showing that the Tranquille beds are Oligocene. The field relations strongly uphold the view that the basalts of both the named groups, which are conformable to, and partly interbedded with, the Tranquille tuffs and sandstones, also date from the Oligocene.

Glaciation.

Routine observations were made on the geology of the Pleistocene formations. The results are essentially like those published by Dawson in his Kamloops report and elsewhere. The imposing silt terraces of the South Thompson river early claimed attention, and the recent observations confirm Dawson's explanation of certain of the silts as deposits in temporary, ice-dammed lakes. The lake in the valley of the South Thompson must have been considerably more than 500 feet deep and at least 20 miles in length. The valley seems to have been dammed above by a large glacier terminating near Shuswap village, and below by a yet greater glacier coming out of the wide valley of the North Thompson. Remarkable deformation of similar silt-beds on the southern shore of Kamloops lake has been produced by an ice-sheet, which occupied that basin in late Pleistocene time and may have been the lower continuation of the North Thompson glacier itself.

Adams lake and, apparently, each of the larger divisions of Shuswap lake, are true rock basins, though Mara arm and Little Shuswap lake have become nearly barred off from the main Shuswap lake by the growing deltas of Eagle river and Adams river respectively. These valleys are fiord-like and the rock-basins doubtless originated in differential glacial erosion.

GEOLOGY OF FIELD MAP-AREA, YOHO PARK, B.C.

(John A. Allan.)

Introduction.

The field season of 1911 was spent in continuing the section begun last season in the Ice River district across the Rocky mountains, along the main line of the Canadian Pacific railway. The topographical map used was that issued in 1909 by the Department of the Interior on that portion of the Rocky mountains. It was enlarged to a scale of 1 mile to 1 inch for field use. The area mapped was about 300 square miles, including that portion examined in 1910. Only a few days were spent in the Ice River district in order to clear up some points of doubt. The whole area thus covered extends from the Continental divide west to Palliser, a distance of about 20 miles, and from the railway at the divide south 24 miles. It lies almost entirely within the Yoho Park. A section has been made across the area along the railway.

The last week of the season was spent in the Van Horne range as far as Mt. Hunter and Mt. King. A reconnaissance trip was made into the Beaverfoot range which is the most western range of the Rockies south of the railway. As it was not possible to use horses in much of the area, travel was necessarily slow.

A close study was made of all the deposits and occurrences of metalliferous and non-metalliferous products within the area. In this work I was most heartily assisted by those interested.

I am particularly grateful to Mr. H. H. Lavery, superintendent, and Mr. J. A. Thomson, manager, Mt. Stephen Mining Syndicate; Mr. R.' Kidney; Mr. Geo. Hunter, Park superintendent; Mr. W. T. Oke, Mr. W. Haygarth, and Mr. M. Dainard; to Mr. Kilpatrick, superintendent, and others of the Canadian Pacific railway for their information, assistance, and courtesy during the two seasons spent there.

Satisfactory and efficient assistance was rendered by Mr. Fred. J. Barlow. His previous acquaintance with the region was a material benefit in the technical work.

Summary and Conclusions.

The area includes a very thick series of sedimentary rocks which ranges in age from lower Cambrian to Silurian. The Cambrian formations and, at least, the basal beds of the Ordovician are conformable upon one another. The softer and more thinly-bedded sediments have been folded and at a later period strongly sheared so that the cleavage planes cut across the previously formed folds. An irregular mass of alkaline magma has been intruded across and between the sediments. The main type of rock is nephelite syenite. The exact age of intrusion cannot be determined, but it is believed to be later than the folding and prior to the final movements which highly sheared the sediments.

Mineralization is wide-spread but the individual occurrences of ore are on a small scale. These small deposits can only be worked profitably when the cost of production and extraction can be reduced to a minimum.

General Character of the District.

The area is extremely rugged and mountainous. The greatest average elevation, which is over 10,000 feet, is reached in the Bow range which forms the Continental watershed. There is a gradual downward slope in the whole system to the Columbia valley, with the exception of a few peaks in the Ottertail range,[1] of which Mt. Goodsir (11,676 feet) is the highest in this part of the Rocky mountains. The general appearance of the Bow range is quite distinct from those to the southwest. It is made up chiefly of heavy-bedded quartzites, limestones, and dolomites, mainly of lower and middle Cambrian age. The beds are lying nearly horizontal, and weather, in large part, into precipitous castellated cliffs which show up an "alcove" form of erosion in certain cliff-forming limestones and dolomites.

In contrast with the general appearance of the Bow range, there is the broad drainage area of the Ottertail valley to the southwest, which is floored by slates, shales, and argillites, all soft, highly cleaved, and weathering readily into rounded-topped ridges and broad talus slopes.

The Ottertail range contains a massive band of limestone which forms a precipitous cliff, frequently 2,000 feet high, along the southeast edge of the Ottertail valley. The broad Beaverfoot valley with a N.W.-S.E. trend, underlain by soft slates and argillites, separates the Beaverfoot range, which is the last range to the west, from the rest of the Mountain system. The Beaverfoot range has a very irregular zigzag summit made up of harder Ordovician and Silurian sediments.

The Van Horne range is the northwest continuation of the Beaverfoot and Ottertail ranges across the Kicking Horse valley.

The Kicking Horse river (Wapta[2]) forms the main traverse westward drainage of this portion of the Rocky mountains. It has its source in a broad saddle of the Kicking Horse pass, with an elevation of 5,329 feet. The westward slope from the pass is much steeper than that to the east. In a distance of about 8 miles the river drops 1,300 feet to an elevation of 4,064 feet at Field, and 1,100 feet of this drop occurs within 5 miles. The river is about 42 miles long and has a total fall of 2,750 feet. This valley in pre-Glacial time was drained to the southeast. The general character and uniformity of direction of the main tributaries were described in 1910.[3]

There is one main north and south depression in the area which is now occupied by Cataract Brook, McArthur Creek, and Moose Creek valleys.

General Geology.

The thick sedimentary series in the area has been subdivided into various formations largely on fossil evidence, and in part on a lithological basis.

The beds below the graptolite shales, which are definitely Ordovician in age, were formerly divided into the Bow River group at the base and the Castle Mountain group above.[4]

These have been subdivided into formations by Walcott on purely fossil evidence and fully described in his Mt. Bosworth section.[5] The following local names were first given to various formations in this section—Sherbrooke, Paget, Bosworth, Eldon, Stephen, Cathedral, Mt. Whyte, St. Piran, Lake Louise, and Fairview.[6]

[1] Summary Report, 1910, Geol. Survey, Canada, p. 136.
[2] Originally called 'Wapta' by the Stoney Indians.
[3] J. A. Allan. Geology of Ice Diver District: Summary Report, 1910, Geol. Survey, Canada, p. 136.
[4] R. G. McConnell. Ann. Rep. Part D, Geol. Survey, Canada, 1886, p. 15 D.
[5] C. D. Walcott. Cambrian Sections of the Cordilleran Area. Smithsonian Misc. Coll. Vol. 53, No. 5, 1908, p. 204.
[6] C. D. Walcott. Nomenclature of some Cambrian Cordilleran Formations. Smithsonian Misc. Coll. Vol. liii, No. 1, 1908, pp. 1-5.

The sedimentary series in the Ottertail range can be readily separated into three distinct formations, and since it has not been possible to correlate them with any others already recognized, they have been named by the writer in order to facilitate the description of each. The names are local and are taken from localities in which the beds are best exposed.

In the table the approximate thickness of each formation is given. There is a minimum thickness of 24,433 feet represented in this area. The thicknesses of the Halysites and Graptolite beds are those given by McConnell; the lower three formations have been measured and estimated by the writer; the remaining formations have been measured and estimated by Walcott and are well exposed in Mt. Bosworth.[1]

The igneous rocks have been described in summary for 1910,[2] but several types have since been determined.

[1] In Mt. Bosworth, upper Middle and lower Cambrian beds are exposed in a section. C. D. Walcott. Cambrian Sections of the Cordilleran area. Smithsonian Misc. Coll. Vol. liii, No. 5, 1908, p. 204.

[2] J. A. Allan. Geology of the Ice River District. Summary Report, 1910, p. 139.

Table of Formations.

System	Previous Classification.	Formation.	Approx. thickness feet.	Lithological characters.
Pleistocene and Recent.	....	Fluviatile.......	....	Gravel, sand.
		Lacustrine......	... .	Gravel, sand, clay, silt, conglomerate (stratified).
		Glacial........	... .	Till.
Erosion Surface.				
Silurian	Halysites beds..	Halysites beds..	1,300+	Greyish dolomites, white and brown quartzites.
Ordovician.....	Graptolite shales	Graptolite shales	1,500+	Black and dark brown fissile shales.
	....	Goodsir formation.	6,040+	Cherts, cherty limestones, thin-bedded siliceous dolomites, grey dolomitic limestones, siliceous and calcareous slates and shales; weathering brown, purplish grey, light grey, light yellow, buff.
Upper Cambrian	....	Ottertail formation.	1,725+	Massive blue limestone with shaly bands.
		Chancellor formation.	2,500+	Thin-bedded grey argillaceous and calcareous slates, weathering reddish, yellowish, and fawn; underlain by greyish calcareous meta-argillites, shales, and argillites highly cleaved and phyllitic; weathering greenish, greyish, reddish, yellowish, and buff.
	Castle Mt. Group	Sherbrooke[1]...	1,375[2]	Grey, thin-bedded, cherty, oolitic limestones and arenaceous dolomitic limestones.
		Paget	360+	Massive bluish grey limestone with bands of oolitic dolomitic limestones.
		Bosworth.....	1,855+	Massive grey, arenaceous, dolomitic limestone; weathering yellowish buff; underlain by thin-bedded dolomitic limestone with interbedded greenish siliceous shale weathering buff; arenaceous shale weathering buff, greenish, yellowish, deep red, and purplish.
Middle Cambrian.	....	Eldon	2,728	Thin-bedded siliceous and dolomitic limestones, underlain by massive bedded arenaceous limestones, cliff-forming, weathering light grey to buff.
		Stephen	640+	Thin-bedded dark and bluish grey limestone interbedded with shale; with 150 feet of Ogygopsis shale in Mt. Stephen and 'Burgess shale' in Mt. Field.
		Cathedral.....	1,595+	Arenaceous dolomitic limestones; weathering grey and buff.
Lower Cambrian	....	Mt. Whyte...	390	Siliceous shale, sandstone, and thin-bedded limestone.
Base not exposed	Bow River Group.	St. Piran.	2,600+[3]	Ferruginous quartzitic sandstone.

Total thickness........ .... 24,608 feet.

Table of Formations—*Concluded.*

IGNEOUS ROCKS.

Post-Cretaceous ?....	Dyke intrusions.....	Camptonite, tinguaite, phonolite, ouachitite, etc.
	Alkaline intrusion...	Nephelite syenite, sodalite syenite, foyaite, urtite, jolite, theralite, essexite, jacupirangite, etc.

NOTE—Colours in this table refer to the fresh rock unless specified.

[1] The remaining formations first named by: C. D. Walcott—Nomenclature of some Cambrian Cordilleran Formations. Smithsonian Misc. Coll. Vol. 53, No. 1; 1908, pp. 2-4.

[2] Thickness of formations determined by C. D. Walcott in Mt. Bosworth section—Smithsonian Misc. Coll. Vol. 53, No. 5; 1908, p. 216.

[3] Exposed above talus south of Lake O'Hara.

DESCRIPTION OF FORMATIONS.

St. Piran and Mt. Whyte Formations.

These formations consist essentially of quartzitic sandstones and siliceous shales. Some beds contain many annelid borings. There is a maximum thickness of almost 3,000 feet of these beds exposed in the Bow range above Lake O'Hara, but a much greater thickness has been examined by Walcott on the east side of the range at Lake Louise.

At the base of the north slope of Mt. Stephen about 600 feet of lower Cambrian quartzitic beds are exposed in a small anticline on both sides of the Kicking Horse valley.

Cathedral, Stephen, and Eldon Formations.

These occur only in the northeastern portion of the area mapped this summer, and consist largely of calcareous and dolomitic beds as shown in the table. They are characteristically developed in Mts. Stephen, Cathedral, Odaray and in the Bow range. The Eldon in particular forms steep castellated crags on the erosion surface which make the formation readily recognizable. Many of these beds are fossiliferous and it is in the Stephen formation that the "fossil bed," Ogygopsis shale of Mt. Stephen occurs, and the recently discovered fossil bed in the Burgess shale on Mt. Field.[1]

Bosworth, Paget, and Sherbrooke Formations.

These are best exposed in the Mt. Bosworth section, referred to above. It has not been possible to trace these formations to the southwest owing to a fault which crosses between Mt. Stephen and Mt. Dennis. The downthrow is on the southwest side, and beyond this break the beds are tightly folded and greatly metamorphosed so that fossils could not be found in them. This zone of highly sheared rocks occupies the great part of the Ottertail valley. The bedding of these rocks has become subordinate to the cleavage which has a general N.W.-S.E. trend. The beds are sometimes tightly folded and in other places are lying almost flat so that it is not possible to estimate the thickness represented in this zone. The folding is prior to the shearing.

Chancellor Formation.

This formation is well exposed in the Ice River valley and especially in the base of Chancellor peak. It consists of a thick series of grey meta-argillites, well cleaved along the bedding plane, weathering reddish, yellowish, and fawn. This series con-

[1] C. D. Walcott. Smithsonian Misc. Coll. Vol. 57, No. 3, 1911, p. 51

tains upper Cambrian fossils. It is the lowest formation exposed in the Ice River valley, where it has a measured thickness of 1,660 feet,[1] but on the northeast side of the Ottertail range it has an estimated thickness of over 2,500 feet exposed. In the Ottertail valley this formation can be traced down into highly sheared phyllitic slates and soft, calcareous argillites[2] in which the bedding becomes subordinate to the cleavage. This sheared zone which iucludes the whole of the Ottertail valley has been mentioned above. Fossils could not survive this intense alteration. Less altered rocks corresponding to this zone may be found to the northwest, but until such are examined it will not be possible to correlate these badly sheared rocks with those upper Cambrian formations to the northeast.

The Chancellor formation floors a part of the broad Beaverfoot valley, but becomes faulted off in the side of the Beaverfoot range. It also forms the lower end of the Van Horne range towards Mt. King and Mt. Hunter. The reddish weathering character of these beds in the range is typical of the formation. The top of the ridge on which Mt. Hunter is situated is composed of a band of massive bluish limestone with thin-bedded layers.[3] This band pitches to the southeast and disappears below the till-covered floor of the Beaverfoot valley about 2 miles above Wapta falls. Walcott found upper Cambrian fossils in this limestone at this poiut.

Ottertail Formation.

This formation consists almost entirely of blue limestone, massive towards the top and rather thinly bedded towards the base. It has a measured thickness of 1,550 feet in the Ice River valley,[4] and in the Ottertail mountains overlooking the Ottertail valley it measured about 1,600 feet. In Limestone peak to the east of Moose Creek valley this formation is over 1,725 feet thick. Since this formation is especially well developed throughout the Ottertail range, forming a precipitous escarpment along the east side, and since it cannot be correlated with any of those previously named, it has been given a name.

A few fossils were collected from these beds but no good species have yet been determined which would definitely fix the age as upper Cambrian.

Goodsir Formation.

This formation is best exposed in the upper part of Mt. Goodsir where it has a measured and estimated thickness of 6,040 feet.[5] It lies conformably on the Ottertail limestone and consists at the base of almost 3,000 feet of alternating hard and soft bands of argillaceous, calcareous, and siliceous bands of slate which weather light yellowish grey and buff. These beds are especially well exposed on the east side of Moose creek where they give a striped appearance to the mountain. In Mt. Goodsir they are more massive in composition. In the summary for 1910 this well banded series with a thickness of 2,975 feet was added to total thickness of sediments, but this series is only the more highly cleaved and metamorphosed beds of the Goodsir formation.[6]

The upper part of this formation consists of banded cherts, cherty limestones and dolomites, thin-bedded and very dense siliceous beds weathering into angular fragments.

Fossils have been found in the lower half of the formation. These have been determined by Walcott. He recognizes four new species which would place these beds in the Ordovician.[7] On both palæontologie and lithologic evidence the boundary

[1] J. A. Allan. Summary Report, 1910. Geol. Survey, Canada, p. 137
[2] R. G. McConnell. Ann. Rept., Part D, Geol. Survey, Canada, 1886, p. 25 D.
[3] R. G. McConnell. Ann. Rept., Part D, Geol. Survey, Canada, 1886, p. 39 D.
[4] J. A. Allan. Summary Report. 1910, Geol. Survey, Canada, p. 137 (No. 2 in table).
[5] J. A. Allan. Summary Report, 1910, Geol. Survey, Canada, p. 137 (No. 3 in table).
[6] J. A. Allan. Summary Report, 1910, Geol. Survey, Canada, p. 138 (No. 4 in table).
[7] C. D. Walcott. Cambro-Ordovician Boundary in British Columbia, etc.: Smithsonian Misc. Coll., Vol. 57, No. 7, 1912, p. 229.

between the Cambrian and the Ordovician in this district is placed at the top of the Ottertail limestone and at the base of the Goodsir formation.

No fossils have been found in the upper half of this formation although the beds have been examined to their highest horizon in the top of Mt. Goodsir.

Graptolite Shales.[1]

These shales occur in the Beaverfoot range and are rich in graptolites. They are well exposed in a creek a few yards west of Glenogle station. The same band was found 15 miles to the southeast on the same range, with the beds dipping very steeply to northeast. They consist chiefly of very black fissile shales which weather into thin angular fragments. These Ordovician beds are faulted against the soft highly cleaved phyllitic slates which underlie the Beaverfoot valley.

Halysites Beds.[2]

These beds consist of white and brown quartzites, brown siliceous shale, and grey dolomite. On account of the hardness of these beds they form the top of the Beaverfoot range. Certain beds are rich in corals, especially Halysites, which make them of Silurian age. The section through the Beaverfoot range has not yet been completed, so that the relation of these uppermost beds to one another has not been determined.

Pleistocene and Recent.

The deposits of glacio-lacustrine origin may be noted here. On the retreat of the glacier from the Beaverfoot and Kicking Horse valleys a lake filled both of these depressions, into which the glacial detritus from the surrounding slopes was washed, together with material carried down by the remnant tongues of ice. This stratified gravel, sand, and silt form distinct terraces to an elevation of 4,650 feet. At Emerald, 3 miles below Field, there are five terraces noticeable.

In the upper part of Porcupine creek the gravels and sands have been cemented to a conglomerate. The present stream in one place has cut its course through the slates at the side of the old valley on account of the hardness of the conglomerate.

Fluviatile deposits cover the broad portions of the valley floors. In the Kicking Horse valley they form a flood plain 2 miles wide and in several places have aggraded the depressions left in the floor of the valley by the melting out of the ice.

STRUCTURAL GEOLOGY.

There is a large fault with a north-south trend between Cathedral mountain and Mt. Stephen, with the downthrow in the latter. The displacement, which is over 1,500 feet, brings the lower Cambrian beds up against the middle Cambrian. This break continues to the south, passing between Mt. Duchesnay and Mt. Odaray. Another break with N.-S. trend cuts across the shoulder of Mt. Bosworth and follows south along Cataract valley.

At the south end of Lake McArthur the lower Cambrian beds to the east are faulted up against the middle Cambrian to the west. The displacement is over 800 feet.

A large break with N.W.-S.E. trend passes between Mt. Stephen and Mt. Dennis, the beds in the latter having slipped down. This break in Mt. Odaray has been offset by the Stephen-Cathedral fault which shows that there were at least two periods of faulting.

[1] R. G. McConnell. Ann. Rep. Geol. Survey, Canada, 1886, Part D, p. 22.
[2] R. G. McConnell. Ann. Rep. Geol. Survey, Canada, 1886, Part D, p. 21.

In the Van Horne range the southwest side of the Mt. Hunter ridge is bounded by a fault. Another break follows along the northeast side of the Beaverfoot range. There are several small faults, especially in the vicinity of the igneous mass.

All the main valleys are of pre-Glacial age widened and deepened by the action of the ice.

ECONOMIC GEOLOGY.

There are several occurrences of ore in this part of the Rockies, but little development has been done on any of them. The Monarch mine on Mt. Stephen is the only one being operated at present. Most of the important prospects in the area have been examined and will be mentioned in this chapter. Other prospects and certain building and ornamental stones were described in the Summary for 1910.[1]

Argentiferous galena, sphalerite, and copper sulphides are the principal metalliferous ores.

The following table gives the results of assays made from some of the ores by Mr. H. A. Leverin, chemist for Mines Branch.

—	Gold oz.	Silver oz.	Lead %	Zinc %	Copper %	Iron %
(1) Black Prince Mining claim (Mt. Field)..........	none.	0·82	16·9	21·5		
(2) Waterloo Mining claim (Moose creek)..........	0·5	2·90	3·69	16·10	1·59	27·30
(3) Hercules Mining claim (Silver Slope creek).....	trace.	4·50	15·33	6·87	0·035	
(4) Sunday Mining claim (Ottertail river)..........	"	5·12	15·66	31·68	3·25	

MONARCH MINE.

The location and general description of the mine were given in the Summary Report for 1910, page 142.

The mine is owned and operated by the Mt. Stephen Mining Syndicate of which Mr. J. A. Thomson is managing director, with office in Vancouver.

Mr. Harry Lavery is superintendent and has been employed by the Syndicate to erect a concentrating mill suitable for the treatment of the ore, and to develop the mine so that the ore can be produced economically. The location of the ore body in the precipitous cliff of the mountain, over 1,000 feet above the railway, and the old method of getting the ore down, made the cost of production very high.

On June 25, Mr. Lavery began work on the construction of a mill, which is located on the side of the railway at the base of the mountain. The mill and aerial tramway were completed in Janaury, 1912, and operations continued after that date.

It is a gravity concentrating mill 110 × 60 feet in 5 bents with room for enlargement. It has a capacity of 50 tons per day. The machinery used is a Blake crusher, 2 sets of rolls, trommels, Tamarack classifiers, Harz jigs, and Deister tables.

The power is supplied by a Pelton wheel under a head of 280 feet which will generate 140 H.P. The pipe line is 1,706 feet long and the pipe at the head is 12 inches in diameter, being gradually reduced to 8 inches at the wheel. The water is taken from the stream coming down between Mt. Stephen and Cathedral mountain.

The ore will be brought down from the mine by an aerial tram from an upper terminal in the face of the mountain above the mill. From this terminal a drift will be run for about 180 feet and a raise of 147 feet will connect with main tunnel of the mine, about 180 feet from its mouth.

The following mill-run was made: jig-cup producers gave 67 per cent lead, and 4 per cent zinc; table products ran 52 per cent zinc and 3·5 per cent lead; lead con-

[1] J. A. Allan, Ice River District, Summary Report, 1910, p. 141.

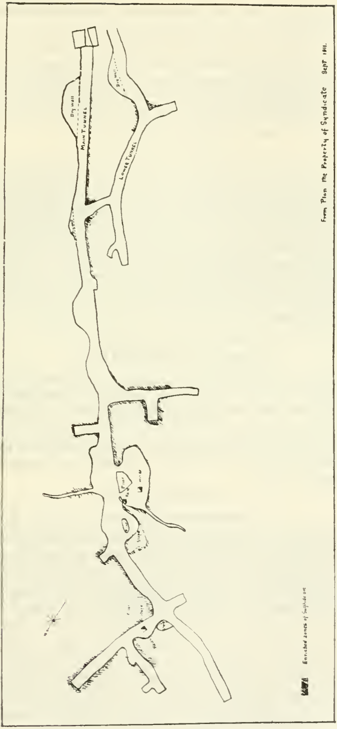


FIG. 7.—Plan of underground workings of Monarch mine.

centrate gave 76 per cent lead and 4 per cent zinc; tailings ran 0·6 per cent lead and 0·9 per cent zinc.

The accompanying plan shows the workings in the mine. The main tunnel is about 380 feet long and follows along a vertical fissure. There are several cross fissures, some of which are followed by drifts. The ore is always in or along the fissures. In some places the siliceous dolomitic limestone is highly fractured and crusted material is partly replaced by and cemented together with the lead and zinc ores. Pockets of almost pure galena or sometimes sphalerite are found along the cross fissures. The ore body is irregular and at the inner end of the workings is bending round to the south, following the fissure.

BLACK PRINCE MINING CLAIM.

This claim is situated at an elevation of 5,050 feet on the south slope of Mt. Field. The mode of occurrence is quite similar to that in the Monarch mine on Mt. Stephen. The ore body lies along a fractured zone in a siliceous dolomite, and varies in width from a few inches to 6 feet. The ore minerals are galena, sphalerite with some pyrite and a very small amount of reddish coating on weathered surfaces which suggests mimetite. The ore solutions have replaced some of the country rock and have cemented the broken fragments together in the shear zone. The development, which has been done by W. T. Oke, shows that the ore body is somewhat irregular along the fissure, which contains a gouge clay, but the latest work shows up another pocket of galena ore in the end of the tunnel. An assay of the ore is given in the table, but is undoubtedly too high in zinc for an average sample.

Prospects in the Ottertail Valley.

There are several small prospects in the valley of the Ottertail and its tributaries, Frenchman, Haskins, and Silver Slope creeks, which are the first three large creeks entering the Ottertail from the west side. Some development work has been done on these within the last decade. All the prospects occur in the highly cleaved slates of the Chancellor formation.

There is nothing being done with these various prospects at present. The Canadian Pacific railway crosses the mouth of the valley and a good trail extends 5 miles up Ottertail river.

Each of these prospects will be mentioned briefly.

SILVER SLOPE CREEK GROUP.

This group consists of three claims, the Hercules, Phoenix, and the Tamarack mining claims. They are situated at the head of the southeast branch of Silver Slope creek. The workings are at elevation of 6,800 feet, which is the border of timber line. On the Hercules claim a tunnel 200 feet long crosses the beds which strike S. 65° E. and dip 40° to 45° S. These beds, dipping into the mountain, consist of reddish weathering slates of the Chancellor formation. The ore occurs as small lenses in a bed of limestone 6 feet thick, interbedded with the slates, partly recrystallized, and seamed with calcite stringers. On account of its hardness, this band stands out on the weathered surface. The ore minerals impregnating the limestone in irregular lenses and frequently in calcite stringers, are galena, sphalerite, and pyrite, with a small amount of chalcopyrite and probably argentite.

The tunnel was started 75 feet down the slope in order to strike the mineralized band at greater depth, but the end of the tunnel is still a few yards from where the ore should be reached. These claims were originally staked out and assessment work done by Messrs. W. T. Oke, T. Hebson, and Adams. Very large assay values have been reported from picked samples. An average sample, which the writer collected from the mineralized band of limestone, gave the results of No. 3 in the table of assays.

HASKINS CREEK PROSPECT.

A prospect at the head of this creek was first worked several years ago by Messrs. Summers and Bullard. The workings have become filled up. The ore is largely chalcopyrite and pyrite associated with quartz as veins in slates.

QUEBEC MINING CLAIM.

This claim is situated in Frenchman creek which is the first large creek entering the Ottertail river from the west and about 3 miles from the railway. This claim, together with the Ontario and the Empire, formed a group controlled by a syndicate. The workings on the Quebec are at elevation 4,625 feet or 900 feet above the railway. There are two tunnnels; the lower one is about 200 feet long and has a shaft about 60 feet deep at the inner end, the outer one is 175 feet long. The country rock is red weathering calcareous slates highly cleaved and cut by quartz-calcite veinlets. In these veinlets the ore minerals are galena, tetrahedrite, azurite, malachite, pyrite, and some arsenopyrite. No work has been done on the property for over twenty years, but when in operation, a tramway, with wooden rails, about 2 miles long was built from the workings down to near the railway, where it was intended that a spur should receive the ore. The ore was taken down in a car by gravity and the empty car hauled back by a mule. Only about 20 tons of ore were brought down when a forest fire destroyed a large part of the tramway, and development on the property was discontinued.

A large boulder very rich in similar ore minerals has been found on this slope in the woods which suggests some other occurrence of the ore in this slope of the range.

ONTARIO MINING CLAIM.

This claim lies partly on the north side of the Ottertail river. A tunnel has been driven into the soft greenish slates and argillites on the north bank of the river, but has since been covered by talus.

EMPIRE MINING CLAIM.

Very little development has been done on this claim. The exposure is about half a mile up the Ottertail river from the railway. The main tunnel has become closed up, but two small prospect holes show the greenish soft argillites and calcareous slates fissured, and these breaks filled with quartz calcite sericite which carry chalcopyrite, tetrahedrite, galena, and some bornite. The ore minerals sometimes occur in small pockets along fracture or between the veins and the highly cleaved slates. A vein 1 to 3 inches wide of pure galena was noted along a joint fracture, in which the galena showed evidences of having been intensely squeezed.

SUNDAY MINING CLAIM.

This claim with two others, the Monday fraction and another fraction, form another group. Of these only the Sunday will be mentioned. The workings are situated opposite those of the Empire and consist of a shaft 100 feet deep, but now filled with water. The main tunnel is about 75 feet long and cuts across the strike of the soft greenish calcareous slates and argillites. The ore minerals are sphalerite, galena, pyrite, chalcopyrite, with a little tetrahedrite. The gangue minerals are fluorite and calcite, occurring as veins along and across the bedding of the slate and also in pockets along fractures or small faults. The fluorite varies from white to greenish blue colour; one pocket of this mineral is 1 foot in diameter. There is not enough of this mineral to give it an economic value. Sphalerite is frequently associated with the fluorite. Ore minerals can be readily separated from the gangue. A small amount of development work was done during the past summer. Assay No. (4) in the table was made from an average sample collected from the veins containing the ore.

WATERLOO MINING CLAIM.

This prospect is situated at an elevation of 7,100 feet, near the head of Moose Creek valley, and was described in Summary Report for 1910.[1] The ore minerals are sphalerite, galena, chalcopyrite, pyrrhotite, arsenopyrite, and pyrite in a gangue of quartz and calcite, which occur as segregations in or along fault planes in a mica porphyry sheet lying almost conformable with the bedding of the siliceous limestones.

A representative ore sample taken from this prospect by the writer gave assay No. (2) in the table of assays.

Other Prospects.

In Porcupine creek considerable prospecting has been done. About 3 miles up the valley at an elevation of 4,300 feet small fractures in a dolomitic slate are filled with vein material, 1 to 6 inches wide, consisting of fluorite, ferruginous dolomite (ankerite), muscovite, and some lepidomelane. The ore minerals are argentiferous galena and pyrites; these occur segregated in the gangue.

In Mt. Field a short tunnel has been driven along a quartz vein 2 to 4 feet wide, which follows the strike of the ferruginous quartz interbedded with soft, chloritic slates. The ore minerals are chalcopyrite, tetrahedrite, malachite, and azurite. These minerals occur both in the vein and along its sides.

On the south slope of Mt. Stephen at an elevation of 7,200 feet mining locations have been made on quartz veins along fissures in dolomitic limestone. Chalcopyrite and the carbonates are the essential ore minerals.

MERCURY.

Native quicksilver is reported to have been found in the gravels of the Kicking Horse valley in the vicinity of Field. This metal was first found by Mr. Flindt in a water pipe in the Mount Stephen Hotel, which must have come from the source of the water supply in the southwest slope of Mt. Stephen. Some of this material was sent to the Survey office. At a later date five samples of gravel were collected by Mr. C. E. Cartwright, consulting engineer, Vancouver, from the flood gravels within 2 miles of Field, and were panned by Mr. C. M. Bryant, Vancouver, with the result that a trace of quicksilver was found in three out of the five samples. Mr. Busteed, general superintendent Canadian Pacific Railway Company in Vancouver, also stated that he obtained quicksilver by panning the gravels "from the edge of the river a few hundred feet below the bridge," opposite Field station, from a depth of about 2 feet below the surface, "where the high water had cut down about that depth."

These facts seem to show that the quicksilver does occur disseminated through even the surface gravels in the floor of the Kicking Horse valley and that its source must be in some of the surrounding mountains. Two claims have been staked out

[1] J. A. Allan, Summary Report, 1910, Geol. Survey, Canada, p. 141.

on the talus on the southwest slope of Mt. Stephen about the intake of the water supply for the hotel. A considerable amount of work was done in an attempt to locate the source of the mercury, but without results.

Some time was spent by the writer at the beginning of the field season in examining the rocks in Mt. Stephen, Cathedral, Field, and the Yoho valley. The most likely rock was assayed for mercury, but no trace of this mineral was found. Nevertheless, it seems possible that some compounds of this metal may occur even within these mountains which may have given rise to the native quicksilver now found in the gravels of the Kicking Horse valley.

Cinnabar is reported to have been found several years ago in a massive limestone ridge on the north side of the valley between Emerald creek and the Amiskwi river. It was also found in a calcite vein close to Glenogle station in the lower Kicking Horse canyon.[1]

MARBLE.

Within the past year claims have been staked for marble in the Yoho valley. A cross-section of this band of marble is exposed at the switchback on the Yoho road, 2 miles from the mouth of that river. At this point it has a thickness between 350 and 400 feet. The rock is a dolomitic marble and varies largely in both colour and texture. In colour it is dark grey, mottled grey with white spots or vice versa, light grey, white with greyish bands a fraction of an inch in width, and pure white. These last two types occur towards the top of the band and are of the most economic importance. The rock takes a smooth polish, the grained material can be readily carved and will take a sharp edge. This band of marble extends along the eastward slope of Mt. Ogden which makes the quantity very large.

The exposed surface of the marble is badly fractured so that it would be hard to get large blocks of the material, but this fractured zone may not be very deep. The presence of small cavities in certain layers is also detrimental to the value of the marble. Pyrite is only sparsely scattered through certain layers which might be avoided in quarrying.

No development has yet been done on the property. The beds are lying almost horizontal with a maximum dip of 12 degrees. The railway is less than 2 miles distant and on the same elevation.

GRAVEL.

There is an extensive deposit of stratified glacial gravels more than 100 feet thick in the valley of the Kicking Horse river between Field and Ottertail. At Emerald, 3 miles below Field, the Canadian Pacific Railway Company have installed a washing plant in which the clayey material is washed from the gravels, giving a clean product which is used for ballast.

CLAY.

A small deposit of clay of glacio-lacustrine origin occurs in the Yoho valley about 3 miles from its mouth. It is yellowish in colour when wet and much lighter in colour when dry. The lime content is high in it and the finest powder is gritty. This material might be manufactured into an earthenware or a variety of pottery.

At the town of Field there is a colluvial clay of indefinite extent, washed down from the talus slope of shales and argillites between Mt. Stephen and Mt. Dennis.

Another small lake deposit of glacial clay or silt occurs near the head of Ice River valley at the base of Chancellor peak. The clay is light buff in colour and highly calcareous. Tests on this silt prove it to be of very low grade and of little or no economic importance.

[1] R. G. McConnell. Annual Report, 1886, Part D, p. 41.

CAMBRIAN OF THE KICKING HORSE VALLEY, B.C.

(Charles D. Walcott.)

In continuation of the field work of the season of 1910, a camp was established on the north side of Burgess pass, 3,000 feet above Field, a trail was built up to the fossil bed on the west slope of the ridge between Mount Wapta and Mount Field, and the systematic quarrying and collecting of fossils continued from July 20 until September 9. A section of the Burgess formation in which the now celebrated fossil bed occurs, was measured as follows:—

Section of Burgess Shale of the Stephen Formation.

Typical Locality.—East side of Burgess pass on west slope of Mount Field, facing towards Mount Burgess and Emerald lake, B.C., Canada.

The Burgess[1] shale is overlain by massive bedded arenaceous limestones of the Eldon formation.[2]

	Feet.	Inches.
a. Greenish colonred argillaceons shales .... Annelid trails.	6	
b. Grey arenaceous limestone	3·6	
c. Bluish-black and grey finely arenaceons shale and thin layers of grey, rongh sandstone in massive layers	24·6	
d. Grey arenaceons magnesinm limestone in massive beds, that break up into thin irregular layers. Some of the thin layers weather huff and others dirty-grey, passing gradnally into more and more shaly beds of hlnish-grey colour and huff weathering .... *Fauna.*—Fragments of fossils and trails.	22	
e. Coarse highly arenaceons limestone..............	4	
f. Grey siliceous shale in beds 2 to 4 feet thick, weathering greyish-hnff, and banded .... *Fauna.*—Fragments of trilobites.	42	
g. Finer grained shales than in *f*, and with thin layers of grey siliceons, slightly calcareons, shale .... *Fauna.*—Large and varied. Locality $\frac{(35\ k)}{10}$	80	

Among the species identified are the following:—

Sponges—
Vauxia gracilenta, n. g. and n. sp.

Annelida—
Banffia constricta Walcott.
Pollingeria grandis Walcott.
Ottoia prolifica Walcott.

Brachiopoda—
Micromitra (Iphidella) pannula (White).
Nisusia alberta Walcott.

Pteropoda—
Hyolithes carinatus Matthew.

[1] Smithsonian Misc. Coll., Vol. 57, 1911, p. 51.
[2] Idem, Vol. 53, 1908, p. 3. Idem, 1910, p. 208.

Crustacea—

Opabinia ? media Walcott.
Yohoia plena Walcott.
Burgessia bella Walcott.
Bidentia difficilis Walcott.
Carnarvonia venosa Walcott.

	Feet.
h. Bluish-grey, fine, strong, arenaceous and siliceous shale. About 90 feet down the shales became thinner and darker........	228
Fauna.—Between 30 and 40 feet from the base the Phyllopod fauna occurs in great abundance. The described species are listed on page 190.	
Total thickness of Burgess shale................	420

Below, the Stephen[1] formation continues downward as a thin-bedded bluish limestone.

Detailed section of the Phyllopod bed that occurs between 30 and 40 feet from the base in the lower part of h.

The Phyllopod bed is overlain by a bed of slightly arenaceous shale of a bluish-dirty-grey colour. This shale weathers on exposed edges to a yellowish ochre-brown colour, and serves to mark the upper horizon of the Phyllopod bed. At the fossil quarry it has a thickness of 19 inches.

	Inches.
1. Bluish-grey shale with partings of dirty brownish-grey shale......	21
2. Dirty-grey earthy shale	8
3. Thick layers 3 to 4 inches in thickness, of bluish-grey very compact hard siliceous shale............	12
4. Dirty-grey shale..................	2
5. Bluish-grey, tough, brittle layer of siliceous shale.....................	2
Fauna.—Medusæ, Holothurians, Annelids, Crustaceans.	
6. Bluish-grey compact shale that splits on partings, finally on lines of bedding..........	8
7. Alternating dirty-grey and bluish-grey shale.........................	9
Fauna.—This is the great *Hymenocaris perfecta* bed, and also contains many Annelids, Sponges, and Crustaceans.	
8. Same as 6.	
9. Dirty-grey earthy shale	2
10. Solid bed of bluish-grey hard compact shale that splits more or less evenly parallel with the bedding of the layers..............	16
Fauna.—Sponges, Annelids, Pteropods, Crustaceans.	
11. Dirty grey earthy shale............	1·5
12. Very fine bluish-grey compact shale..................................	1·5
Fauna.—*Marrella splendens* layer.	
Total thickness	7 feet 7 inches.

Below 12 the shales are more or less irregular, arenaceous, and not favourable for the preservation of fossils.

The layers at the fossil bed have a very gentle dip to the eastward. A short distance to the westward they dip abruptly downward and disappear beneath the debris slope.

The fossil bed is limited in extent by a fault on the north that has brought the Eldon limestone down against them, and by shearing and breaking a short distance to the south. The fossil quarry is now 65 feet in length on the steep slope of the ridge, with a floor extending back into the ridge 10 feet, and a vertical wall on the back side of from 10 to 12 feet. About 150 cubic yards of the shale have been quarried

[1] Smithsonian Misc. Coll. Vol. 53, 1908, p. 3. Idem, 1910, p. 209.

and split up. The fossils are scattered more or less irregularly, and are rarely very abundant, with the exception of a few species.

The fauna thus far described from this remarkable deposit is as follows:—

BURGESS SHALE FAUNA.

Annelida.[1]

Amiskwia sagittiformis.
Miskoia preciosa.
Aysheaia pedunculata.
Canadia spinosa.
Canadia setigera.
Canadia sparsa.
Canadia dubia.
Canadia irregularis.
Selkirkia major (Walcott).
Selkirkia fragilis.
Selkirkia gracilis.
Wiwaxia corrugata (Matthew).
Pollingeria grandis.
Worthenella cambria.
Ottoia prolifica.
Ottoia minor.
Ottoia tenuis.
Banffia constricta.
Pikaia gracilens.
Œsia disjuncta.

Holothurians.[2]

Eldonia ludwigi.
Laggania cambria.
Louisella pedunculata.
Mackenzia costalis.

Medusæ[2] (Scyphomedusæ).

Peytoia nathorsti.

Crustacea (Branchiopoda[3]).

Opabinia regalis.
Opabinia ? media.
Leanchoilia superlata.
Habelia optata.
Emeraldella brocki.
Yohoia tenuis.
Bidentia difficilis.
Molaria spinifera.
Nathorstia transitans.
Naraoia compacta.
Marrella splendens.
Burgessia bella.
Anomalocaris gigantea.

Crustacea (Malacostraca).

Waptia fieldensis.
Hymenocaris perfecta.
Hymenocaris ? circularis.
Hymenocaris obliqua.
Hymenocaris ovalis.
Hymenocaris ? parva.
Hurdia victoria.
Hurdia triangulata.
Fieldia lanceolata.
Carnarvonia venosa.
Tuzoia retifera.
Odaraia alata.

Crustacea (Trilobita[4]).

Mollisonia symmetrica.
Mollisonia gracilis.
Mollisonia ? rara.
Tontoia kwaguntensis.

Crustacea (Merostomata[5]).

Sidneyia inexpectans.
Amiella ornata.

The Burgess shale undulates with more or less sharp anticlines and synclines across the broad pass and disappears beneath the mass of limestones of Mount Burgess. With the exception of the localities on the western slope of Mount Field and

[1] Smithsonian Misc. Coll. Vol. 57, No. 5.
[2] Idem, No. 3.
[3] Idem, No. 6.
[4] Smithsonian Misc. Coll. Vol. 57, No. 6.
[5] Idem, No. 2.

its north ridge, no distinguishable fossils were found in the shale. The Burgess shale is a part of the Stephen formation which is exposed on the northwest slope of Mount Stephen, above Field.

Van Horne Range.—A reconnaissance made in the vicinity of Leanchoil station, about 18 miles southwest of Field, resulted in the discovery of Cambrian fossils in the railway cut just east of Leanchoil station; also at Wapta falls, southwest of Leanchoil. The finding of these fossils in eastward dipping beds is important, as it proves that Mr. McConnell's impression of the structure of the Van Horne range and the Ottertail range just to the south of the Canadian Pacific Railway track, as a broad synclinal, was essentially correct.

From the northern slope of Mount Vaux the synclinal nature of the Van Horne range was very clear.

The limestones of the southwest ridge of Mount Hunter strike to the northwest and appear to be above the fossil-bearing rock just east of Leanchoil.

Traces of fossils of apparently Cambrian age were found in Hoodoo canyon, between Chancellor peak and Mount Vaux. I noted in this canyon large light-grey quartzite sandstone boulders, with many vertical annelid (*Scolithus*) borings filled with white quartz. The borings were more irregular than those of *Scolithus linearis*, and are from 5 to 10 millimetres in diameter. The only other recognizable fossil is a small species of *Acrotreta* that occurs in a dark bluish-grey limestone.

On September 14 I camped on Amiskwi pass and found in the nearly horizontal limestone layers on the northwest side of the pass, traces of upper Cambrian trilobites that probably belonged to the lower thin-bedded limestones of the Bosworth formation.

All field work was suspended after September 20, owing to a heavy fall of snow.

GEOLOGY OF BLAIRMORE MAP AREA, ALBERTA.

(W. W. Leach.)

During the season of 1911 only two months, September and October, were spent in the field.

Location and Area.

The district under examination is situated in the eastern or Alberta entrance to the Crowsnest pass and is one of great importance on account of the extensive coal mining operations being there carried on. The map, now being compiled, will cover an area 17 by 12 miles in extent and will be published on a scale of 1 mile to 1 inch. The towns of Blairmore and Frank on the Crows Nest branch of the Canadian Pacific railway are situated near the centre of the map area sheet.

Previous Work.

Dr. Dawson in 1883-4 traversed the Crowsnest pass and in a general way outlined the chief geological features (see Report on the Bow and Belly Rivers region 1882-3, and Report on a portion of the Rocky mountains, Vol. I, 1885). In the year 1902 the writer spent the summer in this district, the results obtained, together with a sketch map, being published in the Summary Report for 1902. In 1903 Messrs. Brock and McConnell wrote a special report on "The Great Landslide at Frank, Alberta," issued by the Department of the Interior, Part VIII, Annual Report 1903.

Summary and Conclusions.

As the time available for field work was very limited it was considered advisable to devote the greater part of it to measuring as accurately as possible a section across the whole of the strata represented in the area so that the relative positions of any characteristic beds, which might be used as horizon markers, could be determined. As several faults of great throw are present and the rocks are often severely folded it will be seen that this is a matter of much importance in determining the available amount of coal present.

The main structural features of the district to the west of Blairmore are a number of great step faults with persistent easterly downthrow, which bring the coal-bearing horizon to the surface at several places. The line of faulting in nearly all cases follows closely the strike of the beds. To the east of Blairmore the strata have been subjected to much folding, complicated by a number of faults.

The strike of the beds is approximately north and south so that the railway crosses it nearly at right angles and many active mining camps have sprung up in the vicinity of the various outcrops of the coal-bearing strata.

The class of the coal produced here is essentially of the steaming and coking variety and is much used for railway purposes, while a large number of coke ovens are either in commission or under construction.

Near Burmis station, at the eastern edge of the map sheet, a very extensive fault with easterly downthrow cuts off the Kootenay coal-bearing formation, the Burmis outcrop being the last one to the east.

The most prominent horizon markers noted in the field are: a massive, very hard cherty conglomerate at the base of the Dakota formation and immediately overlying the coal-bearing beds; a thin bed of bluish, shaly limestone, associated with seal-brown weathering calcareous sandstones, and occupying a middle position in the Dakota formation; the volcanic breccias and ash beds overlying the Dakota and overlain by the Benton shales, and a bed of very hard, siliceous light-weathering sandstone, about 20 feet thick, which occurs about 500 feet above the base of the Benton shales.

The similarity in general appearance of the Benton and the Fernie shales is apt to lead to confusion when, by faulting, they are brought into juxtaposition.

Topography.

The Crowsnest river crosses the map sheet diagonally with a course approximately northwest and southeast and occupies a wide terraced valley with a comparatively light gradient, thus affording an easy route for the railway to the summit of the Crowsnest pass in which it takes its rise.

In the area to the west of Blairmore, to which last season's operations were confined, all the principal streams entering the river with the exception of York creek follow generally the strike of the rocks and have, in consequence, north and south courses; York creek, however, cuts across the strike nearly at right angles. The crests of the ridges, intervening between the streams, as a rule follow the outcrop of some of the harder beds, while the valleys in many cases are underlain by the softer shales. The higher points of the ridges rarely exceed 7,000 feet in elevation while the river valley is comparatively high, the elevation of Blairmore station being 4,226, so that the maximum difference of relief seldom reaches 3,000 feet.

General Geology.

TABLE OF FORMATIONS.

Quaternary	Glacial and river drift.
	(1) Allison Creek Sandstone (Belly River ?)
	(2) Benton-Niobrara.
Cretaceous	(3) Crowsnest Volcanics.
	(4) Dakota (?)
	(5) Kootenay.
Jurassic	Fernie Shales.
Devono-Carboniferous.	

DESCRIPTION OF FORMATIONS.

Devono-Carboniferous.—The Palæozoic rocks included in this area consist almost entirely of massive limestone with some thin beds of quartzite and calcareous sandstone towards the top. They form the backbone of the Livingstone range and of Bluff and Turtle mountains, but have not as yet been studied in detail and no attempt has been made to ascertain the total thickness of these rocks represented here.

Fernie Shales.—These rocks overlie the Palæozoic limestones apparently conformably and as their name implies, consist largely of very fissile shales, usually dark grey in colour, but also contain a few thin arenaceous bands and some more massive beds of clay shale. The line of demarcation between these shales and the overlying Kootenay formation is not very sharply drawn, but may be assumed to be at the base of the lowest heavy bed of sandstone underlying the coal seams.

Owing to the soft character of these beds very few natural exposures are to be seen. Almost invariably they occupy valleys or depressions and are heavily drift-covered; the harder sandstones of the Kootenay and the massive Carboniferous limestone usually forming the ridges on either side.

South of the railway opposite Blairmore, the Fernie shales are exposed in two pits which have been opened for the purpose of obtaining shale which is used in the manufacture of cement nearby. A section measured there from the topmost exposure of the Palæozoic rocks to the base of the lowest outcrop of Kootenay sandstone showed a maximum thickness of Fernie shales of 750 feet. A great part of the ground at that point is covered so that it is possible that this thickness is too great.

On York creek, a short way below the fan-house of the International Coal Company, the Fernie shales are again exposed to some extent. There, however, the base of the beds is not seen, being cut off by a great fault, and the shales themselves are tremendously crumpled rendering it impossible to obtain even an approximate idea of their thickness. No fossils were found in these rocks in this district, but from fossil evidence gathered elsewhere they have been determined to be of Jurassic age.

Kootenay.—This formation is of the greatest commercial importance containing, as it does, all the coal seams now being exploited in this district. It is composed of an uppermost bed of hard cherty conglomerate in a siliceous matrix, massive, moderately hard, dark-coloured sandstones, thin-bedded dark sandstones, grey, black, and carbonaceous shales and a number of coal seams. The following section was measured on York creek near the fan-house of the International Coal and Coke Company:— (Descending order.)

		Feet.
1.	Hard, siliceous, cherty conglomerate	19
2.	Hard, dark grey, thin-bedded sandstone	12
3.	Partly covered, shaly sandstone and dark shale	36
4.	*Coal*	16
5.	Carbonaceous shale, thin beds of shaly sandstone and two thin coal seams (8 inches and 14 inches)	30
6.	*Coal*	10
7.	Thin-bedded shaly sandstone and grey and carbonaceous shale	55
8.	Grey and brown shale	20
9.	Hard, siliceous dark grey sandstone	38
10.	Partly covered, carbonaceous shale, thin beds of shaly sandstone, and thin seams of coal (a 3 foot seam 50 feet from top)	165
11.	*Coal*	8
12.	Massive, rather coarse, greenish sandstone	41
13.	Covered	40
14.	Greenish, crumbly, thin-bedded sandstone	75
	Total	565
	Total coal	38 feet 10 inches.

The last sandstone bed is underlain conformably by the Fernie shale. This section is not complete and as the beds are in places locally crumpled may be considered as subject to revision.

Elsewhere in the field a coal seam was noted underlying the hard, thin-bedded sandstone immediately below the conglomerate (No. 2 of section); it was not seen at this point but the outcrop may be drift covered. It is generally rather irregular in character and is locally known as No. 1 seam.

A large proportion of the coal mined at Coleman and Blairmore is from the 16 foot seam (No. 4 of section), known as No. 2.

From Turtle mountain westward along the valley of Crowsnest river, the Kootenay rocks outcrop in three roughly parallel bands due to two large faults. The most easterly outcrop is at Blairmore, the second about three-fourths of a mile farther west, and the third at the western end of the town of Coleman.

A section of part of the Kootenay formation, including the principal coal seams, compiled by the West Canadian Collieries from information obtained in a short tunnel and a number of open-cuts in the first, or Blairmore outcrop, about 1½ miles north of that town, is as follows:—(Descending order.)

		Feet.	Inches.
1.	Conglomerate	27	
2.	*Coal*	10	
3.	Sandstone and shale	53	
4.	Conglomerate	8	
5.	*Coal*	17	
6.	Shale	1	6
7.	*Coal*	3	6
8.	Sandstone	24	
9.	*Coal*	3	6
10.	Sandstone	42	
11.	*Coal*	17	
12.	Sandstone and shale	65	
13.	*Coal*	6	
14.	Shale		
	Total	277	6
	Total coal	57	0

The 17 foot seam or No. 2 (No. 5 of section) is probably the same as that now being mined by the West Canadian Collieries at Blairmore on the south side of the river.

An incomplete section measured near the Blairmore mine showed a total thickness of Kootenay rocks of about 610 feet.

On the second outcrop (three-fourths of a mile west of Blairmore), but little work has been done and that merely surface prospecting, No. 1 seam underlying the conglomerate having been stripped at one point just south of the railway. The fault which brings the Kootenay rocks to the surface here apparently lies very close to the east of the conglomerate outcrop, and it is possible that the lower seams are cut off and never reach the surface here.

To the north of the railway along the strike of the strata the Kootenay rocks are not seen, the fault evidently cutting the strike of the beds at a narrow angle in such a manner that the overlying Dakota beds outcrop on either side of it.

The third or Coleman outcrop is very persistent and regular and has been traced, and the coal seams uncovered, for long distances both to the north and south of the railway. The McGillivray Creek Coal and Coke Company and the International Coal and Coke Company are operating mines on this outcrop on the north and south sides of the valley respectively. The York Creek section given above was measured on the Coleman outcrop where cut by York creek about 2 miles south of the town of Coleman.

The age of the Kootenay formation has been determined by fossil evidence (chiefly plants), to be lower Cretaceous with the possibility that some of the lower beds should be included in the Jurassic. No fossils have been as yet determined from the area under consideration; the nearest locality where any have been obtained being the South Fork of the Oldman river (about 10 miles southeast of Blairmore), where Dr. Dawson collected some fossil plants among which Sir J. W. Dawson recognized Podozamites lanceolatus (Linde) and Zamites Montana (Dn.). (See Annual Report, Vol. I, p. 58 B).

Dakota (?).—This formation overlies the Kootenay without any evidence of unconformity unless the conglomerate at the top of the Kootenay should mark a short cessation of deposition at that period.

The Dakota consists essentially of sandstones, varying greatly in colour and texture, with one thin bed of bluish shaly limestone towards the middle of the series, which, on account of its persistent nature, serves as a most useful horizon-marker.

The formation as a whole appears to show marked differences in total thickness within comparatively short distances, as the following measured sections will indicate.

(1.) Section measured from top of Kootenay conglomerate at second outcrop, three-fourths of a mile west of Blairmore station to first outcrop of volcanics on York creek near dam site =2,200 feet.

(2.) From top of Kootenay conglomerate near fan-house on York creek to base of volcanics at Forks of York creek = 2,500 feet.

(3.) From top of Kootenay conglomerate on north end of McGillivray ridge to base of volcanics on Ma butte = 2,865 feet.

(4.) From top of Kootenay beds at Coleman along road to base of volcanics in railway cut = 2,810 feet.

The most complete section was that measured near Ma butte and is as follows:—(Ascending order.)

		Feet.
1.	Yellowish-weathering, soft shaly light-greenish sandstone with some irregular, thin, harder beds	550
2.	Moderately hard greenish sandstone	15
3.	Shaly light-greenish sandstone	35
4.	Moderately hard greenish sandstone	12
5.	Shaly, light-greenish sandstone	340
6.	Massive, hard, coarse-grained, light-grey sandstone	16
7.	Shaly light-greenish sandstone	190
8.	Bluish shaly limestone	14
9.	Covered	20
10.	Massive, seal-brown-weathering calcareous sandstone, dark greenish grey on fresh fracture, alternating with shaly, dark green sandstone	226
11.	Hard, rather thin-bedded, coarse-grained, greenish sandstone with obscure plant impressions	40
12.	Mostly covered, a few exposures dark-greenish, shaly sandstone and some thin beds of seal-brown-weathering calcareous sandstone	370
13.	Generally dark, bottle-green, very crumbly, shaly sandstone with irregular patches of claret-coloured argillaceous sandstone and a few thin beds of seal-brown-weathering calcareous sandstone.	510
14.	Dark, fine-grained cherty conglomerate	8
15.	Dark, bottle-green crumbly sandstone with irregular claret-coloured patches	370
16.	Hard-massive, light-grey sandstone	65
17.	Dark green, crumbly sandstone with irregular dark red patches..	84
	Total	2,865

Generally speaking the lower beds up to the limestone are light in colour, usually greenish in tint and weathering yellowish. These are followed by several hundred feet of strata in which calcareous beds predominate, while the upper members are dark in colour, green being the prevailing tint although the irregular dark red patches are very noticeable. They are almost always soft and readily-weathering, breaking up into small angular fragments.

The conglomerate noted here is not very persistent, being missing in the other measured sections, although on York creek a prominent outcrop of conglomerate was seen, but relatively much lower down in the section. On the east flank of McGillivray ridge a thin bed of volcanic material was noticed, consisting of ash rock and agglomerate about 12 feet in thickness and occupying a position about 250 feet above the limestone bed. This was not seen elsewhere.

No recognizable fossil forms were observed in these rocks, but obscure plant impressions are frequent, and on York creek, near the top of the formation, two small streaks of coaly material were seen. Dr. Dawson collected a number of fossil plants from similar beds on the northwest branch of the Oldman river. He estimated the zone at which they occurred to be about 400 feet below the Crowsnest volcanics.

The following species were recognized by Sir Wm. Dawson:—

Alnites insignis ?, Dn.
Platanus affinis, Lesq.
Macclintockia Cretacea, Heer.
Laurophyllum debile, Dn.
Aralia, sp.
Paliurus montanus, Dn.
Juglandites Cretacea, Dn.

(*See* Annual Report, Vol. I, page 88 B.)

Crowsnest Volcanics.—These rocks consist of an important intercalation of volcanic breccias, tuffs, and flows, varying in colour from purplish to greenish-grey, and in texture from coarse agglomerates to fine-grained ash beds. These rocks were in 1905 microscopically and chemically examined by Mr. C. W. Knight, and from about sixty specimens he distinguished four predominant rock types, viz: augite-trachyte breccia, tinguaite, andesite tuff, and analcite-trachyte tuff.[1]

At one point where these rocks cross the Crowsnest valley near Coleman, Dr. Dawson noted "small segregations of copper pyrites forming scattered granules in some of the agglomerates."[2]

These rocks cross the valley of the Crowsnest river at two points, the most easterly being about 2½ miles west of Blairmore, and the second about 1 mile west of Coleman. At the first of these outcrops a total thickness of 440 feet was measured, while to the west of Coleman they reach a thickness of 1,150 feet.

It appears that the volcanics reach their greatest thickness about 2 miles to the east of Crowsnest mountain, thinning out rapidly to the eastward. They have been traced in a north and south direction for over 45 miles, but at both extremities are only a few feet thick.

On account of their superior hardness and homogeneity these rocks usually outcrop on the crests of comparatively high north and south ridges, and have been found especially useful in working out the structural features of the area.

Benton Niobrara.—The volcanics are overlain conformably by a great thickness of shales. It seems probable that these are referable to the Benton formation, possibly including rocks of Niobrara age towards the top. This series consists almost entirely of shales, but includes at least two sandstone beds. The lower of these occurs about 250 feet above the volcanics, is about 12 feet thick, dark-coloured, thin-bedded, and often shows ripple markings, and secondary quartz developed along jointage planes. The upper sandstone bed is found about 220 feet above the first; it is a notable horizon-marker, being apparently very persistent throughout the area, and by reason of its superior hardness is often found outcropping when the softer shales on either side are completely drift-covered. This bed is usually from 15 to 20 feet thick, is very siliceous and hard, and, although generally dark grey on fresh fractures, weathers to light-whitish tints.

From the volcanics to the first sandstone the beds are composed of fissile, dark grey shales with a few thin dark arenaceous beds. Between the sandstones the shales are generally somewhat sandy, often rusty-weathering and showing sparsely scattered clay ironstone nodules. The upper sandstone bed is overlaid by dark sandy shales and shaly sandstones for 150 feet, which are succeeded by dark rusty-weathering sandy shales and grey nodular clay shales.

On account of their soft, readily weathering nature these rocks are seldom well exposed, and where seen frequently show considerable minor folding and crumpling;

[1] See "Analcite-trachyte Tuffs and Breccias from Southwest Alberta": C. W. Knight, Canadian Record of Science, Vol. IX, No. 5.
[2] See Annual Report, Vol. I, page 69 B.

in consequence any estimate of their thickness must necessarily be approximate only. It seems probable, however, that they are at least 2,750 feet thick and possibly several hundred feet more.

The best section available of these beds is seen on York creek, but even there exposures are few especially towards the top of the formation. On Pelletier creek the lower members of the series are well seen in many places.

A number of fossils were found at various exposures on York and Pelletier creeks; of these Dr. Raymond has identified:—

Scaphites ventricosus, Meek and Hayden.
Inoceramus labiatus, Schlotheim.

On the northwest branch of the Oldman river, Dr. Dawson collected a number of fossils from this formation, the following of which were identified by Dr. Whiteaves:—

Pholadomya papyracea.
Scaphites Warreni.
Scaphites vermiformis ?.[1]

Allison Creek Sandstones.—A series of sandstones succeeded the dark shales apparently conformably; they are generally soft, of pale greenish to yellowish shades, weather to light colours, and are rather coarse in texture. The lower beds of this series are well seen on York creek, about half a mile below the fan-house, where about 250 feet are exposed; above this point they are cut off by a large fault.

On McGillivray ridge a measured section showed 1,900 feet of these rocks, when they are again interrupted by faulting.

The sandstones are somewhat similar in appearance to the lower members of the Dakota, but differ from the latter by being usually of lighter colours, more massive, and in not so readily disintegrating into crumbly angular fragments.

It is possible that these beds are equivalent to the Belly River series, but as no fossils have as yet been found it was decided to use the above name provisionally.

Structural Geology.

From Turtle mountain westward the rocks almost everywhere dip to the west, at angles varying from 30 to 70 degrees, except in a few instances where the soft shales of the Kootenay and Benton formations were seen locally crumpled. As before mentioned the coal measures, and the other formations in part, have been repeated three times between Turtle mountain and the western boundary of the area. The repetition is due to two very extensive faults, the most easterly, which may be termed the Blairmore fault, crosses the valley about half a mile west of Blairmore station while the second or Coleman fault passes through the town of that name.

The strike of both faults follows that of the rocks closely, although at times cutting the latter at very small angles. The dip of the fault plane has in neither case been clearly seen; at several points on the Blairmore fault it seemed to be nearly vertical and similar conditions were noted in several minor faults. Assuming that the dip of the fault planes in both the large faults is vertical the throw of the Blairmore fault must be close to 2,000 feet and that of the Coleman fault over 8,000 feet; the downthrow being in each case to the east.

The topography of the country does not appear to be materially affected by the faulting, but depends on the nature of the rocks, the alternating ridges and valleys following approximately the strike of the harder and softer rocks respectively. In many cases the crests of the higher ridges are composed of either the volcanic rocks

[1] See Annual Report, Vol. I, page 89 B.

or the hard cherty conglomerate forming the upper bed of the Kootenay formation, while some of the valleys, notably the upper end of Blairmore Creek valley, follow the strike of the soft Benton shales.

Economic Geology.

Coal mining is by far the most important industry in this district, but until the map is completed and the structure more fully worked out, it is impossible to even approximately estimate the amount of available coal. Three companies are operating to the west of Turtle mountain. The West Canadian Collieries at Blairmore, and the McGillivray Creek Coal and Coke Company and the International Coal and Coke Company at Coleman, while considerable prospecting has been undertaken by the Head syndicate on the Coleman outcrop where it crosses the headwaters of the South fork of the Oldman river.

At Blairmore the Rocky Mountain Cement Company is utilizing the Carboniferous limestone and the Fernie shales in the manufacture of cement; both materials are quarried in open pits and transported to the plant by aerial trams. During 1910 the output of cement from this plant exceeded 60,000 barrels, the daily capacity being about 500 barrels.

BURMIS IRON ORE.

At the end of the season a hurried visit was made to a number of iron claims in the vicinity of Burmis station, about 9 miles east of Blairmore. These claims have been prospected by means of open-cuts and a short tunnel along a line extending for about 8 miles northwards from a point near Burmis station; most of the prospecting, however, having been done near the northern extremity of this line on the headwaters of Cow creek.

The iron-bearing beds occur interbedded with a series of soft, rather coarse, light-coloured sandstones which outcrop along the foothills 2 or 3 miles east of the Livingstone range. This range is composed of Palæozoic limestone with a narrow belt of the coal-bearing Kootenay formation, evidently with a faulted contact, lying along its eastern flanks. The sandstone series containing the iron-bearing beds apparently forms part of the upper Cretaceous group which extends eastward towards the prairie, but as no fossils were found and its stratigraphical relations not seen, its proper horizon is not known. It is evident, however, that the great fault noticed in the Crowsnest valley near Burmis must extend northward, a short distance east of the Livingstone range, and with its eastern downthrow brings together the Kootenay rocks and the upper Cretaceous.

On the most northerly claims, where most work has been done, there are at least three iron-bearing beds contained in a thickness of not more than 250 feet of strata; the rocks here, however, are rather severely folded, causing difficulty in identifying the beds on which the various openings have been made.

In the valley of a small creek, rising in the Livingstone range, three distinct beds were seen, on the middle one of which a tunnel about 100 feet in length has been driven with a cross-cut 34 feet long, driven to the west, at the end. The tunnel and the first 20 feet of the cross-cut are in ore, but unfortunately this work was done on the axis of a synclinal fold with gentle dip on its easterly limb and slightly overturned to the west, the result being that at the tunnel entrauce the ore is lying almost flat while at the end of the cross-cut it is standing vertical. The ore is also somewhat fractured, is much slickensided, and shows considerable calcite developed along fracture planes. It is impossible at this point to gain a fair idea of the size or quality of the deposit. About 200 yards to the south of the tunnel an open-cut on the same bed also near the axis of the syncline shows it to be 8½ feet thick and fairly uniform in character.

Another open-cut about one-half mile south of the tunnel exposes a second bed which is probably below the first and is here 10½ feet thick. The strata at this point are nearly horizontal, dipping from 5 to 8 degrees to the west; and the ore appears to be of a very uniform nature. A sample taken across the bed in this cut was analysed by the Mines Branch with the following results:—

Fe (metallic)	39·80 per cent.
SiO_2	18·33 "
CaO	2·21 "
MgO	2·25 "
TiO_2	5·56 "
P	0·073 "
S	trace.

The writer was informed that there are a number of other openings both to the north and south of this point, but none of these were examined with the exception of a couple of small cuts, about 1 mile north of Burmis, where two beds of iron ore were seen. The ore, where stripped, was found to be dipping with practically the same angle as the slope of the hill so that it was difficult to measure the thickness of the beds, the larger bed showing about 5 feet and the smaller 3 feet of ore with the top in neither case clearly defined.

A sample of the smaller and richer-looking bed was taken and analysed by the Mines Branch, the results being as follows:—

Fe (metallic)	55·50 per cent.
SiO_2	12·53 "
CaO	2·78 "
MgO	0·52 "
TiO_2	5·74 "
P	0·10 "
S	trace.

It would appear that this deposit consists of a number of beds of indurated black magnetic sand, probably in the form of an ancient shore concentration. Under the microscope the ore was seen to be composed of more or less rounded particles of magnetite, quartz, and augite with a little secondary calcite, apparently derived from plagioclase, the whole being cemented with iron oxide. It is possible that the titanium dioxide shown in the above analyses may be due, at least in part, to the presence of sphene or rutile; if this is the case a product might be obtained by some method of magnetic concentration, sufficiently free from titanium to be of commercial value. Experiments are now being conducted in order to ascertain the nature of the titaniferous minerals present in the ore.

I.

GEOLOGY OF ROCHE MIETTE MAP-AREA, JASPER PARK, ALBERTA.

(*D. B. Dowling.*)

Introduction.

The activity in prospecting for coal in the Yellow Head Pass region, noted in the Summary Report for 1910, was continued during the past summer and has resulted in the establishment of a shipping mine—the Jasper Park collieries. Coal seams were also found east of Brulé lake at no great distance from the Grand Trunk Pacific, so that when there is a railway on each bank of the Athabaska four coal-mining centres will probably be actively engaged in producing coal. That is, a mine or mines on each side of Brulé lake and others farther westward on either bank of the Athabaska, above Fiddle creek, will furnish coal to the Canadian Northern and the Grand Trunk Pacific railways.

The energies of the party during 1911 were expended mainly on the mapping of the above-mentioned areas of economic importance. The previous season having been devoted, in the main, to mapping the southern portion of the coal area west of Fiddle creek, therefore the continuation of this area north of the Athabaska and those areas to the east of the first range received more particular attention this season.

The topographic details secured, consist of various traverses of roads and streams made to supplement the photographic records obtained while extending the triangulation inaugurated last year. The photographic work was carried out by L. H. Gass and A. J. Merrill, and the triangulation and angular measurements were by S. E. Slipper and E. H. Orser. Traverses were made by all the members of the party as opportunity arose, and it is a pleasure to record the cheerful and energetic assistance rendered.

Summary and Conclusions.

The coal-bearing Kootanie formation, of lower Cretaceous age, forms two coal areas, each of which extends in a general N.W.-S.E. direction on both sides of the valley of the Athabaska. One of these coal areas is situated east of the first range of the Rockies and crosses the Athabaska in the neighbourhood of Brulé lake. The second lies to the west of the first, inside of the first range of the Rockies.

The lower Cretaceous rocks brought up in the eastern coal area, east of the first range of the Rocky mountains, form an anticlinal ridge. There is evidence that Devono-Carboniferous rocks were overthrust from the west for a short distance on these Cretaceous beds. The anticline reached its maximum uplift in the hill known as Folding mountain, and the denuded northern end of the hill shows that the Carboniferous limestones form its axis, while overlying coal-bearing Cretaceous beds are present only as an encircling band. A part of the eastern limb of the anticline is available as a coal-mining area, and probably also a part of the western which, however, may be either much crumpled or overridden by the Devono-Carboniferous. South from this point of maximum upthrust, the elevation of the outer range decreases and it seems probable that the Kootanie rocks will be found exposed in several of the ridges which form the continuation of the Folding Mountain anticline. Northward the anticline is very hard to follow since, where it crosses the Athabaska valley, erosion has been heavy and the strata are largely hidden by detrital matter. In the hills to the north and west of Brulé lake, the anticlinal axis, along which outcrop the coal-bearing beds of the upper part of the Kootanie, is seen in close proximity to the first range where it is very evident that the western limb of the Cretaceous anticline passes beneath the Devono-Carboniferous limestones of the first range. These Cretaceous beds may also be seen beneath the same limestones on the south side of the river in Drystone creek.

The coal area inside the first range crosses the Athabaska from the valley of Moose creek on the north and follows south along the east face of the range which terminates at the river in Roche Miette. The southern part is divided along its length by a broken anticline which shows in places older strata. The eastern portion is probably a narrow basin in which only the lowest seams are likely present. The western part, which is a monoclinal block for part of its length, presents more favourable conditions for mining from the edge of the valley by tunnels along the seams. Three workable seams of steam coal in beds of 5, 10, and 13 feet, respectively, have been prospected at the Jasper Park collieries situated in this western portion.

North of the Athabaska the eastern trough narrows, finally disappears, and at about 4 miles from the river the basin may be said to be unbroken except for folds in the measures toward the western edge. At the canyon on Moose creek, half a mile below the crossing of the 6th principal meridian, a small seam of coal is found below a conglomerate band. Above the canyon, at a point 3 miles up stream, five workable seams have been discovered, for which details are given later.

Topography.

The general structure of the Rocky mountains from the International Boundary north to the Saskatchewan river is that of a series of westerly dipping fault blocks of similar strata resting against each other. A repetition of form and of strata, and a continuity in the ranges, therefore, obtains, but in going northward, more diversity in the form of the blocks is noticeable. The uniform westerly dip and the regular repetition of beds is to a great extent replaced by folding of the strata, while a greater variety in the outline of ridges is apparent. This departure from the regularity of form that holds in the south, is exemplified in the district visited this summer. This district forms a part of the outer ranges of the Rocky mountains, and is crossed in an east-west direction by the deeply eroded valley of the Athabaska river, into which drain several streams flowing between the tilted and folded blocks of strata that form the ranges.

One mountain chain occurring in the southwestern part of the district, seems to be quite persistent although its general direction is deflected at the Athabaska. A flat-topped, cliff-sided point on this range, south of the Athabaska, has long borne the name Roche Miette and forms one of the most striking features in the landscape. Between this range and the foothills, the mountains, largely owing to their geological structures, are more irregular.

In the northern portion of the map-area, the outer ridges are the upturned edges of the harder beds of a wide fault block. At the Athabaska river, this block shows signs of longitudinal folds and breaks, which, farther south, have prevented any continuity of the ranges. One short ridge south of the Athabaska, occupying a position in advance of the mountains, is plainly caused by a simple fold, and the arch so formed—a short ridge of limestone exposed by the erosion of the softer rocks of the original surface—bears the descriptive name, Folding mountain.

The foothills near the Athabaska valley are not prominent and to the south are somewhat irregular especially near the mountains; to the north the ridges have steep faces towards the mountains and long easy slopes northeastward.

The drainage channels that are cut through the mountains or foothills in many instances seem to owe their origin to breaks in the upthrusted blocks.

The stream occupying the Athabaska valley above Brulé lake is, for some distance, depositing considerable fine-grained material along its bed, and its present meandering course by many channels, through a swampy flat with the evidence of discarded channels, seems to indicate that it has partially filled a former lake which extended from Brulé lake to Jasper lake, and that possibly the present shallow basins may eventually become silted up. The presence at Brulé lake of lake deposits at elevations of 100 feet above the preseut water level tends to show that probably the outlet has been lowered.

Gravel terraces similar to those in the Saskatchewan and Bow valleys are found at elevations up to 300 feet above the present river. These probably belong to the same period as the transported deposits known as the Saskatchewan gravels.

The tributary streams entering on each side are moving a large amount of gravel into the Athabaska valley and in almost every case show a steady growth of fan deposit near the mouth. Thus at the mouth of Fiddle creek, the steeper grade of the tributary stream has enabled it to move material toward the Athabaska river that could not be removed by the current of that stream. Consequently the river has been forced over against the rocky walls of the ridges on the north side. At the mouth of Moose creek a smaller collection of river-borne material forms a flat fan, which occupies a part of the river flat. This appears to be due to the activity of the current of Moose creek and its growth shows a corresponding influence in deflecting the course of the river away from the north bank. The large tributaries, such as Rocky and Stone Indian rivers, which enter the Athabaska from both north and south, may have been the cause of the formation of Jasper lake, by moving material into the valley and thus forming an obstruction partially damming back the water. Brulé lake, although it seems to be silting up, has no doubt also been lowered by the erosion of the barrier at the outlet. This barrier consists of tilted beds of Cretaceous sandstone that, separated by shale, form a succession of hard ribs. The channel which is being cut through them from Brulé lake to the mouth of Prairie creek, although it has a fairly uniform and heavy gradient, is still in process of erosion where it crosses each of the ribs. The gradient of the channel through this barrier steepens perceptibly a short distance below the lake, and there are several rapids. None of them, however, are at the outlet, so that the erosion, still going on, does not immediately threaten the existence of the lake.

Forest.

The largest extent of green forest. containiug timber of marketable size, occupies a triangular area of country lyiug to the east of Brulé lake. Other fairly large areas of unburned timber are found withiu the mountains, on the flat lands through which wind the many chaunels of the Athabaska river. Another area of green forest extends in patches from the head of Drystone and Prairie creeks to the western sources of McLeod river. Although throughout the district there are, here and there, small patches of living trees, the greater part of the original forest has been burnt. This burnt forest. however. remains standing, or when falleu, decays very slowly and is free from borers. There is thus a large quantity of material in a dry state that should not be allowed to rot or by subsequent burning further destroy the soil and seedlings already springing up. The measures to be taken to remove this material which is an eyesore and an obstacle to travel through the country may be successfully arrived at. In the vicinity of the mines, much of it can be used as lagging and in timbering.

National Park.

The facility with which the mountains can be reached since the construction of the Grand Trunk Pacific railway to the mouth of Miette river, offers great inducement to those seeking change for health or recreation, and the adaptability of this area for health and pleasure resorts may be noticed. The scenery of Jasper park is pleasing, since the valley of the Athabaska which is wide and well furnished with lake-like stretches of water, forms a contrasting foreground to the mountain peaks and ranges on either side. The outer ranges, while not grand masses, are sufficiently high to afford difficulties in mountain climbing, besides which they offer in their folded strata, studies in the great processes of mountain building and evidences of the mighty forces of nature. The approach to the mountains by way of the Athabaska valley offers ever-changing scenic views of river stretches and wooded hills, above which can be seen the rugged ridges of the outer range. The upper waters of the Athabaska have their origin in the main range and in this, at no great distance from the railway, some of the highest peaks in the Canadian Rockies are to be found.

A new town, Fitzhugh, is now being laid out at the mouth of Miette river, a few miles above the site of Wm. Henry's old trading post, and from it the adventurous have choice of many high peaks. The picturesque Maligne lake, the description of which is from the pen of Mrs. Schaffer, the first lady, and possibly the first explorer, to describe its valley,[1] is within a distance of less than two days' travel from the town. A survey of its waters was made this season by Mrs. Schaffer, and will no doubt appear in one of the geographical magazines.

Another townsite is being surveyed at Fiddle creek, and it is also the location for a large hotel selected by the Grand Trunk Pacific Railway Company under the shoulder of Roche Perdrix, commonly called Fiddle mountain. From this point it is proposed to construct a road to the hot springs, a distance of about 7 miles up Fiddle creek, passing through a very rough canyon. The waters of the springs, of which there are several in a group, vary in temperature—the highest observed being 127 F.—and give off a decided sulphurous smell. The medicinal value of the springs has been tested by the workmen on the railway construction with favourable results to alleviate rheumatic attacks induced by exposure and hard labour.

Transportation.

Trains on the Grand Trunk Pacific railway are run west as far as Fitzhugh, near the mouth of Miette creek and the site of Henry House. Progress is being made on the construction of the line through the pass, but on Miette creek this is retarded by considerable rock-cutting. The difficulty in the construction of the piers for the bridge across the Athabaska caused considerable delay and a temporary structure was ultimately used. The Canadian Northern Railway Company is also actively engaged in the construction of a through line to the Pacific coast, and the section from Edmonton to the mountains will probably be completed during 1912. This road passes through the park on the northern and western side of the Athabaska. The coal areas on both sides of the river have thus excellent shipping facilities in two directions—eastward to the network of railways traversing Alberta and Saskatchewan, and westward through British Columbia to possible smelters requiring coke.

General Geology.

The section of the consolidated rocks of this district includes a sequence of beds from the middle Cretaceous downward to and including argillites, sandstones, and limestones of Cambrian age. The crests of mountain ridges are almost wholly of the harder members of this series, namely the heavy limestone beds referred to the Carboniferous and Devonian. Among the formations so far recognized are certain thin-bedded, shaly sandstones found between the red beds of the Triassic and the limestones of the Carboniferous, to which in the absence of fossils, either a Permian or upper Carboniferous age might be assigned. There is also a series of shales between the Devonian and Cambrian rocks in which no fossils have been found. These are provisionally referred to the Silurian but may be lower Devonian.

[1] Bull. Geol. Soc. Phila. Vol. VII, No. 3, 1909.

TABLE OF FORMATIONS.

Recent	River deposits.
Pleistocene	Boulder clays.
"	Cemented gravels (similar to Saskatchewan gravels).
Cretaceous	In the disturbed area of the foothills, beds of the Edmonton series are found. In the mountains the lower part of the Cretaceous is exposed.
Jurassic	Shales and sandstones.
Triassic and Permian	Red and yellow sandy shales and yellowish sandy dolomites.
Carboniferous	Limestones and shales in thick beds.
Devonian	Heavy bedded limestones.
Silurian (?)	Shaly limestones.
Cambrian	Yellow sandy limestones and reddish argillites.

CRETACEOUS.

Kootanie Formation.

The beds of this formation are the highest of the Cretaceous exposed within the mountains at this latitude and are the coal-bearing beds of the foothills and mountain areas. They are of fresh-water origin, though salt water deposits are not entirely absent. Plant remains are to be found throughout the whole thickness of the measures. A small collection of plants was brought from these beds on one of the branches of McLeod river from the Nikanassin basin. The species represented as determined by Dr. Knowlton include the following:—

Podozamites Lanceolatus, (L. and H.) Nahorst.
Sequoia Reichenbachii, (Geinitz) Heer.
Sequoia Smittiana ?, Heer.
Oleandra gramniæfolia, Knowlton.
Zamites acutipennis, Heer.
Asplenium Dicksonianum, Heer (of Dawson).

From the shales above a coal seam at Folding mountain, Mr. W. J. Wilson and Dr. Knowlton recognize the following forms:—

Sequoia Reichenbachii, (Geinitz) Heer, and *Sphenolipidum Kurrianum,* Heer.

The sections as found south of the Athabaska, when compared with those of the Bighorn basin, are found to be somewhat similar, having in each a conglomerate band beneath the productive part of the coal measures. North and east the principal apparent change is the introduction of beds of conglomerate in the upper or coal-bearing portions.

A varying amount of the Cretaceous is exposed within the mountains. Since it is not certain that the top of the Kootanie is present, an estimate of the total thickness is not possible.

JURASSIC.

Fernie Shales.

The best exposures of these beds occur on Fiddle creek below the mouth of Sulphur creek, and consist of black shales, among which sandstone beds are distributed. These sandstone beds contain marine shells. In the first rib of sandstone below the plant-bearing beds of the Cretaceous, and separated from them by 100 feet of shales, forms similar to *Arctica (Cyprina) occidentalis* and *Nemodon sulcatinus* were found. The first of these is recorded by Dr. Whiteaves from the lower shales of Queen Charlotte islands, and regarded as Jurassic. The second is probably one of the forms from the same horizon described under the name *Arca* (Nemodon).

Below and separated from these sandstones by approximately 100 feet of dark shales, lies a second sandstone rib. In this, specimens of *Gryphaea planoconvexa, Ostrea strigicula,* and a species of *Terebratulina* were found. Of these Mr. Raymond says: "The fossils and their mode of occurrence strongly suggest the Ellis formation of Montana and the Yellowstone National park." The Ellis formation has been considered as Jurassic, and this, therefore, furnishes the first correlation between the Fernie shale horizon and the Jurassic of Montana, although previous to this the Jurassic age of the Fernie shale and the lower shales of Queen Charlotte islands has been admitted.

TRIASSIC AND PERMIAN.

In the Cascade basin the beds included in the above were the Upper Banff shale and the Rocky Mountain quartzite. Here a subdivision has not as yet been made. The series consist of reddish shales and dolomites resting on yellow to brown shales and sandstones or quartzites. No fossils have been collected from any of the beds, but the presence of Triassic rocks in the mountains along the Brazeau has been established by the finding of fossils of the Monotis type. The Monotis beds on Peace river to the north are also included in the Triassic.

PALÆOZOIC.

Carboniferous.

Immediately beneath the thin bedded brownish quartzites and shales there are two heavy limestone formations separated by thinner bedded limestones and dark shales, which occupy positions similar to the Upper and Lower Banff limestones. The Lower Banff shale, which in the south separates these limestones, is here of somewhat similar character, but occupies a much greater thickness in the section. From the upper limestone band a few fossils were collected, but their determination is only provisional, and detailed study and comparison with those from Banff may alter the list considerably.

The thickness of the two limestone bands, with intervening shales, approximates only about 3,000 feet, which even with the addition of the shales below would be thinner than the Banff section.

Devonian.

The rocks of Roche Miette show a heavy limestone bed of a somewhat yellowish weathering appearance superimposed on shales and sandy limestones, the lowest of which represent horizons below the Devonian. It is probable that the same heavy limestone is repeated in the cliffs on the west side of Brulé lake. The Roche Miette limestone is thus similar to the Intermediate beds of the Bow River section. From the lowest part of this limestone Mr. McEvoy collected the following[1]:—

Atrypa reticularis, (Linne).
Dyphyphyllum, sp.
Cyrtina, sp.
Spirifer (or *Spiriferina*), sp.
Casts of elongated spiral gasteropod.

[1] Ann. Rep. Geol. Survey, Vol. XI, p. 29 D.

Our collection from Mr. Raymond's list includes:—

Syringopora, sp.
Favosites cf. *F. digitalus*, Rominger.

These are from the loose material on the face of the limestone.

From the summit and in thinner beds than the mass of the heavy limestone band, the forms found are:—

Proetus, sp. ind.
Schuchertella, sp. ind.
Cyrtina, sp. ind.
Atrypa reticularis (Linne) var.
Gypidula cf. *G. comis*, Hall.
Fish tooth.

Mr. L. M. Lambe has furnished the following description of the fish tooth mentioned in the above list:—

"The small, anterior, detached fish tooth, labelled 'summit of Roche Miette, Alberta, D. B. Dowling, 1911,' is apparently referable to the genus Helodus, Agassiz, of the Palæozoic selachian family Cochliodontidae.

"The specimen was embedded in bluish-grey limestone holding many fragments of crinoid stems. It is transversely elongated and arched, and rises in the centre to a rounded prominence. Its measurements are: diameters, 12·7 mm. by 4·6 mm., max. height, 4 mm. The surface of the crown is smooth and exhibits numerous minute punctæ.

"Detached teeth which have been referred to this genus occur in the Chemung (upper Devonian) of Pennsylvania. Over a dozen species have been described from the Subcarboniferous of the central States (Iowa, Indiana, etc.), and the genus is sparingly represented in the Coal Measures of Illinois. The Carboniferous Limestone series of Great Britain has furnished material for a number of specific forms.

"As the fish tooth from the summit of Roche Miette is not apparently referable to any known species of the genus to which it is considered to belong, and as this genus ranges from the Chemung up into the Coal Measures, there is no evidence supplied by the tooth in question as to the exact age of the limestone beds in which it was found, whether they are uppermost Devonian or belong to a rather higher horizon.

"A portion of another fish tooth, labelled 'Falls, north side of Athabaska river, Brulé lake, Dowling, 1911,' is preserved in a piece of limestone similar to that from Roche Miette, and also holding numerous remains of crinoid rings in a like state of preservation. This locality is within 6 miles of Roche Miette.

"The second specimen is incomplete and consists of a portion of a flat-pavement tooth. The part preserved is four-sided with two rounded angles, one of the sides being the line of fracture. It measures 9 mm. in length and breadth. The surface is smooth and polished, and, as in the Roche Miette tooth, punctæ are present. At the unbroken end the bony base projects beyond the margin of the upper polished surface.

"Traquair has shown that in a connected dental series of the Cochliodont sharks there is a great variation, according to location, in individual teeth, in both shape and size. It is, therefore, probable that this second specimen belongs to the species represented by the Roche Miette tooth."

The limits of the Devonian can scarcely be defined as yet without further collection of fossils and study, but it seems to include the shale band above the limestone as well as the thin-bedded limestone beneath. An approximate thickness of 3,000 feet will probably include all that is definitely Devonian.

Silurian (?).

As there is no marked unconformity in the series down to the lowest rocks found, namely, the middle Cambrian, there is, therefore, a series of shaly beds which may be grouped under the above head. The only fossils found were in beds 200 feet above the Cambrian, and of these Dr. Shimer says:—

Upper Part of Yellow Bed, Roche Miette.—Stromatopora (Syringostroma) sp. (Genus characteristic of the Devonian). "From the known distribution of the species . . . the age of the beds containing these forms should be lowest Devonian or possibly Silurian."

Cambrian.

Near the base of the series which forms the mass of Roche Miette a distinct yellow band is exposed near the fault line which separates the lower rocks from the Cretaceous. Along the range to the south, a few hundred feet of lower beds intervene, but this yellow band is very near the base of the limestone series as exposed in the outer ranges. The evidence of age is given by Mr. Raymond as:—

Crepicephalus cf. *C. iowensis*, (Owen).
Ptychoparia affinis, Walcott.
Ptychoparia cf. *P. wisconsonensis*, Owen.
Dicellomus, sp. ind.

"These species indicate a horizon about the same as the upper part of the Gallatin limestone of Montana which Dr. Walcott has referred to the upper part of the middle Cambrian. The fauna is also similar to that of the upper middle Cambrian of the upper Mississippi valley, and not of the same type as the middle Cambrian at Mount Stephen and elsewhere."

ECONOMIC GEOLOGY.

CEMENT AND LIME.

The wide use of cement in the building industry in Alberta, has led to the construction of cement works on both branches of the Canadian Pacific railway near the mountains, since the necessary calcareous material is found only in very small amounts in the rocks of the plains. Calcareous deposits in the form of marl beds have been found in the vicinity of the Grand Trunk Pacific railway west of Edson. The foundations of cement works in the vicinity have already been laid and it is probable that the manufacture of cement will be assured in a few years.

It is also probable that the limestone and shale of the outer ranges of the mountains may be used for a similar purpose.

Locations for the quarrying of limestone, presumably for lime manufacture, have been applied for on both sides of the Athabaska valley—on the western slope of Roche Miette and the same beds on the slope of Roche Ronde.

IRON ORE.

Some of the shale bands which separate the limestone formations contain a small amount of iron oxide. The greatest impregnation noticed is to be found in a series of siliceous shales between the limestone and the overlying coal-bearing rocks. As red bands, these rocks have been traced northward from the Kananaskis river, and their increased thickness and extent increases the probability of finding in them mineable bodies of iron ore, though, as a rule, these would be of low grade. Samples of thin beds of richly impregnated rocks which looked promising were brought in by assistants on the party from the slopes of the hills east of Moose creek. These appear to have been obtained from rocks just below the red band and may be the result of infiltration from the beds above.

COAL.

The rocks of the Kootanie, which is in general a sandstone and shale formation, contain coal seams. These rocks, previous to the formation of the Rocky mountains, were deeply buried, but are now found outcropping in the valleys of the outer ranges, having been elevated along with the great blocks of the underlying limestones. In the foothills, they are occasionally found in advance of the first range. The uplift necessary to bring these beds to the present surface was accompanied by the formation, to the east, of a wide syncline in the rocks of the plains. This basin, at the latitude of Edmonton, is wide, but farther south narrows, and the dip of the beds on either limb of the syncline steepens perceptibly. Near the Athabaska an anticline or elliptical dome, showing by denudation a central axis of limestone, has formed in front of the first range. Beds of coal and the lower part of the coal-bearing series thus outcrop in elliptical form round the exposed limestone mass (Folding mountain), but portions on the west side may be entirely over-ridden by the limestone of the first range. North of Brulé lake, the anticline in the Kootanie beds appears to be a continuation from Folding mountain, and coal seams have been exposed by prospecting on both sides of the axis.

Coal Areas.

Scovil Creek.—Mention was made last year of the finding of coal on this creek. The claim known as the Keywood location covers a width of a mile on the creek. The original outcrop of coal was near the summit of the anticline, so that the seam has an exposure of a short distance only on the side of the valley. The part on the eastern slope of the anticline is the most promising for mining, as the thickness is 9 feet 6 inches and the dip is only 25° northeast. Some prospecting has been done on the slope of the hills toward Brulé lake. One hole was found in which a 12 foot seam had been uncovered. The outcrop shows many dirty streaks in the coal and a portion only may be good mining coal. This portion is an upper seam and is separated apparently from the one on the gully by a band of conglomerate. On this same creek, but above the apex of the anticline, some prospecting has been done on the westerly-dipping beds by Mr. Bartholemew, who has secured a lease on property west of the Keywood claim. Two seams showing cross-faulting have been located. The upper one is very dirty and has hardly enough coal to mine. The lower one is about 5 feet in width and is of a very fair grade of coal. Mr. Bartholemew's sample analysed by Mr. J. O'Sullivan, Vancouver, June 20, 1911, gives:—

Moisture	0·5
Volatile matter	19·0
Fixed carbon	73·5
Ash	6·0
Sulphur	1·0
	100·0

This shows the result of greater pressure on the beds in that it has more fixed carbon than the Keywood 9½ foot seam. No prospecting has been done between this 5 foot seam and the one down stream on the Keywood claim on account of the indefinite nature of the boundary between the claims. Northward, several leases have been applied for, and there is every prospect that mineable seams will be found, since the foothills on the west side of Solomon creek, which comes from the northwest in a large valley, are composed of the Kootanie rocks.

North End of Folding Mountain.—Prospecting on the lower beds of the coal-bearing Kootanie rocks, lying on the east flank of Folding mountain, was inaugurated in 1910 by Mr. McEvoy for the Northern Alberta Coal Syndicate. The operations during the past season have proved the presence of a seam of coal about 11 feet in thickness crossing the southern part of section 29 and the northern part of section 21, township 29, range 27, west of 5th. It was discovered on the east flank of Folding mountain in a gully near the eastern edge of northwest quarter, section 21, and traced for a fourth of a mile to the northern slope. At a distance of about a mile and at a much lower elevation, or near the foot of the slope of Folding mountain, a similar seam, believed by Mr. McEvoy to be above the first, was found by trenching across the measures. The section or the distances between the seams thus found in the vicinity of the boundary between the southeast and southwest quarters of section 29, ending at the southern boundary of the section, is given in the following in descending order:—

Sandstone.	
Highest coal seam—*Coal*..	2 feet
Clay..	4 "
Sandstone.	
Trenching showing shale and sandstone..	153 "
Coal..	4 "
Trenching showing shale and sandstone..	258 "
Coal..	11 feet 3 inches
Trenching showing shale and sandstone..	340 "
Wedge of coal 6 feet at surface pinching out with depth..	6 "
Partly trenched, shale, etc..	460 "
Small showing of coal dust.	
Sandstones in heavy bed forming rib on side of mountain..	50 "
	1.288 feet.

In this section, the rocks strike N. 69° W. astronomic and dip S. 65° to 80°. The dip will probably increase with depth and change to the northward. Of the two seams with 11 and 4 feet of coal, respectively, the prospecting has been confined to a small shaft on the 4 foot seam and a tunnel run from a suitable tipple level on the strike of the 11 foot seam. The tunnel had reached a distance of 100 feet from the entry where the seam was of fairly solid coal with a few dirty streaks which raised the ash of the sample taken across the seam. The analysis shows this coal to be slightly softer, containing about 3 per cent more volatile matter than that of the tunnel seam at the Jasper collieries. It is, however, not quite as bituminous as the upper seam at the above locality by about 3 per cent less volatile matter, but has strongly marked coking qualities.

Attempts have been made at tracing the measures westward toward Brulé lake, but the surface deposits proved very thick and of a sandy nature, thus allowing the contained water to accumulate in the pits. The addition of pumping appliances is required.

West Fork McLeod.—South of Folding mountain the Kootanie measures are exposed in front of the first range. Considerable prospecting has been done in this area on the exposed coal seams, but its development must await the building of railway connexion with the main lines to the north. This amounts to a probable distance of 25 miles. The locality was not visited, but the following information is given by Mr. Jas. McEvoy, a former member of the staff, who was in charge of the prospecting work.

The section on the south branch of this stream shows beds dipping north 20° east at an angle of 70°. The section there shown in decending order is:—

Shale	200 feet.	
Sandstone	120 "	
Coal	2 to 3 "	
Sandstone and shale	75 "	
Coal	8 "	6 inches.
Sandstone and shale	115 "	
Coal	4 "	
Shale	7 "	
Coal	28 "	

The two lower seams from the prospecting samples taken across the seams show the customary amount of ash for surface samples, which is principally in the broken and softer parts of the seam and is attributable partly to impurities filtered from the surface. A specimen of lump coal from the 8½ foot seam, assayed as follows (Thos. Heys and Son, of Toronto, assayers):—

Moisture	0·54
Volatile	25·28
Fixed carbon	69·95
Ash	4·23
	100·00

It is predicted that an average of 600 feet vertically may be mined above the entry on the coal seams in the valley of the creeks.

The Mountain Coal Basins.

Within the outer ranges strips of the lower Cretaceous rocks have been preserved on the lower edges of some of the fault blocks and form the rocks through which some of the lateral streams have eroded channels. There are several valleys in which possibly the lower part of the Cretaceous may still remain, but as a coal formation the most important is the Cretaceous block which is found in the valley of Moose creek and southward in front or to the northeast of Roche Miette, along the west side of the valley of Fiddle creek. The coal-bearing beds are in the upper part of the Kootanie series, and remnants of this part are found both in the centre of the valley and in contact with the next succeeding fault block. The fault line, which is the western boundary of the coal area, is generally concealed by detritus, but its approximate position is indicated by changes in the dip of the beds and by local folding.

Owing to a differential uplift of the western edge of the coal measures, and to a deformation of the block by anticlinal folding, the southern end of the block is raised and the beds containing the workable seams have been eroded. Continuing south this elevation results in the cutting away almost entirely of the rocks of the lower part or non-productive portion of the Kootanie formation, so that only a very narrow band, if any, remains to form a connexion with the Nikanassin basin to the south. The measures containing mineable coal seams extend south from the Athabaska to about Sulphur creek. Northward they extend up the valley of Moose creek, and are reported as continuous to the headwaters of streams running to Smoky river, thus forming a trough that extends some considerable distance north.

The southern part of this basin is divided into two parts by an anticlinal fold along its length. At the south end, the coal areas are separated by faulting as well, but this gradually disappears northward. The eastern part is mainly in trough form, while the western, although composed of westerly dipping beds, may, in the vicinity of the major fault, which terminates the western extension of the measures, be greatly modified by foldings from the monoclinal form. It is a wedge-shaped block, narrow to the south but broadening northward, the rocks dipping toward the southwest at fairly constant angles which vary from 50° to 70° in different parts of the field. This part occupies the western edge of the fault block of which it is an upper member and is partly overridden by rocks of the next range.

The measures near the western fault are sometimes upturned and folded back, especially the highest beds at the fault contact. Those near the fault and lower in the series, and consequently seen at lower elevations, are overridden by the limestone and show less folding. The strong ribs of sandstone and the rib of conglomerate near the base of the productive coal measures form prominent ridges that show a continuity arguing well for the condition of the coal in their proximity; the lower seams, therefore, at least for this block, should be mineable southward to Villeneuve creek. Northward the block appears to widen, and should be from that fact of greater value as a coal field, since higher beds may be exposed and a greater number of seams found.

The eastern part of the coal field is in the form of a trough, the southern end of which is elevated and south of Villeneuve creek eroded away. On that creek the trough is too shallow to warrant the expectation of finding in it mineable coal seams, but on Morris creek it is much wider and the beds of the eastern limb of the syncline are not so much disturbed as those of the western limb. The inference from the exposed part of the section is that the upturn on the west was accompanied by faulting and that this fault line which separated the two coal areas reached nearly to the Athabaska valley. The section on Villeneuve creek shows an upturn of the beds on the western limb of the syncline, but after a short interval of concealed beds, lower sandstones are found dipping to the west in conformity with those of the block next the mountains. This indicates a displacement by faulting. On Morris creek there is an apparent trough, but at the point of reversal of dip, which should be the centre of the trough, the beds on the east belong at least 1,200 feet higher in the section than those on the west. There is here probably a break in the western limb and a push up of the block on the west; the amount of displacement is evidently greater than 1,200 feet.

The surface drainage north of Morris creek runs to the Athabaska, and the rocks exposed are lower down in the series than those of Morris creek. The only exposure there along the eastern edge of the western block is on Mountain creek, quite near the probable line of break, and shows sandstones containing a 9 foot seam of coal lying almost horizontal, and evidently from the attitude of the neighbouring beds forming the centre of a syncline. Near the Athabaska, the eastern block is traced only by the sandstone ridges of its eastern margin which are almost vertical. The outcrop of the rocks on the western side is concealed so that the structure is inferred from the outcrops on the opposite side of the river. The western block is traced by sandstone ridges almost to the Athabaska, where two coal seams are being mined at present. The conglomerate bed is exposed in Mountain creek, and is crossed by the stream near the edge of the terrace where the erosion of the softer beds above it has formed a fall into a narrow canyon. The erosive action of the water on the face of the conglomerate wall has hollowed out a basin at its foot and local usage has given it the descriptive name Punchbowl fall.

North of the Athabaska, the break in the centre of the eastern basin is not very evident, and the anticline on the eastern edge of the western block is plainly seen on the side of the valley, where the conglomerate stands out prominently. The double fold that is thus shown narrows down in going northward and disappears on Moose creek within 5 miles of the Athabaska valley. North of this the field is practically a continuation of the western block, and is a modified monocline. The modification is in the introduction of a second anticlinal fold which is found to the west of the first and near the fault line that limits the field in that direction. The effect of this second fold is not noticed in the beds 6 miles north but may be present on the western side of the valley.

Western Block.

Villeneuve Creek.—The lower shales and sandstones of the Kootanie appear by the sections on this creek to contain very little coal, thin streaks only being observed from the bottom sandstone almost up to the conglomerate bed. Some coal dust, occurring below this conglomerate, may indicate a small seam but its thickness cannot be very great. Above the conglomerate, the beds show the following section:—

Measures.	Feet.	Remarks.
Coal clear seam	10	
Sandstones	250	
Coal	12	Sample and analysis.
Sandstones, some shale	350	
Coal thin streaks		
Sandstones	100	
Coal	5	Analysis by F. G. Wait. Moisture 2·37 Volatile 22·38 Fixed carbon 68·58 Ash 6·67 100·00
Sandstones and shales	250	
Conglomerate	30	

Morris Creek.—On Morris creek, the first western branch of Fiddle creek, the following section is given but it is only approximate, the distances being estimated by pacing.

Heavy sandstone bed—			
Coal	3 feet	10 inches.	Coal 10 feet 11 inches sample and analysis.
Shale	0 "	6 "	
Coal	7 "	1 "	
Sandstone	150 "	0 "	
Sandstone and shale	100 "	0 "	
Coal	9 feet	7 inches.	Analysis by F. G. Wait. Moisture 1·34 Volatile 22·91 Fixed carbon. 68·51 Ash 7·24 100·00
Sandstone	350 feet	0 inches.	
Coal	5 "	6 "	
Sandstone	2 "	0 "	
Coal	3 "	0 "	
Sandstone and shale	300 "	0 "	
Conglomerate.			

Mountain Creek.—Below a point where several streams coming from the eastern face of Roche Miette unite to form this brook, an exposure of a seam in a shallow syncline shows 9 feet of coal. This may be in the bent-over eastern edge of the western block. In the gorge somewhat higher up the stream, the beds have a regular dip for a short distance of about 42° southwest. In these a seam showing 5 feet 7 inches of coal has been uncovered. Neither of these seams has been traced toward the Athabaska. The sandstone ridge between them continues to the vicinity of the river, and the supposition is that the larger is one of the seams at the Jasper collieries, which is found just below this sandstone ridge. This has been traced along the face of the ridge for about a mile, but not to Mountain creek. The mining on this seam is by level entry near the Athabaska, at the surface level of the gravel terrace, and later from tipple level above the tracks of the Grand Trunk Pacific. The seam dips 56° to the southwest and is here about 500 feet horizontally west of the conglomerate outcrop. This is a distance representing about 414 feet of beds. The section at the tunnel shows a slight thickening of the lower coal in going to the south-east, but will average somewhat as follows:—

Coal	9 feet 6 inches.
Sandstone	1 to 2 feet.
Coal	3 to 4 feet.

Another seam apparently about 13 feet thick has been located 1,050 feet south-west of the tunnel. It is an upper seam, apparently 870 feet above the tunnel seam.

It is possible that other seams that are indicated in the sections on the creeks to the south may also occur here; if this is found to be so, it will add materially to the value of the mine.

North Bank of the Athabaska.—In the portion next the Athabaska river, the exposures of sandstone and conglomerate are confined mostly to the lower part of the formation. On the western limb of the anticline, five seams of coal above the conglomerate have been found. One which appears to be the continuation of one of the big seams at the Jasper Park collieries, has an outcrop exposure of 11 feet 7 inches of coal, and below this and between it and the conglomerate a 5 foot seam is reported.

In a gully which joins Moose creek from the west near the 6th meridian, there are several exposures of conglomerate, and it is suggested that these may not represent one bed, but three distinct horizons with 2,000 feet between the two lower and 1,000 between the upper ones. It is at present impossible to verify owing to portions being concealed, but that it is possible is proved by the section of MacVicar creek which shows three conglomerate beds. The section thus interpreted would give over 3,000 feet of measures above the lowest conglomerate and would possibly contain several coal seams.

The section up this gully from the lowest conglomerate includes a trough one-fourth mile wide at Moose creek, in which the conglomerate forms the east and west sides. The western side then turns abruptly down to the west, and 3,000 feet up the gully a 10 foot bed of conglomerate dips 67° S.W. At 4,300 feet an 18 foot bed of conglomerate dips 42° S.W. but comes up again at 4,500 feet dipping 64° S.E. This bed then passes over an anticlinal fold and is seen again at 5,600 feet, dipping 82° S.W. The beds above this conglomerate are exposed for 175 feet and contain at 103 feet from the conglomerate, the first exposed seam of coal on the creek. The following section occurs there:—

Coal	0 feet	6 inches.
Shale	0 "	6 "
Sandstone	4 "	0 "
Shale	3 "	0 "
Coal	1 "	5 "
Shale	2 "	0 "
Coal	5 "	6 "
Sandstone	4 "	0 "
Coal	0 "	8 "
Shale	1 "	0 "
Coal	3 "	4 "

Measures to conglomerate 103·0.

The upper part of the valley is eroded diagonally across the measures and at a distance of 6 miles above the 6th meridian is in the upper measures. The only exposure of coal on this part of the creek is of a seam which is above the lowest conglomerate and near the northwest end of the eastern trough. It seems to be in a disturbed portion of the area, but will probably be found in a less disturbed place. The section here shows about 5 feet of clean coal as below:—

Shale roof—	
Clean coal	2 feet 5 inches.
Dirty coal	1 " 0 "
Broken coal and shale	1 " 7 "
Shale	0 " 7 "
Coal	5 " 2 "
Sandstone	0 " 6 "
Shaly coal	2 " 4 "
	13 feet 7 inches.

Samples from the top and middle portions, analysed by Mr. Wait of the Mines Branch, give the following results:—

Moisture	2·29
Volatile combustible	19·63
Fixed carbon	66·08
Ash	12·00
	100·00

The upper part of the valley being eroded mostly in the upper beds of the Kootanie, the hills forming its northeastern sides are of the westward-dipping beds of the coal measures. Although little prospecting has been done, Mr. MacVicar has furnished the following information relative to a section across this block in a gully from the east. Ascending this gully from Moose creek three bands of conglomerate are passed, and except for minor variations, the strike of the beds is quite uniform. The dip increases in the lower members of the section or toward the east side of the valley. Exposures between the two lower conglomerate beds seem to be few and no coal seams are recorded. From Moose creek to the second conglomerate, a very good section showing all the changes in character of the beds has been measured. A summary of this section is introduced here, beginning at the first exposure from Moose creek, the highest beds seen.

Section on MacVicar Creek—(In descending order.)

Shale	200 feet	0 inches	
Sandstone and shale	236 "	0 "	
Coal seam 1	5 "	9 "	
Shale and concealed	85 "	0 "	
Coal and shale	5 "	0 "	
Coal	1 "	4 "	
Shale	101 "	6 "	
Coal seam 2	6 "	10 "	Strike N. 40° W. mag., dip 53° S.W.
Shale	69 "	3 "	
Coal seam C	14 "	8 "	Strike N. 30° W. mag., dip 68° S.W.
Concealed shale and sandstone	163 "	0 "	
Conglomerate	45 "	6 "	
Coal seam B	5 "	6 "	Strike N. 49° W., dip 69° S.W.
Sandstone and shale	333 "	6 "	
Coal seam A	6	2 "	Strike N. 34° W. mag., dip 76° S.W.
Shale and sandstone	272 "	2 "	
Coal seam 3	5 "	8 "	Strike N. 47° W. mag. dip 77 to 89 S.W.
Sandstone with 4 thin coal seam	92 "	6 "	
Sandstones	136 "	7 "	
Conglomerate	40 "	0 "	
Concealed measures estimated at	2,000 "	0 "	
To conglomerate.			
	3,878	11	

Details of seams in above section.

Seam No. 1—

Sandstone hanging wall.	
Shale	0 foot 4 inches.
Coal	0 " 7 "
Shale	0 " 4 "
Coal	1 " 6 "
Shale and coal	0 " 9 "
Coal	2 " 3 "
	5 feet 9 inches.

Coal seam No. 2.

Shale hanging wall.—

Coal	0 feet 4 inches.
Shale	0 " 9 "
Coal	2 " 2 "
Shale	0 " 3 "
Coal.	3 " 4 "
	6 " 10 "
Coal	5 " 10 "

Coal seam C.

Shale hanging wall.—

Coal	3 feet 6 inches.
Shale	0 " 9 "
Coal	0 " 3 "
Shale	0 " 2 "
Coal.	0 " 3 "
Shale	0 " 4 "
Coal	4 " 0 "
Shale	0 " 11 "
Coal and shale	2 " 3 "
Coal	2 " 3 "

Sample. Analysis by Mr. Wait.

Moisture	8·78
Volatile	31·83
Fixed carbon	47·16
Ash	12·23
	100·00

Coal seam B.

Conglomerate hanging wall.—

Coal	0 feet 5 inches.
Shale	0 " 3 "
Coal	0 " 6 "
Shale	0 " 5 "
Coal	0 " 4 "
Shale	0 " 4 "
Coal	1 " 7 "
Shale	0 " 5 "
Coal	1 " 3 "

Sample from coal excluding shale. Analysis by F. G. Wait.—

Moisture	2·67
Volatile	21·05
Fixed carbon	72·42
Ash	3·86
	100·00

Coal seam A.

Sandstone and shale roof—

Coal (dirty)	0 feet 10 inches.
Shale	0 " 2 "
Coal	0 " 4 "
Shale	0 " 2 "
Coal	0 " 10 "
Shale	0 " 3 "
Coal (dirty)	0 " 6 "
Coal (clean)	0 " 5 "
Coal (dirty)	0 " 2 "
Coal (clean)	0 " 11 "
Shale	0 " 2 "
Coal	1 " 5 "
	6 " 2 "

Coal sample, probably from this seam, sent by Mr. MacVicar. Analysis by F. G. Wait.

Moisture	4·10
Volatile combustible	22·28
Fixed carbon	58·04
Ash	15·58
	100·00

Seam 3—

Shale hanging wall—

Coal	1 foot 1 inch.
Clay	0 feet 0½ inches.
Coal	4 " 3 "
Clay	0 " 0½ "
Coal	0 " 2 "
Clay	0 " 2 "
	5 feet 8¾ inches.

Eastern Trough.

The southern limit of the eastern trough, considered from the point of view of its value as a coal-mining area, will be found to be between Morris and Villeneuve creeks, since, on the latter, only the lower part of the coal-bearing beds remain, the bottom of the trough passing probably less than 800 feet below the trench cut by the creek. On Morris creek, the trough is much deeper, and the measures, consequently, in greater thickness, so that the coal seams near the conglomerate, although probably folded at the bottom of the trough or near the fault line, may prove of value. On this creek in the same trough, and on the eastern side, a seam was observed standing at a high angle and having a thickness of 13 feet 6 inches. This thickness includes many partings of clay and shale which may render a part of the seam unfit for mining. On the western side of the basin, a small seam was also noted but it did not appear to be important.

Northwest toward the Athabaska there are exposures of the sandstones and of the conglomerate ridge of the eastern edge of this trough only, so that its depth or western edge can only be inferred by comparing the sections on Morris creek with those on the north bank of the river. One coal seam, at some distance above the conglomerate, has been found on a small eastern branch of Mountain creek, and although nearly vertical seems to belong to the eastern limb of the syncline. Its thickness is about 5 feet 2 inches.

North of the Athabaska, the trough narrows and it is probable that the seams above the conglomerate may prove to be of little value. There are also probabilities that below the conglomerate some of the indications of coal seen farther south may here develop sufficient thickness to be mineable. One such exposure is noted up Moose creek where the stream breaks through the conglomerate ridge. A small seam of coal 2 feet thick is found just below the bed of conglomerate, and at a point 40 feet below this another measuring 4 feet in thickness is found. This contains the hardest coal in the district A sample of the whole seam, as analysed by Mr. Wait, shows the following:—

Moisture	0·71
Volatile combustible	15·92
Fixed carbon	71·07
Ash	12·30
	100·0

In the laboratory it gives a firm coke, so that this is still a coal of the bituminous class.

Character of Coal.

The resemblance and behaviour of the coal of this district to that from the Crowsnest pass has been remarked and confirmed by the mechanical department of the Grand Trunk Pacific railway. It is slower-burning than the Ohio coals used in the eastern section of the railway, and its use requires different methods of firing. Experiments in a small way show that it is practically all coking, so that when a demand for coke in northern British Columbia is made the supply may be drawn not only from this district but from the nearby fields on the eastern slope of the Rocky mountains. As was expected, variations have been found in the coals of the different seams showing a slight increase in fixed carbon in the lower seams, and in the areas within the mountains a slightly higher fixed carbon percentage over coals from outside. Thus, in the area inside the mountain, three examples show this general rule.

	For dry and clean coal.	
	Fixed carbon.	Volatile.
13 foot seam at collieries	74·21	25·79
Tunnel seam	78·46	21·34
4 foot seam below conglomerate	81·69	18·31

Comparison between seams in the foothill areas and those within the mountains is difficult, but it may be assumed that the seams already discovered outside the first range are as low in the formation as those inside, and the analyses show this coal to contain about the same volatile combustible matter as the higher seams in the western fields.

Samples from the outcrop exposures are sure to give misleading analyses, since the alteration by exposure seems here to be greater than farther south. Thus the outcrop sample of the seam at Jasper collieries would indicate a coal bordering on the sub-bituminous class. Reference to this is made in the Summary Report for 1910, and analyses were given. A summary of these for the tunnel seam is interesting, as the workings are now far in from the surface.

	For clean dry coal.	
	Fixed carbon.	Volatile.
Surface outcrop	68·66	31·34
Thirty feet from surface	78·46	21 34
Nineteen hundred feet on entry, 250 feet from surface	78·83	21·17

In several seams there is a streak of dark soft coal and shale that is high in ash and requires to be mined out. In the tunnel seam the upper part contains the most ash, but by careful mining and picking this can be reduced in the commercial product and need not exceed about 7 per cent, though in practice it probably runs to 10. The samples from the seam at Folding mountain and from the Jasper collieries give the same ash content, and it is quite probable that if a streak is wasted in each a clean coal will result.

DEVELOPMENT WORK.

The prospecting which was noted last year was continued during the past season with renewed vigour. On the west of Brulé lake, little was done in development work, but several parties were engaged in tracing the measures northwestward to streams flowing to Solomon creek, and it seems probable that the northern extension of the Scovil Creek measures will become utilized after the Canadian Northern railway is built. A large party was employed south of Brulé lake tracing seams and testing them by tunnels near Folding mountain. On Moose creek, the seams on the headwaters were found and sampled, but little development work was done.

The greatest activity was confined to the south side of the river, where at the Jasper collieries every effort was made to be ready to ship some coal as soon as the railway could be connected by a spur with the temporary tipple. The first carload was delivered to the railway company in the last week of September. By November

13 the output was 130 tons per day, and this was increased by December 16 to 275 tons. The latest returns, to March, 1912, give 400 tons per day with a maximum of 490. All the works and shipping facilities are temporary, the permanent tipple and main entry requiring to be located after careful survey. In the meantime, the temporary works do not interfere with this installation, and the present entry 240 feet above the permanent entry will be required for ventilation, timber, etc. The situation at the mine at present is as follows: the line of the Grand Trunk Pacific, on the south side of the Athabaska, skirts the foot of a gravel-faced terrace rising about 270 feet above the tracks. From the brow of the terrace there is a gentle rise to the foot of a sandstone ridge up which the stope steepens. Along the eastern face of the ridge a coal seam has been traced. An entry on this coal seam, with only grade enough for drainage, has been effected by a tunnel along its strike from the terrace level. This has been extended into the hill somewhat over 2,000 feet, obtaining a vertical depth of over 200 feet. Mining above the entry has been started at this point, and a small output to the amount stated above has been made from this block of coal. The cars are loaded in the tunnel at chutes and drawn by horse to the top of the terrace and then lowered by cable and hoisting engine on an outside slope to a temporary tipple at the siding. An inside slope on the seam is in progress to reach the level of the permanent entry, which will be about 240 feet below the present one, and will enter the hill from a point near the permanent tipple. The seam dips at about 56° from the horizontal. The system of mining will depend greatly on local conditions. There should be for some time a large supply of coal above this entry and the mining and haulage should be done at low cost.

II

NOTES ON COAL OCCURRENCES AND THE PROGRESS OF DEVELOPMENT WORK IN ALBERTA AND SASKATCHEWAN.

Coal Area West of Brazeau Range.

Notice of the discovery of this area of coal-bearing rocks was published in the Summary Report of this department for 1909, page 147. No prospecting had apparently been done toward the discovery of workable seams of coal until the summer of 1911, when a party under the direction of Mr. Norman Fraser spent a short time in the search. Three seams were uncovered, one of which is of workable thickness, being reported as having nearly 14 feet of coal. This has been traced southeastward from Mire creek, over a ridge, having an elevation of 1,500 feet almost to the Saskatchewan. As the dip of the beds is not at a high angle, there will be a large tonnage of coal above the entry level, which may be made from either the Mire creek or Saskatchewan valleys. The character of the coal as reported from analyses will be slightly lower in fixed carbon than that of the Bighorn basin, but one having good coking qualities.

On the main Brazeau river, the continuation of the measures of the Bighorn basin have been found, and several seams opened. The principal one is reported as having about 20 feet of coal. As the locality was not visited by any of our parties, more definite information cannot be given.

Kananaskis River, Branch of Lusk Creek.

Development work on the continuation of the measures of the Cascade basin, southward on Kananaskis river, has not been very actively prosecuted this year, as the building of a railway is necessary before mining operations can be resumed. On the head-waters of this stream and east of Tombstone mountain, a narrow strip of the coal-bearing rocks is found high above the Kananaskis valley. Some claims or leases have been applied for but access to the area may be difficult.

In the foothills east of Kananaskis river, the crest of an anticline running northwest from Moose mountain is dissected by streams draining east to Jumpingpound creek and west to Lusk creek, a branch of Kananaskis river. At the apex of this anticline some of the dissecting streams have cut through the soft beds of the Colorado group of the Cretaceous, and one or two through to the heavy conglomerate bed at the top of the Kootanie. The nearest of these exposures to the existing railway lines is on an east branch of Lusk creek. A prospecting party located a camp in this valley, and by means of a hand diamond drill was piercing the upper part of the Kootanie. That this method was inadequate is shown by the fact that the drill hole reached a depth of only 175 feet and went through the upper part of the sandstone. As the hole was near a fault or break which runs along the valley, the water forced downward through the drill did not return, so that though small seams of fractured coal may have been pierced in that distance, the existence of such was not proved. It is probable that better facilities for testing the measures will be installed.

Edmonton Coals, West of Edmonton.

The coal horizon which underlies the city of Edmonton is being mined only on the outskirts of the town since the possible damage to property by the sinking of the surface is becoming too great. Attempts at reaching the horizon at points available for shipment are being made. Progress has been made on the sinking of shafts at Saint Albert, on the Canadian Northern railway, about 6 miles northwest, and the coal will be raised about 250 feet to the surface. The seam, as tested by boring, is reported to be 7 feet. Farther west, the coal of the top of the Edmonton formation outcrops at the surface near Wabamun lake, and mining on it has been commenced in the vicinity of the Grand Trunk Pacific railway. A shaft at Gainsford had this summer about reached a seam which is stated to be 10 feet in thickness. Near Pembina river, several shafts have been put down to the seams that are found in the banks of the river, and it is expected that coal will be mined there shortly. Farther west the coal horizons are again brought to the surface in the edge of the disturbed belt of the foothills, and from the thickness and number of the seams it is probable that the coal seams represent the same horizon as that of the upper part of the Edmonton formation. An uplifted block of these rocks is found on the head-waters of the Embarras river and southeast to the Pembina. On the Embarras head-waters, the Yellowhead Pass Coal and Coke Company is preparing to mine from several seams as soon as the railway branch is completed from the Grand Trunk Pacific. This is reported as being constructed at the present time a distance south of 30 miles. This line will also pass near mines operated by the Pacific Pass Coal Fields, Limited, whose holdings extend to the Pembina river.

Eastern Outcrop of Edmonton Coal Formation.

The report on the Edmonton coal-field (No. 1115) contains notes on localities south and east of Edmonton, at which the same coal horizon has been discovered and in many places mined. These include Tofield, Round Hill, Bawlf, Camrose, Battle River, Red Willow Creek, Paint Earth Creek, and the Kneehill country west of Red Deer river.

Grand Trunk Railway East from Edmonton.

TOFIELD.

The exposures of the Edmonton coal measures on the Grand Trunk Pacific extend eastward past Beaver lake. In this vicinity coal is being mined and quarried. Just south of the town of Tofield, a flat-lying seam about 9 feet in thickness is found having from 15 to 20 feet of cover, consisting mostly of sandy shales with a few streaks of hardened sand approaching sandstone. This is now being mined by stripping (two companies operating steam excavators), and the exposed coal quarried and loaded either on railway cars or on wagons. Drilling at the town, which is below the level of the coal seam, has resulted in the finding of another seam at a horizon approximately 200 feet below the surface seam. This would appear to be the lowest seam in the Edmonton measures. An analysis of both seams shows them to be excellent fuels of the sub-bituminous class. The surface seam does not appear to have suffered to as great extent as has been reported from weathering due to its thin covering. Small areas of the exposed coal show the upper surface somewhat decomposed, but the main part of the bed may be taken as having the following characters. Analysis of sample from 9 foot seam, Tofield Coal Company:—

Moisture	15·55
Volatile hydrocarbons	35·09
Fixed carbon	44·30
Ash	5·06
	100·00

The sample reported to have come from the bore-hole 200 feet below is slightly more compact, but is apparently of much the same grade of fuel as that at the surface. Analysis:—

Moisture	11·12
Volatile hydrocarbon	37·88
Fixed carbon	42·81
Ash	8·19

Canadian Pacific Railway Branches.

The various eastern branches from the Calgary and Edmonton line cross the eastern part of the coal field underlain by the Edmonton formation. On the Wetaskiwin branch, coal mines have been opened near Camrose and another near Bawlf.

THE BAWLF COLLIERIES.

This is on sec. 10, tp. 46, R. 18, west of the 4th meridian. The coal is under a thick cover of sandstone and should be easily mined on account of the solid nature of the roof. At a depth of 140 feet, a seam of 10 feet is found. Beneath this, separated by 10 to 15 feet of sandstone, lies another seam of 6 feet. Shafts were completed and hoisting machinery installed and the mine opened in 1910.

The extension of the Canadian Pacific Railway branch east from Lacombe has opened for settlement a large area east of Sullivan lake, and a prosperous town, Castor, is now built at the crossing of Beaverdam creek. The influx of settlers and the establishment of a town at this point have created a demand for coal, and the coal seam that here underlies the town at a depth of only a few feet, is being mined by two companies operating on either side of the town.

CASTOR COAL COMPANY.

Sec. 3, tp. 38, R. 14, west of the 4th meridian.

At the outcrop of the seam in a small coulée on legal subdivision 2, near the railway, some coal is being mined by stripping, but as the cover is increasing by a westward dip in the coal, mining by tunnel will follow shortly. The seam is 6 feet 2 inches with a parting of 1 inch clay, 29 inches below the top. A sample from the tunnel 57 feet from the outcrop gives the following analysis, according to Mr. Wait:—

Moisture	25·89
Volatile	34·13
Fixed carbon	35·31
Ash	4·67
	100·00

On subdivision 9, the first opening or mine was made on this seam. The coal shows a thickness of 6 feet 6 inches at the eastern part of the mine, and increases westward to 7 feet 6 inches. This part of the property has a cover above the coal of 6 to 9 feet, and it is proposed to strip this for about 30 acres. The coal under this light cover shows a slight deterioration in the upper part of the seam, but samples from the lower part show very little, and the coal is in fact of the same grade as that of the former sample from the tunnel. Analysis of sample from old mine by F. G. Wait, Mines Branch:—

Moisture	24·75
Volatile	33·94
Fixed carbon	36·33
Ash	4·98
	100·00

On subdivision 8 and 9, the cover runs to 30 feet and the coal seam from 8 to 9 feet, as reported from borings.

A spur from the railway is graded through the western and northern part of the property, and two entries will be run north and south through from subdivision 9 to entry No. 1 on subdivision 2. The western part of the property will probably be mined by shaft at the railway.

THE BATTLE AXE MINE.

Southeast ¼ sec. 26, tp. 37, R. 14, west of the 4th meridian.

The seam on this area varies from 6 feet to 4 feet, with considerable less cover than on the property to the north of the town. It is quite probable that this could be more economically stripped than mined.

This coal horizon has been traced southward by the settlers for 60 miles from Castor, and at the following localities the thickness and cover over the coal is given as reported below:—

At Garden Plains on sec. 1, tp. 34, R. 14, west of the 4th meridian, the seam is 4 feet, with cover ranging from 5 to 10 feet. It has also been found on sec. 8, tp. 32, R. 13, but thickness is not known. Colonel Walker's mine on Berry creek, or between Berry creek and Bull Pound creek, seems to be on the top of a hill. The coal may thus be restricted to an irregular oval-shaped area, but should be repeated west. The locality is southeast ¼, sec. 19, tp. 29, R. 12, west of the 4th meridian. The south half of this ¼ section is under lease to W. Oscar. The seam is reported at 11 feet with 8 or 10 feet of cover.

In the same locality, 8 miles south on sec. 12, tp. 29, R. 13, west of the 4th meridian, 8 feet of coal is reported with light cover, and another report is to the effect that midway between these above exposures, the seam has been found.

What might be termed a stripping area is thus pretty well defined along the eastern outcrop of the Edmonton measures reaching from Tofield in township 50 to the Berry Creek locality in township 29, a distance of 132 miles, with a seam having a maximum thickness of 11 feet and a general average of 8 feet, but in places as thin as 4 feet. The amount of domestic fuel easily obtained in large measure by stripping is thus seen to be enormous.

Northern Extension of Medicine Hat Area.

On the Red Deer river, the Lethbridge seam was mapped by G. M. Dawson as outcropping on the banks for many miles below the mouth of Bull Pound creek. Last year, a mine was opened at Fieldholme, on secs. 6 and 7, tp. 23, R. 14, west of the 4th meridian, with a coal seam of 5 feet 6 inches.

MANNVILLE.

The northern portion of the exposed coal-bearing rocks belonging to the Belly River formation, or the continuation of the coal-bearing beds of Medicine Hat and Lethbridge, is exposed northward to the valley of Vermilion river north of Mannville, Alta., a station on the Canadian Northern railway. Small seams of coal are reported at several localities. A few inches of coal occur on sec. 13, tp. 52, R. 10, west of the 4th meridian, and probably the same seam reappears at Spruce Bridge, a point about 2 miles upstream.

An occurrence most likely to be a mineable seam is found in the valley of Vermilion river, on the farm of W. H. Warwood, on sec. 16, tp. 51, R. 9, west of the 4th meridian about 6 miles from Mannville. A well at Mr. Warwood's house went through a seam of coal at a depth of 17 feet, which, by general report, had a thickness of 5 feet. An abundant flow of water which occurred at a depth of 14 feet from the surface would make mining difficult, but if the seam were persistent, points farther from the creek might be found that would not be so troubled by the drainage. Samples of the coal were picked out of the excavated material and show that it is a lignite holding a large percentage of water. Analysis made by Mr. F. G. Wait, Mines Branch, of loose pieces from well, give:—

Moisture	27·47
Volatile combustible	30·26
Fixed carbon	28·98
Ash	13·29
	100·00

Brock, Saskatchewan.

Another locality in the northern extension of the Belly River beds at which coal is found, is in the vicinity of Brock, about 100 miles southwest of Saskatoon. This is a station on the Calgary-Saskatoon branch of the Canadian Northern railway, and is the nearest present exposure of coal to this important Saskatchewan town. The discovery was made while drilling a well on sec. 22, tp. 28, R. 20, west of the 3rd meridian. The district is rolling, and the well which was put down on the top of a hill pierced the coal seam at a depth of 130 feet. To the northwest a dry coulée crosses the section and it is probable that the seam lies beneath the bed of this valley, and could be reached at a much less depth. An open shaft 6 feet square was dug on the hilltop to a depth of 140 feet and stood untimbered and dry. Last winter several tons of the coal were raised by block and tackle, but at the time of my visit, July 19, 1911, some of the wall of the shaft had fallen in, concealing the greater part of the seam. Information given by Mr. McKay, manager, Northern Crown Bank, is to the effect that the seam is nearly 10 feet thick on one side, but can be averaged as having about 7 feet of coal.

The upper part of the seam is mostly dust and black dirt, but 2 feet in the middle is solid coal. From a sackful of the extracted coal, samples that would be representative of the mass, including the dirty part as well, were taken and gave the following analysis:—

Moisture	25·70
Volatile	26·95
Fixed carbon	28·42
Ash	18·93
	100·00

It is quite evident that if only samples of the solid coal were taken the ash content would be much reduced. The locality is in the unforested area, and this field, although of about the grade of the Souris coal, would be valuable to the surrounding district. Mining would be expensive on account of lack of timber, but as the country is dry there seems to be no great need for expense in drainage, and the roof, although of clay, stands up well. The untimbered pit had no water in it and the walls stood remarkably well; but without a casing of boards it would seem to be a menace to those attempting further development.

Boring at Egg Lake, near Morinville.

The operations of the American Canadian Oil and Gas Company have been concentrated in an effort to pierce the Cretaceous beds to the depth of the tar-bearing sands. This has been a work of patient drilling, and a depth of 3,340 feet is now reported to have been reached (December, 1911). The well was visited September 30, and operations were suspended long enough to have the depth of the well measured and samples of the sludge examined. At that date, the depth from the floor of the drilling-shed was ascertained to be 3,305 feet 7½ inches.

The drill was in very hard sandstone, but the casing was not down to this hard rock, consequently some of the shale from the walls was found in the sludge. Besides very finely pulverized shale, the sludge contained small particles of sandstone and a few pieces of coal, which would tend to establish the Dakota age of this sandstone. When the water was removed from the material brought up, the whole mass bubbled up like yeast, and a large number of bubbles showed the iridescence, called by the drillers, "colours of oil." A few small specks of brown oily matter were found in the washed material. This gives great hope to the drillers that the top of the tar sands has been reached.

In the Athabaska valley, the tar sands are resting on the Devonian, the supposed source of the oil. In the foothills other formations, not of an absorbent nature, intervene, so that there is a limit to the western extension of the productive part of the Dakota. The presence of even a small amount of oily matter in what seems here to be the Dakota formation, shows that the western limit has hardly yet been reached, and there is great hope of ultimate success in the boring operations. The indications of oil are reported as becoming more promising. Some delay caused by caving in the lower part of the hole is reported, and the casing will necessarily have to be put down to the top of the sandstone.

I.

REPORT ON PROGRESS OF INVESTIGATION OF CLAY RESOURCES.

Heinrich Ries.

Introductory.

During the summer of 1911 I spent about three months in the field. Up to the middle of July, Mr. Joseph Keele was associated with me, but from that time on, with the exception of a few days in September, we were working separately in order to cover more ground.

The main object of this year's work was to fill out the gaps left in last season's work in the western provinces, in the region west of Winnipeg.

Most of the localities visited, therefore, had not been heretofore examined. In a few cases certain districts were revisited in order to find out what developments had taken place in the intervening twelve months.

A summary of the past season's work must, therefore, be a somewhat detached set of statements.

Great Plains Region.

In our report for last year particular attention was called to the shale deposits of the Great Plains region. These included the Pierre, Niobrara, Belly River, Laramie, Edmonton, and Tertiary. Of these the Pierre and the Niobrara shales are each worked only at one locality.

PIERRE SHALES.

The general character of these was referred to in last year's report, and their rather low plasticity in the unweathered condition was referred to. They also burn to a rather porous body. The area around LaRivière was visited this year, and this is the only point at which the Pierre shales are worked, there being abundant exposures of the material.

The plant in operation there was erected for making pressed brick, and was first equipped with a dry-press machine; but this being unsatisfactory, a semi-plastic process was employed. The plant is still in the experimental stage. It is probable that better results will be obtained by mixing some surface clay with the shale, and our tests of last winter demonstrated this.

NIOBRARA SHALES.

These are worked at Leary, Man., and were described in last year's report. No deposits of this age were visited by myself this season, but Mr. Keele examined some north of Regina. They are more promising than the Pierre shales, being more plastic and burning to a denser body. These show an extraordinary tensile strength.

BELLY RIVER SHALES.

This represents, perhaps, the most extensive series of shale deposits in the Great Plains area, and a number of samples of these were tested for last year's report.

Attention was also called to their use by the sewer-pipe works of the Alberta Clay Products Company of Medicine Hat, and the Red Cliff Brick Works. The supply for the former was being obtained from a ridge along Bullshead creek, near Coleridge, and, although only a small excavation had been made, the opinion was then expressed that the different types of shale found there occurred in lenses. A re-examination this year, when more extensive quarrying had been done, showed that this theory was correct. One bed for example, as the so-called fireclay seam, which showed up last year with a thickness of about 6 feet, has thinned out to a few inches in less than 50 feet. The shales now being obtained at Coleridge appear to work well for fireprofing and pressed brick, but they cause considerable trouble by cracking when worked up for sewer-pipe. Efforts are, therefore, being made to obtain a pipe-clay from some other locality, and at the time of our visit favourable preliminary tests had been made with a clay from west of Calgary.

We also made an examination of the Bullshead Creek valley for a distance of several miles up stream, and beginning at a point about 4 miles above the Coleridge bank.

Both sides of the valley here showed numerous shale exposures, interbedded with sandstone beds. The shales varied from very sandy to smooth fine-grained ones, and some of the lenses showed a maximum thickness of 30 feet. To the southward, or up the valley, the shales appeared to pass into sandstones.

The tests on the samples from this valley are now in progress and will soon be available.

Reference was made last year to the exposure of Belly River shales, along the Belly river near Lethbridge, but there are a number of other points along the stream where these are exposed, although many of them are at present located too far from the railway to be of commercial value.

A new district visited this season was that north of Taber, Alberta, where the Belly river flows about 2 miles north of the town.

An opportunity of examining the shales is afforded by the numerous small lignite mines which are in operation and have openings on the side slopes of the river valley.

The shales of this locality are similarly variable to those near Coleridge, but gypsiferous ones appear to be more abundant. However, a moderate amount of gypsum grains need not necessarily interfere with their workability.

Only one attempt has been made to work the shales near Taber, and this was done in the crudest way at a small yard located on the river bank. The poor results obtained were due to the methods rather than to the material.

Samples were taken for testing from several points along the river, and of the shale from above and below the coal in the shaft of the Rock Springs mine of the Superior Coal Company, northwest of Taber. The following two analyses were supplied by the Company, No. 1 being the top clay and No. 2 the bottom clay.

	I.	II.
Silica	63·2	68·4
Alumina	19·2	18·0
Ferric oxide	5·4	4·0
Lime	0·6	0·4
Magnesia	1·2	1·0
Loss on ignition	9·0	7·7
	98·6	99·5

A well was being sunk at Taber in the summer of 1911 with the hope of striking gas, and at the time of my visit had reached a depth of 1,500 feet. The cores showed a series of shale beds, some of them quite smooth, and occasional layers of sandstone. A 4 foot layer of coal was struck at 70 feet, and a 2 foot 8 inch bed at 370 feet.

At 670 feet the drillers struck a strong flow of water, yielding 950 gallons per hour. At 620 feet there was a slight flow of gas.

Shale exposures are also to be found on the banks of the Belly river near Bow island. It was hoped that shale beds might be found in the horseshoe bend of the river south of Bassano, but the cutting, though deep, is in glacial drift.

LARAMIE.

Several days were given to an examination of the district along the new branch of the Canadian Pacific railway from Weyburn to Forward and Ogema. It was hoped that we might find a southern extension of the white-clay formation of the Dirt hills, but owing to the heavy mantle of Pleistocene clays, no Laramie material was found.

Twelve miles south of Forward, at Stowe on the Souris river, there are small exposures of greyish-white plastic clay, and brown and bluish smooth shales, all probably of Cretaceous age.

Since a branch line of the Canadian Northern passes this point, these shales are worth looking into in greater detail. There is the possibility, however, that they may contain too frequently interbedded sandstones, although it is not safe to say this without further prospecting.

The Pleistocene surface loams and stony clays form a somewhat heavy mantle throughout this region.

It is interesting to note that the refractory clays of the Dirt Hills region, which have remained so long unnoticed, are beginning to excite considerable interest, due, in part, to the attention given them in the Geological Survey work. One plant will shortly be established there, and two others are contemplated.

EDMONTON FORMATION.

This formation was referred to in last year's report, and attention called to the fact that the shales of the upper beds of Edmonton might be developed for brick manufacture. A plant has since been started near Strathcona and is employing these shales for dry-press brick manufacture. The shale being used underlies those which we sampled and tested last year. It is red-burning, but further tests are not yet available.

One of the best series of shale exposures found in Alberta, is that seen along the Pembina and Lobstick rivers west and northwest of Entwhistle on the Grand Trunk Pacific. These outcrop in considerable thickness, are favourably located for working, and some of them, at least, appear to be favourably constituted for making vitrified structural wares.

Since coal has been found in borings at no great distance below the surface, the necessary fuel for burning these shales could be easily obtained. The shale formation extends east of Entwhistle, but no shale outcrops are visible along the railway.

TERTIARY SHALES.

Those near Brickburn, west of Calgary, were referred to in last year's report, and the suggestion made that further prospecting to the eastward of the brick pits might show other beds containing fewer sandstone layers. Developments made at this point since then have demonstrated the presence of some very promising shale beds in the escarpment east of the brickyard, and some of the material has been shipped to Medicine Hat for sewer-pipe manufacture. The shale that has been shipped from here to Medicine Hat, is from a lower bed than that used for brick at the Brickburn 'yard' and is of appreciably higher refractoriness, standing cone 3 to 4.

A more careful examination was made of the shale sections along the Bow river between Morley and Cochrane, which resulted in the collection of samples for testing from the section west of Mitford. The shales occurring there appear to be promising.

When a branch line of the Canadian Pacific railway from Langdon, on the main line east of Calgary, is extended to Carbon, the shale deposits exposed along the Red Deer river will become available, but there are no shale exposures along the present line from Langdon northward.

OTHER LOCALITIES.

At Red Deer two yards manufacturing common brick were in operation last year, both of them using surface clays. One of these has recently been reorganized and it is proposed to use a mixture of local surface clay and the shale which outcrops along the river just above the railway bridge. This was tested last winter. A search was made along the Red Deer river south of Red Deer, but only glacial clays were found.

At Medicine Hat the stiff-mud yard of Purmal and Pruitt, which had been destroyed by fire, is again in operation, but Hofmann's yard, 2 miles east of town, is not running.

The Acme Brick Company, 7 miles north of Edmonton, has been remodeling its plant and introducing a patent system of drying and burning.

The clay pit at these works presents a rather unique section.

The upper clay is a tough laminated material, and is underlain by 12 to 15 feet of a dense sandy clay containing layers of gypsum rosettes.

Mountain Region.

Shale exposures are abundant in the valley between Fernie and Coal Creek mines, as well as in the valley in which Morrissey lies, but they are all too hard and siliceous to work up into a plastic mass. Those near Morrissey are slightly less siliceous than those near Coal creek.

This then still leaves the shales near Blairmore and Coleman as the most promising thus far tried along the Crows Nest Pass line. Those at Blairmore are still being worked for dry-press brick, but give some trouble in burning. They are not adapted to a stiff-mud process because of their low plasticity.

Attempts are still being made to exploit as a fireclay proposition some streaks of talcose schist in quartzite, which occur about 9 miles south of Elko along the Great Northern railway. Tests made by us on this show that it is not even refractory.

An examination was also made this year of clays in the Columbia River valley north and south of Golden. There is no reason why deposits of clay should not be found underlying the flood plain of Columbia river. Near Golden there is a considerable area underlain by this clay, which may be of value for brick manufacture. It is very plastic in the field.

Pockets of tough silty clay are also found in the glacial drift bordering the valley, but little can be expected of them.

In the Nicola valley there was found a most extensive deposit of plastic laminated clay, evidently a lake deposit, which may prove useful for brick and tile-making. It can be traced almost continuously from Merritt to Nicola.

The Tertiary coals of the Nicola valley, which are being worked at Merritt, are interbedded with sandstones and siliceous shales. The latter are not very promising, but some are being tried. West of Quilchena the coaly shales are overlain by that peculiar type of clay known as Bentonite, which is found in such abundance in the state of Wyoming. The Bentonite bed is at least 6 feet in thickness.

Vancouver Island.

The shales of the Nanaimo coal basin were also examined this year. Most of them appear rather siliceous, but some near East Wellington have given satisfactory results in a preliminary trial on the stiff-mud machine.

ONTARIO AND QUEBEC.

Towards the end of the season some days were spent in examining certain feldspar deposits. Those visited were in the Parry Sound district, near Verona and Godfrey, Ont., and the Lièvre River district of Quebec.

The Parry Sound deposits consist of veins or lenses of a coarse-grained mixture of plagioclase and orthoclase, with numerous large flakes of biotite and some quartz. These veins are abundant in this region, but as it is impossible to separate the biotite by any economical methods, they are of no value as a source of spar.

The quarries near Verona and Godfrey are worked for both quartz and feldspar, the two occurring in the same vein, but in large masses, so that no difficulty is experienced in separating them. The wall-rock is a grey biotite gneiss.

Much of the spar obtained from this region is shipped to the United States, and on account of its high purity finds a ready market in the pottery trade.

A visit was also made to the kaolin deposits located 7 miles west of Huberdeau, Que., and controlled by the St. James Construction Company of Montreal.

These are all the more interesting because of their occurrence in a glaciated region, but the reason for this soon becomes evident. The kaolin has been formed by the weathering of pegmatite veins, which have been injected along joint planes of the Pre-Cambrian quartzite. The veins seem to be numerous, but the largest seen was 20 feet in thickness, and this, at the time of our visit had not been uncovered for more than 8 feet. A washing plant is also being erected. The development of the deposit will be watched with interest.

II.

WHITEWARE MATERIALS IN ONTARIO AND QUEBEC, KAOLIN NEAR HUBERDEAU, QUEBEC.

Deposits of kaolin or white residual clay have always been regarded as rare in the glaciated region of North America, for the reason that even though the decay of feldspathic rocks may have yielded such deposits in pre-glacial times, they have been removed by glacial erosion.

It is conceivable, however, that if such deposits occupied depressions in a hard and comparatively resistant rock they might have been so protected as to remain more or less uninjured.

The upper part of such a deposit occurring in the glaciated area, is likely to be somewhat impure, due to the incorporation of glacial drift in its mass. Such a structural feature should not, however, be confused with an impure iron-stained residual clay. In the former case, we find lumps and patches of glacial material mixed up in irregular fashion with the white kaolin. In the latter the entire clay mass would be more or less discoloured and free from boulders, pebbles, or other material of distinctly glacial origin.

Since kaolin deposits are so rare in the glaciated region, it was with some surprise that I received the announcement of a deposit in Quebec.

The one referred to in this paper lies about 7 miles from Huberdeau, on the road to St. Remi d'Amherst. The former town is a station on the Canadian Northern, about 70 miles northwest of Montreal.

The clay has been encountered in some test pits in a ridge lying on the east side of the wagon road.

This ridge is formed of quartzite, which is covered by a mantle of glacial drift, ranging from 2 to 15 feet in thickness, so far as my observations went. It may be thicker in places, but the figures named represent the thickness observed at the time of my visit in September, 1911.

The quartzite, which belongs to the Grenville series, is cut by two sets of joints, the one striking N. 70° E. and the other set striking N. 40° W.

Several test pits have been put down by different parties, and it is claimed that these encountered kaolin. This fact has led some to assume that the entire ridge was underlaid by a blanket of the white residual clay, a conclusion that is wholly unwarranted on the basis of present evidence.

One cut was excavated from the wagon road eastward into the hill, and encountered a vein of kaolin that was perhaps 15 feet wide, and strikes approximately N. 20° W.

Plate I shows a view of this cut, which was driven about 250 feet before encountering the white clay. It has been uncovered for a distance of perhaps 60 feet, and it was stated that a boring 80 feet deep has been made in it without striking the bottom.

The dip of the vein appears to be very steep.

About 10 feet to the north of the cut referred to, and about 150 feet west of the main road a short vein 4 feet wide was struck.

A second cut was run into the hillside about 300 feet south of the main one. This cut was 8 feet wide and about 100 feet long. At the end, there was exposed in the bottom of the cut a vein of kaolin 4 feet wide, and striking N. 10° W. This, it is claimed, was bored to a depth of 30 feet without striking bottom.

There were also two veinlets 5 inches and 2 inches wide, respectively, which had a strike of N. 40° W., but they pinched out rapidly.

The mode of occurrence is unique, as kaolin deposits in quartzite are comparatively rare. Much careful prospecting will have to be done in order to determine whether there is a large amount of kaolin present in this ridge.

On the west side of the road the rocks are limestone and granite, and show no evidence of kaolin veins.

There is no way of prophesying how deep the kaolin veins are likely to extend, and it would not surprise me to learn that the veins were abundant in this ridge. Their depth will depend on the depth to which the weathering agents have penetrated the pegmatite.

At the time of my visit preparations were under way to erect a washing plant for treating the crude clay.

PROPERTIES OF THE KAOLIN.

The crude clay is a mixture of fine-grained white clay particles and angular fragments of quartz, mostly under one-fourth or one-eighth of an inch in size. A little tourmaline is occasionally present. In some parts of the vein the material is almost free from quartz, but in most portions of the deposit this mineral forms about 50 per cent of the mass.

When put through a washing test in troughing and settling tanks it yielded about 40 per cent of washed product.

A sample of the latter analysed by G. E. F. Lundell gave:—

SiO_2	46·13
Al_2O_3	39·45
Fe_2O_3	0·72
CaO	None
MgO	None
K_2O	0·20
Na_2O	0·09
Loss on ignition	13·81
	100·40

This analysis shows the material to be of high purity.

The washed material worked up with water to a fairly plastic mass, but one of low tensile strength; the latter being characteristic of kaolins.

The washed clay burns white, and is quite refractory, being unaffected by a temperature of cone 33.

The material is no doubt adapted for use as a paper clay on account of its fineness of grain, and whiteness in the unburned condition.

Whether it will also satisfy the requirements of white ware and porcelain manufacture can only be told by actually making up a mixture of the kaolin with ball clay, flint, and feldspar, and then burning it with a colourless transparent glaze.

POTTERY MATERIALS IN CANADA.

The interesting occurrence of the Huberdeau kaolin, brings up the consideration of a pottery industry based on domestic materials.

Let us take the case of whiteware for example. This is made up of the following four ingredients: Kaolin to give whiteness and refractoriness; ball clay to give plasticity and bond, but which does not always burn as white as the kaolin, and hence cannot be used in too great quantity; ground quartz (called flint) to reduce the shrinkage and give the body stiffness; feldspar to serve as a flux.

Whiteware is manufactured to some extent in the Dominion, but the kaolin and ball clay come either from England or the United States, or both.

Up to the present time no true ball clay has been discovered in Canada.

It is possible that the clay over the 13 foot seam at Inverness, C.B., or the washed stoneware clay from Shubenacadie, N.S., could be mixed with kaolin for some sanitary ware bodies, but they are not sufficiently white-burning for whiteware.

Quartz can be obtained from veins, or quartzite free from iron, and there would probably be no difficulty in obtaining this from some of the Ontario localities.

Feldspar has been reported from the several localities in Ontario, and is being worked in the region north of Kingston, indeed, some of the spar mined in the vicinity of Verona and Godfrey is of high grade, and is exported in large quantities to the United States where it is purchased by the manufacturers of whiteware.

The deposits around Verona are worked as open-cuts: one of the most important being the Card mine, 2½ miles west of Verona.

The country rock is a grey gneiss, which strikes N. 30° W. and dips 45° S.E. The vein strikes N. 10° E. and then swings to N. 20° E. at the north end of the cut.

The deposit which has been opened up for about 200 feet, has been traced 600 feet farther, but at the south end of the cut it appears to be pinching out.

Both pink and grey spar are found, intermixed with quartz and occasional tourmaline, and the last two have to be separated by hand picking.

While some of the quartz is intergrown with the feldspar, much of it is of later age, so that veins of the former cut across the latter.

The product from this quarry has to be hauled to the railway for shipment.

The largest feldspar mine in Ontario is the Richardson mine, which is located 7 miles east of Godfrey. This is a large opening of considerable depth. The wall rock is a dark grey gneiss, and the boundary between the feldspar and gneiss varies in its degree of sharpness. The spar is mostly orthoclase, with occasional veins of plagioclase, and some veins of later quartz, but the main body of the latter is in a large somewhat flattened mass, which is in the central part of the vein. In this quartz mass there are cavities with crystals of quartz, mica, and pyrite. Occasional blotches of pyrite occur in the feldspar, and at one place on the northwest wall there are dark vein-like streaks of pyrite.

The feldspar vein forks at both ends of the pit. Patches of tourmaline are found here and there in the feldspar, and one large clump of tourmaline crystals is to be seen close to the hanging wall.

The quartz is used for ferrosilicon and the spar is sent chiefly to potteries in the United States.

The two following analyses indicate the high purity of the feldspar:—

SiO_2	66·23	65·40
Al_2O_3	18 77	18 80
Fe_2O_3	trace	trace
K_2O	12 09	13·90
Na_2O	3·11	1·95
CaO	0·31	None
MgO	None	None
Ignition	None	0.60
	100·51	100·65

There are a number of other feldspar veins in this district, but many of those exposed or exploited show considerable admixture of quartz, or lie so that economical working is difficult.

An example of some of the difficulties encountered is seen at the McDonald mine, about 1½ miles north of Verona.

Here the vein which strikes N. 40° E., dips northwest under a hanging wall of gneiss. The spar under the hanging is purer, but to follow it far in that direction means the removal of a heavy overburden of gneiss. Towards the foot-wall the feldspar becomes mixed with quartz, blotches of hornblende, and some biotite. The quartz in many cases is later than the spar and forms irregular vein-like masses of it.

Even a hasty examination of the spar deposits in this region emphasizes the fact that although the veins may be abundant, comparatively few are apt to be of commercial value.

Spar must be cleaned before shipment by hand-picking, as concentrating machines such as could be used to separate ore from gangue are not applicable.

A vein of spar may be large, the quality of the material excellent, and the percentage of impurities comparatively small, but if they are uniformly distributed throughout the entire vein, the cleansing of the spar becomes a matter of great difficulty, if not an impossibility.

A case which is somewhat of this character was seen on Ross island in Parry Sound. Strong rumours existed to the effect that feldspar veins of commercial value were said to exist in this vicinity, and consequently a visit was made to this locality.

The shores of Parry Sound consist largely of biotite schist cut by numerous pegmatite veins, some of them 20 feet in diameter. They are coarse-grained, and contain both orthoclase and plagioclase, feldspar, as well as quartz and biotite. The quartz and feldspar are intergrown, although in some cases veins of the latter age cut the pegmatite. The pegmatite veins pinch and swell and branch, but the boundaries are usually sharp.

Inclusions of the country rock were noticed, and there has apparently been folding after the intrusion of the veins.

The vein on Ross island is probably 30 feet wide, and strikes a little south of east. It is very coarse-grained, and contains large pieces of orthoclase, plagioclase, biotite, and scattered quartz. But while the lumps of spar are individually clean and often several inches or more in diameter, they are so surrounded by leaves of biotite as to render the mass unworkable.

If feldspar is to be used for pottery purposes it should be free from iron.

I.

NOTES ON TESTS OF CLAY SAMPLES.

Joseph Keele.

The following notes give the results of tests on clay samples, which have been sent in at various times for examination.

The samples generally submitted are in too small amounts. Not less than 4 or 5 pounds should be sent by mail. Then, if the clay deserves a more extended examination, a larger sample may afterwards be forwarded either by freight or express.

There are also included in these notes preliminary tests on samples collected from certain scattered deposits, of which special examinations were made by request, or on material outside the area covered by the field work of the season.

GRAHAM, ONTARIO.

On line of Grand Trunk Pacific railway. Sample submitted by Professor Macoun.

This was a very smooth, non-calcareous clay which, mixed with 30 per cent of water, formed a highly plastic mass that was stiff and hard to work.

The tensile strength of the raw clay was 430 pounds per square inch and the air shrinkage 9 per cent. A good hard red body was produced on burning to cone 010.

Owing to the high shrinkage and difficulty of working, this clay cannot be used alone, but a good common brick may be manufactured by the addition of about one-third sand.

This clay gives a good dry-press brick of red colour, and low absorption when burned to cone 05.

Bricklets made from this clay and burned to cone 03, are deformed and show the effects of overfiring, and are completely fused at cone 1.

ST. JOSEPH, BEAUCE CO., QUEBEC.

A clay deposit in the Chaudière valley, about 2½ miles south of St. Joseph, has attracted attention at various times, and an examination was made of it by request.

The deposit is a river terrace, composed of stratified Pleistocene clay, about 35 feet in thickness and of considerable extent.

The clay is rather silty in character throughout, but the upper part of the terrace contains more plastic material than the lower portion.

A good common brick can be made by the soft-mud process from this clay, but it does not appear to be suitable for any higher grade wares.

It would be unsafe to attempt the manufacture of vitrified wares here, as the clay shows warping and unduly high fire shrinkage when raised to a temperature a little higher than that at which common brick is generally burned.

This deposit was supposed to contain beds of stoneware and fireclays, but there are no such clays in this terrace.

MONTMORENCY, QUEBEC.

A sample of weathered shale, collected by Mr. Percy Raymond, from the escarpment at Montmorency falls.

This is a highly calcareous grey shale which, mixed with 22 per cent of water, gives a mass of fair plasticity, but gritty. It has a tensile strength of 66 pounds per square inch, and air shrinkage of 4 per cent.

It makes a good common brick by either the stiff-mud or soft-mud process, and by dry-pressing will make face brick. The fusing point of the clay is low, and it cannot be used for making vitrified wares. Notwithstanding its high calcareous content, the clay is red-burning.

SUSSEX, N.B.

A small sample of smooth, black clay was sent in by Miss Berry from the above locality.

This is a highly carbonaceous clay, and evidently a swamp deposit.

On firing the moulded test pieces, a considerable loss of volume results, owing to the burning out of the carbonaceous material. It burns to a porous red body at cone 03, with the extraordinary high total shrinkage of 29 per cent, so that it is of no possible value in the clay working industry.

MINTO, N.B.

Samples of shales above and below the coal seam at Weltons mine.

These shales were mixed in the proportions of two parts of the upper beds to one of the lower. This mixture was ground and tempered with water to a plastic mass, from which short sections of tile, 3 inches in diameter, were made in a hard press. These tiles were fired in a sewer-pipe kiln at a temperature of 2,200° F. The results showed that the tile burned to a good hard body, with perfect salt glazing. This mixture is recommended for sewer-pipe. These shales will also produce good common and red dry-pressed bricks or fireproofing.

STONEHAVEN, N.B.

Average sample of top of cliff at shoreline, about 25 feet in thickness of red and greenish weathered shales, without overburden.

These shales when ground and tempered with water worked up into a mass of good plasticity, having a tensile strength when dry of 139 pounds per square inch, and air shrinkage of 5 per cent. Short sections of 3 inch tile made from this shale, and burned in a sewer-pipe kiln at a temperature of 2,200° F., showed a vitrified body with good salt glazing. Good common brick and very fine red dry-pressed bricks can be made from these shales.

They would also appear to be suitable for fireproofing and electric conduits.

CLIFTON. N.B.

Two beds of grey shales, about 4 feet each in thickness, interbedded with sandstones, and very thin coal seams.

These are smooth, very plastic shales, somewhat calcareous, and buff burning. They are not fireclays, but are sufficiently refractory to be made into blocks for boiler-settings, and will make good facing brick of buff colour, when dry-pressed, but must be burned to cone 03 or higher for this purpose.

II

REPORT ON PROGRESS OF INVESTIGATION OF CLAY RESOURCES.

Office Work.

The laboratory work on the samples of clays and shales collected in the western provinces last season (1910) was not finished until June. About 125 samples were submitted to a complete series of physical tests. In addition to the regular tests several special tests were designed and carried out for the purpose of devising a method to cure drying defects in some of the clays. The results of these tests, with very full information on the working qualities, and behaviour under firing, for the different materials, together with a description of the deposits, are included in a report to be published in the near future.

Field Work.

The field work for the season of 1911 consisted of an examination of scattered deposits of clays and shales in various parts of Canada, and will be only briefly referred to in this report. A very complete series of laboratory tests on the samples collected this season is in progress. The results of these, and a detailed description of the deposits, will be included in the final report.

WESTERN CANADA.

A classification of the rock formations in which materials of value to the clay worker are likely to be found, and their distribution in western Canada, was given in the Summary Report for 1910, by Dr. Heinrich Ries, so that it will not be necessary to repeat it here.

The work in the west was begun by an examination of the region traversed by the Pembina branch of the Canadian Pacific railway—which includes portions of southern Manitoba and Saskatchewan—between Winnipeg and Estevan.

Bricks are made at four points on this line, Morris, LaRivière, Darlingford, and Estevan.

The material used at Morris is the Red River Valley surface clay, which makes a good, hard, buff-coloured brick, that always finds a ready market in Winnipeg.

The Pierre shale which occurs so abundantly in the Pembina mountains, is used at LaRivière for making dry-pressed bricks. The chief objection to the use of this shale is that it cannot be burned to a dense body at the ordinary temperatures of burning, the brick produced being generally too soft and porous. On the other hand, if the bricks are burned to a dense body, the shrinkage is excessive, and the operation costly.

Turtle mountain, which lies south of the railway line, between Boissevain and Deloraine, is chiefly built of sandstone, and does not appear to contain any shale beds which could be used for brickmaking.

Except in the Red River valley, clays that could be used in brickmaking are not abundant on this line. The greater part of the surface deposits consists of boulder clay, clay loam, or sandy clay; all of which usually carry pebbles and fragments of limestone. Some shallow deposits of clay fairly free from pebbles have been laid down over small areas in flats or hollows. A quantity of common brick made from a deposit of this kind was burned this season at Darlingford station to supply a local demand.

The Estevan Coal and Brick Company at Estevan, Saskatchewan, is making red, dry-pressed, and buff, wire-cut bricks from shales which lie both above and below a thick seam of lignite. The results of tests of these materials are given in the full report on last season's work. A change has recently been made in this plant by the installation of the Boss forced-draft system for burning. By this means the impure, upper portion of the lignite, hitherto regarded as waste, is now used in firing the kilns.

Two new plants for brickmaking, it is reported, are to be shortly erected at Pinto and Douglas, on the Portal branch of the Canadian Pacific railway. The clays and shales at these points are similar to those at Estevan. None of the clays or shales sampled from along this portion of the Souris valley were found to be refractory or even semi-refractory, and it would be unsafe to attempt the manufacture of vitrified wares from them.

A new brick plant has been erected at Weyburn, Sask., consisting of a dry-press brick machine, and two circular down-draft kilns. A red-burning surface clay from the vicinity of the plant is used. This surface clay is found at intervals along the new branch line of the Canadian Pacific railway, which extends westward from Weyburn.

No surface clays suitable for brickmaking were found near Maple creek, on the main line of the Canadian Pacific railway; the material underlying this vicinity is principally boulder clay. No clays or shales were found on the southern escarpment of the Cypress hills, but on the summit and a few miles north of Belanger post-office some very sandy, white clay was seen, which resembled some of the fireclay beds of the Dirt hills.

Extensive deposits of white clay are reported to occur on the Whitemud or Frenchman river, about 35 to 40 miles south of Maple creek. These clays are at present inaccessible, but will be reached later on when the Weyburn-Lethbridge section of the Canadian Pacific railway is completed. A boring for natural gas was made near Maple creek a few years ago; a depth of 2,200 feet was reached but no flow of gas was obtained. No record was kept of the measures passed through in this boring.

The region in the immediate neighbourhood of Regina is underlain by clay to an unknown depth. The trench recently dug for the trunk sewer exposes a section from the surface downward of 4 feet of dark loamy clay, 15 feet of dark, stiff joint clay, and 3 to 6 feet of yellow, silty clay. The latter could be used for brickmaking if found near enough to the surface, but the joint clay would be too hard to work up, and would check in air-drying.

Shales which appear to belong to the Niobrara subdivision of the Cretaceous were found in the cuttings between Valeport and Regina beach, on the newly constructed Craven-Colonsay branch of the Canadian Pacific railway. These shales would probably make a good quality of red dry-pressed brick, but owing to extreme toughness when wetted, it is doubtful if they can be used in any of the wet moulded processes.

A company formed in Regina has recently acquired sec. 24, tp. 12, R. 24, west of the 2nd meridian, for the purpose of mining coal and clay, and operations were begun on a seam of lignite this season. The lignite outcrops on the eastern portion of the section in a coulée at the base of the Dirt hills. It is overlain by grey or white sandy clay, which is a fireclay, and overlying the fireclay is grey, rusty, easily fusible shale. Higher up on the foothills and at the west of the section are small knolls of brown sandy shales, which are practically useless for brickmaking on account of high shrinkage and cracking while drying. It is the intention of this Company to erect a plant for the manufacture of structural clay wares. The succession of clays and shales found here is very similar to that which occurs a few miles west of this locality, and which was examined and reported on during last season's work.

The clay deposit of the Alberta Clay Products Company at Coleridge is being opened up to better advantage this year, and material for making fireproofing and dry-pressed brick is shipped to their works at Medicine Hat. This Company is bringing shale from Calgary for the manufacture of sewer-pipe, as none of the beds at Coleridge were found suitable for this purpose.

The clay and shale exposures in the valley of Bullshead creek were examined for several miles south of Coleridge. Some thick beds of soft, yellowish shale which could be easily worked were sampled. On going farther southward it was found that the shales beds were largely replaced by sands, and soft sandstone.

The wide valley in the vicinity of Walsh, on the main line of the Canadian Pacific railway, contains exposures of shales, clays, and lignite seams. These clays were found to be heavily impregnated with gypsum, and resemble those which occur at Irvine. The clay beds at the latter point were sampled last season; they were found to be of poor quality, and not to be recommended for brickmaking purposes.

The Red Cliff brickworks, situated 6 miles west of Medicine Hat, are producing wire-cut and dry-pressed bricks, from a series of clay and shale beds which occur on the bank of the Saskatchewan river. The dry-pressed bricks are made from a single bed of soft, yellowish shale, which is mined by drifting. These are burned in down-draft kilns, and a good, hard, red face-brick is produced.

The Purmal Brick Company of Medicine Hat is making dry-pressed bricks this season, using a silty surface clay which is exposed in a high bank at the rear of the works. There are five up-draft kilns at this plant, and the burning is done with natural gas. The clay, however, is unsuited to the dry-press process, as the brick made from it is too porous and soft. A Whittikar repress machine, having a capacity of 18,000 a day, is being erected, and it is also the intention of the Company to install a stiff-mud brick machine. The clay, when worked by these processes, will undoubtedly give better results than with the dry-press.

The Wetaskiwin Brick Company has commenced operations this year, making stiff-mud bricks, about 1 mile south of the town. The deposit used is a surface clay, about 14 feet in thickness, overlying boulder clay. The upper 4 feet of the deposit is a rather sandy and loamy clay, the under portion being stiff, stratified clay. The upper portion alone is used in brickmaking, as the underclay is too hard to work, and cannot be dried without cracking. The underclay could be used by the addition of sufficient sand, but there does not appear to be any sand available in the neighbourhood.

Borings for gas and water at Wetaskiwin show about 90 feet of drift, overlying sandstones and shales. Water is obtained at a depth of 200 feet in a series of sandy shale and sandstone beds. Gas is found at a depth of about 950 feet, and a flow having a pressure of 25 pounds is obtained. The natural gas is used to supplement the producer gas used in the power plant of the town.

Thick outcrops of shales and sandstones occur 5 miles east of Wetaskiwin, in the cuttings on the line of the Canadian Pacific railway, the exposures continuing for a distance of 3 miles. Farther east, in the vicinity of Camrose, especially on the Canadian Northern Railway line in Stony Creek valley, an abundance of clay and shale beds occur either exposed in natural sections on the sides of the valley or in railway cuttings. The clay and shale is also found in the town of Camrose when digging pits or trenches. Among the beds thus exposed is a remarkable yellow clay, which turns whitish on exposure to the air. It is exceedingly smooth and soap-like in character, and indeed possesses marked detergent properties. The clay, when dried, will absorb its own weight in water and works up into a paste, with a great increase in volume. The shrinkage and cracking on drying is inordinate, so that it is not suitable for any burned clay products, but a use may be found for it in the raw state.

The tests made on the samples of clays and shales collected in the Camrose district have progressed far enough to show that most of these have low-fusing points, and nearly all of them crack and warp in drying. These defects are unfortunate, as the deposits are well situated for working, and shipping facilities of finished products are excellent, since the three principal railway companies' lines intersect at this point. The lignite seams which occur interbedded with the shales to the south of Camrose have been mined for some years past, and, although thin, would yield enough fuel for manufacturing.

A brick plant for the manufacture of wire-cut brick was in operation at Camrose for a few years, but is now closed, as the surface clay which was used contained too many pebbles.

An examination of the Grand Trunk Pacific line between Edmonton and Saskatoon shows brick clays occurring at intervals in the flat-lying land between Edmonton and Viking. The rolling country between Viking and Wainwright consists of ridges and mounds, which are either sand dunes or silt and gravel ridges with some clay pockets of small extent. For a long distance east of Wainwright there is a monotonous succession of boulder clay ridges, but some of this clay, which is fairly free from pebbles, occurs between Mead and Kinley, and might be used for brickmaking. The flat depression in the neighbourhood of Scott may also contain some brick clays. Shales are exposed at two points on the line, at Tofield and on the west bank of the Battle river.

The shale at Tofield underlies a coal seam and crops out at the surface. It is fairly refractory, and burns to a good, dense body, but cannot be worked for sewer-pipe or brickmaking as it cracks too readily while drying. The shales at Battle river occur interbedded with sandstones and are exposed in the railway cuttings.

An attempt was made during the season of 1910 to make bricks at Wainwright. The deposit worked consisted of silt and sand, with a few pockets of stiff clay. The bricks when burned were too weak and porous to be of any value as their sand content was too great. Messrs. Taylor and Clark have begun making wire-cut brick this season, at a point a short distance west of the old locality. A few were burned in a test kiln, the result being a good quality of hard red brick. The deposits of clay which occur among the sands and gravels are small and scattered, so that a large area of ground will have to be utilized in order to assemble sufficient clay to keep a plant going.

The brickyard at Saskatoon is owned and operated by Messrs. Elliott and Slack. The deposit worked consists mostly of silty clay, containing lenses of sand and stiff clay, the whole overlying boulder drift. There are also streaks and lumps of a hard clay resembling decomposed shale, which is very difficult to work up, and particles of it behave as pebbles in the burned brick. The whole deposit is worked, the silty clay portion being worked alone, and the stiff clay and sand mixed together. The capacity of the plant is 24,000 soft-mud bricks a day, all going to supply the local demand. Considering the unpromising nature of the deposit, a fairly good red brick is produced, the hardest burned having a good ring.

In addition to the above, some unworked deposits of lesser importance were visited before concluding the work in the west. These will be described in the full report, when the laboratory tests are finished.

EASTERN CANADA.

A special examination was made of a clay deposit near St. Joseph, Beauce county, Quebec, which was supposed to contain beds of fireclay and stoneware clay. The deposit, however, proved to be the ordinary stratified estuarine clay which occurs so widespread in eastern Canada. This clay occurs in great thickness in the Chaudière valley, especially so about 2 miles south of St. Joseph. It is smooth and plastic, and will make good common brick or drain-tile. Its fusing point is so low, that vitrified wares cannot be safely made from it. This clay is similar in every respect to the deposit at Ascot, near Sherbrooke, where common red bricks of good quality are made from it, but nothing more.

The investigation of the clay and shale resources of New Brunswick begun two years ago was resumed late in the summer, but owing to lack of time, as the result of performing the large amount of sampling in the west, not much was accomplished in this Province. A further examination was made of the Grand Lake coal district, where there is a considerable area of middle Carboniferous rocks containing shales and a bed of coal. This district is worth the attention of those intending to erect clayworking plants in eastern Canada. At the numerous openings for coal there is an abundance of plastic shales already mined, a good supply of coal is at hand, and plenty of timber and water. The material that can be made here includes common and both red and buff dry-press bricks for boiler settings, sewer-pipe, fireproofing and electrical conduits.

Shales somewhat similar to those of the Grand Lake area outcrop along the south shore of Chaleur bay, between Clifton and Stonehaven. These shales are of great thickness and have little or no overburden at these points. They overlie sandstones which are quarried for grindstones and building stone. Included in the sandstone are two 4 foot beds of grey shales, locally referred to as fireclays. They are not fireclays, but are sufficiently refractory for boiler settings or coke-oven blocks. They are also useful to mix with the upper and more easily fusible shales for the manufacture of vitrified wares. This series of shales and sandstones is of middle Carboniferous age; they include some thin seams of coal which are too small to be of economic value.

There are extensive exposures of felsitic rocks in the vicinity of Campbellton, which resemble the felsite at Coxheath, C.B., recently described as a refractory, but non-plastic material. The felsite at Campbellton is not quite so refractory as that at Coxheath, but included in it are several seams and pockets of decomposed rock which are fairly plastic. If a large enough deposit of the decomposed rock were known to exist, it might be valuable for many varieties of clay wares.

Deposits of surface clay suitable for brickmaking occur in the vicinity of Chatham and Bathurst. These clays are of estuarine stratified type, and are worked at various points in the valleys and lowlands of the Maritime Provinces. The red sand-moulded bricks produced from these clays in Loggie's two brickyards near Chatham are of exceptionally good quality.

THE ARCHÆAN ROCKS OF RAINY LAKE.

Andrew C. Lawson.

In my reports of 1885 and 1887, I showed that the Archæan of the Lake of the Woods and Rainy lake, in western Ontario, consists of two principal parts:—

(1) An upper division of sediments and volcanic rocks which, though often highly metamorphosed, were originally not essentially different from sedimentary and volcanic rocks that have accumulated at the earth's surface in later geological periods. This division I later designated the Ontarian system.[1]

(2) A lower division of granitoid gneisses, commonly called Laurentian, which up to that time had been regarded universally as metamorphic sediments, the oldest rocks in the Archæan, and the basement upon which all other known sedimentary rocks rested. For these rocks, in accordance with current usage, I retained the name Laurentian, but showed that they are not metamorphic sediments but are batholithic intrusions which had invaded the Ontarian rocks from below as igneous magmas, and in doing so had displaced the original basement or floor upon which those rocks were laid down.

In the upper division, or Ontario system, there were recognized two series:—

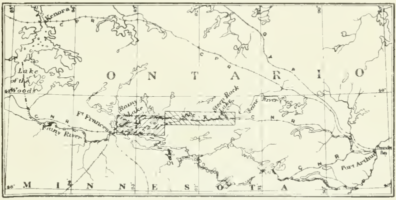
(1) The Coutchiching, a great volume of altered sediments free from volcanic admixture; and overlying these,

(2) The Keewatin, consisting chiefly of volcanic accumulations, but including also sedimentary strata.

This interpretation of the geology of the region established a new point of departure for the study of the Archæan. The studies of the past twenty-five years in Canada and in the United States have confirmed the view first expressed by me that the common Laurentian granitoid gneisses are igneous rocks of later age than the metamorphic rocks which rest upon them, and the whole conception of the Archæan as held by geologists up to the late '80's has thus been changed. The Keewatin series has been widely recognized as a persistent and characteristic constituent of the Archæan complex quite distinct from the Huronian, with which it was formerly confounded.

The Coutchiching series, however, appears to be not so widely distributed and opportunities for its study are, therefore, more limited, so that the Rainy Lake section remains the most convenient one for the study of the relations of this series to other members of the Archæan complex. Officers of the United States Geological Survey, and later an International Committee of Geologists, having visited portions of the field mapped by me in 1887 for the purpose of studying these relations, have stated that I was in error in placing the Coutchiching below the Keewatin. In their view it overlies unconformably the Keewatin with a basal conglomerate and is the correlative of the Huronian. The question raised by these gentlemen is one of peculiar importance in the geology of Canada, where so vast a territory is occupied by Archæan rocks; since the establishment of the sequence of formations in any one section becomes very helpful in the unravelling of the complexities of others. The question at issue is really whether, in general, the Keewatin, composed as it is chiefly of volcanic rocks, is the oldest set of rocks in the Archæan, or whether there is an

[1] Bull. G.S.A., Vol. 1.



DIAG. 8A. Index map of Rainy Lake and Steeprock districts: illustrating Dr. Lawson's Summary Report on "The Archæan rock of Rainy lake."

older set of wholly sedimentary rocks underlying it in some sections, and, therefore, to be expected in any complete series of the Archæan.

When the Director of the Survey invited me in the spring of 1911 to revisit Rainy lake and to review the geology of that field in the light of the work done in various parts of Canada and the United States in the past twenty-five years, I gladly embraced the opportunity to correct the error to which the United States Geological Survey and the International Committee had called attention. To do this I spent over four months in the field, and, assisted by Dr. J. D. Trueman, Dr. R. C. Wallace, and Mr. H. C. Cooke, made a detailed geological survey of a selected portion of Rainy lake, and a reconnaissance of the country to the east of that lake along the Seine river, as far as Steeprock lake and Sabawe lake. The area surveyed is indicated on the accompanying index map. It was selected so as to embrace a field which would reveal as much as possible of the relations of the Keewatin, Coutchiching, and Laurentian. A topographic survey was made on a field scale of 20 chains to the inch, and it is proposed to use this as the basis of a geological map to be published on the scale of 1 mile to 1 inch to accompany my report. The surveys have already been reduced and compiled. In the opportunity which was thus afforded for detailed study of the field, occasion was taken to greatly improve the mapping of the geological boundaries, and the new map is, therefore, more expressive of the structural relations than the old map of 1887.

The general physiographic features of the area mapped were set forth in the report of 1887 and need not be repeated here. In regard to the geological sequence I was gratified as my studies proceeded, to find that these confirmed my conclusions of 1887. I failed to find the evidence which would justify the statement of the United States Geological Survey and the International Committee as to the superposition of the Coutchiching upon the Keewatin. It is with great diffidence that I stand thus opposed to such eminent authorities, but until the latter set forth clearly and specifically the evidence upon which their conclusions are based, a thing that they have not yet done, and how further that that evidence completely nullifies the evidence which I shall assemble in my report, proving that the relations of the Keewatin and Coutchiching are as I stated them in 1887, there is no other course open to me. Some of the arguments sustaining my view of the matter are the same as those advanced a quarter of a century ago, but are more explicitly stated in the report which I am now preparing. Others are new and have to do with the conglomerate of Shoal lake and its equivalents.

The Coutchiching of Rice bay occupies an anticlinal dome completely surrounded by the Keewatin. The Coutchiching of the Bear's passage is similarly anticlinally below the Keewatin, and in its extension to the west-southwest, this belt has in general the structure of an anticline or series of anticlines dipping away from dome-like intrusions of granite-gneiss and flanked on both sides by Keewatin belts which have a synclinal structure. The conglomerate of Shoal lake occupies a well-defined synclinal trough with a belt of Keewatin a mile wide on the south side of it at the east end of Shoal lake. It is the basal formation of a series of rocks which is neither Keewatin nor Coutchiching, but is later than both. To these rocks I have given the provisional name of Seine series, from their abundant and typical exposures along the Seine river. South of the mile-wide belt of Keewatin greenstones, and green schists above referred to, there is another synclinal trough of Seine strata consisting chiefly of pebbly quartzites, quartzites often cross-bedded, and slates, which are notably distinct from the nearby Coutchiching in their obvious clastic structure, feeble metamorphism, bedded structure, and their superposition upon the Keewatin. These Seine strata do not come in contact with the typical Coutchiching mica schists, for to the south of Shoal lake, on the south flank of the syncline, another belt of Keewatin intervenes, and beyond that are the typical Coutchiching mica schists. The conglomerate at Rat Root bay has also been stated to be the basal conglomerate of the Coutchiching resting upon the Keewatin; but, as a matter of fact, this conglomerate also occupies a synclinal trough almost wholly within the Keewatin area, and nowhere comes in contact with the mica schists of the great southern belt of Coutchiching of the Minnesota shore of the lake. It contains large boulders of granite, which are with little doubt derived from an immediately adjacent granite mass intrusive in both Keewatin and Coutchiching; and many of the schist pebbles contained in the conglomerate have no resemblance to the local Keewatin, but were probably derived from the Coutchiching. In the middle of the syncline, which extends from the east end of Dry Weed island to Rat Root bay, are quartzites which bear no resemblance to the Coutchiching mica schists observed in immediate contact with the Keewatin at many localities. These and many other observations will be amplified in my report, all tending to show that the Coutchiching lies below the Keewatin.

The recognition of the Seine series as a new and distinct member of the Archæan complex is an interesting result of the season's work. The contact of the Seine series with the Keewatin has been followed up the Seine river from Shoal lake to Sabawe lake. The contact is characterized on the upper side by lenses of conglomerate occurring at intervals, and on the lower side by abundant evidence of the deep weathering of the Keewatin surface prior to its burial by the Seine sediments. The Keewatin rocks are chiefly greenstones, and the weathering of these has charged them with carbonates and limonite. The carbonates include carbonate of iron. On this same line of contact are bodies of iron ore, the most notable being those now mined just to the east of Sabawe lake. It seems very probable that these workable deposits are the result of the concentration of the iron ores produced by oxidation in the weathered zone of the Keewatin in pre-Seine or early Seine time. It is certain that this contact is a locus of iron-ore concentration, and that the careful mapping of the boundary between the Seine series and the Keewatin in other parts of this region would afford the prospector a valuable aid in his search for iron ore.

Besides these iron ores at the upper surface of the Keewatin where the Seine rocks rest upon it, there are other iron ores within the Keewatin of a quite different origin. These are titaniferous magnetites, probably the result of magmatic differentiation of gabbros which occur in that series. Ores of this kind are known at a number of localities in the Rainy Lake country, and prospecting is in active progress at some of these.

Another interesting and important result of the season's work is simplification of the geology of Steeprock lake and the discovery of fossils in the limestones of the Steeprock series. This series has been an interrogation mark in the Archæan geology of Canada for the past twenty years. I have been able to show that the greater part of the rocks originally included in the series is Keewatin, and that the remnant, or Steeprock series proper, consisting chiefly of a basal conglomerate, several hundred feet of limestone and some volcanic rocks, rests unconformably upon the Keewatin as well as upon the granite gneiss. The series, although post-Keewatin in age, is deeply folded within the Archæan and appears to be unconformably below the Seine series. The fossils which are abundant in the limestone are, so far as I am aware, the oldest well defined organic remains now known to science.

Near Iron Spur, on the line of the Canadian Northern railway, the Seine series is in irruptive contact with the northern edge of an extensive batholith of granite-gneiss which has been mapped as Laurentian on the Seine River sheet. Inasmuch as the Seine conglomerate contains pebbles and boulders of granite-gneiss, it is evident that we have in the class of rocks usually included under the term Laurentian, batholithic intrusions widely spaced in time; and this opens up the question of the significance of the term Laurentian. I shall take occasion in my report to submit some considerations bearing on this important question.

Finally, I may mention that I was fortunate enough to find an outlier of Winnipeg limestone in the immediate vicinity of Fort Frances. A number of people in Fort Frances were aware of the existence of the limestone and were interested in it as a possible supply of lime. The outcrop, which is quite small, emerges from beneath the glacial drift. The rock is fossiliferous, and the fauna which it contains have been determined by Mr. Raymond to be of upper Ordovician (Richmond) age. The discovery of the outlier proves that this limestone once extended from its present easterly boundary in Manitoba as far east as Rainy lake.

GEOLOGY OF ONAPING SHEET, ONTARIO: PORTION OF MAP-AREA BETWEEN WEST SHININGTREE AND ONAPING LAKES.

(*W. H. Collins.*)

Introduction.

For purposes of systematic exploration by the Geological Survey, northern Ontario is subdivided into rectangular areas 72 miles long from east to west and 48 miles wide. Maps of these rectangles, published on a scale of 4 miles to 1 inch, are known as sheets and are distinguished by numbers as well as by distinctive names. During the field seasons of 1910 and 1911, the writer and his assistants were making a detailed reconnaissance of a rectangle of this sort which constitutes sheet No. 139. This hitherto imperfectly known area appears to possess economic possibilities worthy of investigation. Keewatin iron formation was known to exist in it. Diabase sills, with associated silver-cobalt veins like those at Gowganda and Cobalt had been traced into it from the adjoining Timiskaming district. Recently, also, gold-bearing quartz veins have been found in the Keewatin schists.

Sheet No. 139, or Onaping map-area as it may be called after its most important geographical feature, Onaping lake, includes 3,456 square miles of country lying between W. long. 80° 20′ and W. long. 82° from N. lat. 46° 55′ to N. lat. 47° 40′. Its centre is 50 miles north of the town of Sudbury.

The adjacent country to the south and east has been mapped already; sheets 130, 131, and 138. Within Onaping district itself, a strip about 2 miles wide, adjacent to the Nipissing-Sudbury boundary, was examined for the Ontario Bureau of Mines by Mr. E. M. Burwash[1] in 1898. In 1905 Mr. W. J. Wilson[2] began the exploration of this district by surveying such portions of Wanapitei, Sturgeon, and Montreal rivers as traverse it. Nine hundred square miles in the northeastern corner of the rectangle were completed by the writer's party in 1910, and, this year, an additional area of 1,000 square miles in the central part near the Canadian Northern Ontario railway and the Nipissing-Sudbury boundary was mapped. From preliminary explorations and previous work by other investigators, the general character of the remainder is already fairly well known.

Much of the work accomplished this year is due to the assistance given by Messrs. J. R. Marshall, N. B. Davis, T. L. Tanton, R. R. Watson, L. C. Prittie, E. P. Hodgins, A. E. Allin, F. J. Mulqueen, and G. M. Taylor.

Summary.

The area examined in 1911 proves to be a continuation of a Pre-Cambrian geological sub-province, which, so far as it has been traced, covers portions of Sudbury and Nipissing districts in Ontario and continues eastward into Quebec. No field evidence of a westward or southward termination of this province was found, although in the Sudbury district, 50 miles to the south, a different and more complicated succession exists.[3] The whole province, including the present district, is stamped by a profound erosion interval which separates a peneplanated basement

[1] Bureau of Mines Report (Ontario) 1898.
[2] Summary Report, G.S.C., 1905.
[3] Coleman, A. P., Bureau of Mines Report, Ontario, 1905, Pt. III.

consisting of a schist complex intruded by granite batholiths from an overlying cover of gently folded Huronian sediments and associated diabase intrusions.

During August native gold was found in quartz veins in the Keewatin schists of West Shiningtree area, townships of Asquith, Churchill, and McMurchy. Gold also occurs in stratified glacial sand, which forms an extensive plain in the vicinity of Meteor, Shoofly, and Blue lakes, and the Canadian Northern railway, but attempts at placer mining have proved the gold content to be too low for profitable extraction. Silver-cobalt veins of the type found at Cobalt are associated with post-Huronian diabase sills almost as far west as these sills have been traced, but most of the discoveries are of no importance. Those east of Shiningtree lake, in Leonard township, however, show considerable quantities of silver at the surface. An exploration shaft has been sunk 92 feet by Messrs. Caswell and Eplett, and surface exploration has been continued on several other properties. Exploration of the Keewatin iron formation near Shiningtree and Burwash lakes has not revealed ore-bodies of present commercial value.

General Character of the District.

TOPOGRAPHY.

The area examined in 1911, like other neighbouring portions of the Pre-Cambrian region, is rocky and hilly, yet plain-like when only its broader topographic features are considered. It lies between 1,200 and 1,500 feet above sea-level. The Canadian Northern Ontario railway, which crosses it for 50 miles, varies in elevation above sea-level between 1,200 and 1,350 feet, and the rivers that traverse it in various directions have correspondingly small gradients.

The amount of relief depends to a notable extent upon the underlying Pre-Cambrian rocks and upon the thickness of the soil-sheet. Huronian quartzite and the intrusive diabase sills give rise to large, often precipitous hills. Some of the quartzite hills in Leask and adjoining townships are 400 feet high. Granite and schist areas possess a much softer and less imposing appearance. The soil-sheet is deeper and more extensive in this area than in adjacent ones hitherto visited, and consequently the harshness of the Pre-Cambrian rock surface is subdued to a greater degree. In the vicinity of Meteor and Shoofly lakes, also in the townships of Ogilvie, Browning, and Unwin there are extensive sand plains.

DRAINAGE.

The Height of Land divides the area into a northwestern part which feeds several tributaries of Mattagami river, flowing into James bay; and a larger southwestern part drained by Vermilion, Wanapitei, and Montreal rivers, which eventually reach the St. Lawrence; so, near their sources, none of these streams are large. They receive a great number of small creeks that drain an even greater number of lakes. With the exception of Onaping lake, which is 30 miles long, most of the lakes are small. The majority occupy rocky basins, but those in the sand plains fill pit-like depressions in the sand and gravel. These kettle lakes contain remarkably clear water and are frequently without visible outlet.

FLORA AND FAUNA.

The area is entirely covered with the usual forest of mixed evergreen and deciduous trees common to all northern Ontario. The growth is unusually good, however, owing probably to the deep soil-sheet, and the occasional presence of cherry and hawthorne trees suggests slightly milder climatic conditions than usually obtain in that region. Maples one foot in diameter are common near Gowganda Junction.

Pine and spruce are first in commercial importance. Individual white pines are found throughout the district, and on the deep sandy soil near Onaping lake, Shiningtree lake, and the headwaters of Vermilion river there are splendid forests of white and red pine from 12 to 40 inches in diameter.

The country east of Wanapitei and Opickinimika river lies within the Timagami forest reserve, but west and south of this timber berths are held by various lumber companies. From Creelman township southward large quantities of logs are floated down Vermilion river. Much timber has already been cut near Onaping lake and, though little actual lumbering is being done at present, preparations for future operations are under way.

TRANSPORTATION.

The Canadian Northern Ontario railway extends from Sudbury 65 miles northward into the district under consideration. During the summer of 1911, an additional section of 15 miles was constructed from the present terminus, Gowganda Junction, to Deschenes lake. A winter road built in 1909 connects Gowganda Junction with Gowganda, 45 miles to the northeast. It is reported that a sleigh road will also be built, this winter, from the present end of steel at Deschenes lake to West Shiningtree lake, a distance of about 18 miles.

General Geology.

GENERAL STATEMENT.

The geological succession and structure found in this area are common to at least 6,000 square miles of country in Sudbury and Nipissing districts. A schist complex known as Keewatin is the oldest group of rocks. This was intruded by granite batholiths, to which the name Laurentian in its broader sense is applied. Keewatin and Laurentian rocks were afterwards worn down to a peneplain and covered unconformably during Huronian time by a series of clastic sedimentary formations. This unconformity is a pronounced structural feature, for Huronian beds are but gently folded and seldom schistose, while the underlying Keewatin rocks are highly schistose and dip steeply. Diabase, probably of Keweenawan age, was intruded into all the older formations, taking the form of vertical dykes in the Keewatin and Laurentian, and of approximately horizontal sills in or immediately underneath the Huronian.

At the present time a large part of both sediments and diabase are completely eroded, exposing portions of the underlying schists and granites. Glacial boulder clay and imperfectly stratified sand cover much of the Pre-Cambrian rock surface whose exposed parts show the effects of Pleistocene glaciation.

TABLE OF FORMATIONS.

Recent and Pleistocene	Boulder clay, stratified sands, etc.
	Great unconformity.
Keweenawan (?)	Olivine diabase dykes, quartz diabase dykes and sills.
	Intrusive contact.
Huronian	Quartzite, quartz conglomerate, arkose and chert—Lorraine series.
	Conglomerate, greywacke and banded slate—Cobalt series.
	Unconformity.
Laurentian	Biotite and hornblende granites and gneissic equivalents.
	Intrusive contact.
Keewatin	Various extrusive and intrusive igneous rocks; iron formation, conglomerate.

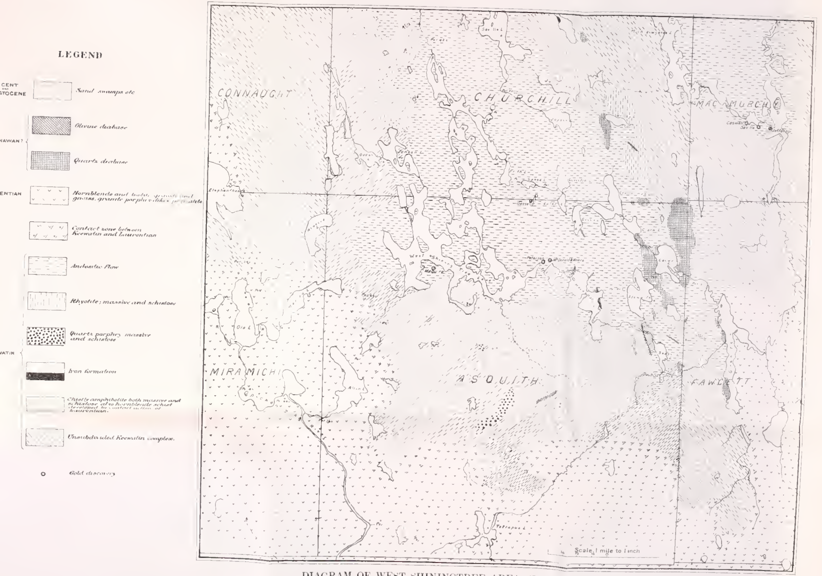


DIAGRAM OF WEST SHININGTREE AREA, SUDBURY DISTRICT, ONTARIO;

GEOLOGY BY W. H. COLLINS, 1911.

DESCRIPTION OF FORMATIONS.

Keewatin.

Only a few small patches of Keewatin were found this year. West Shiningtree area, the most important one, is the extreme southwestern lobe of a great Keewatin area that continues 70 miles northward to Porcupine. A narrow outlier of this, separated from it by a few miles of granite, extends southward through Sheard, Amyot, and Hodgetts townships. A smaller patch occurs east of Meteor lake.

The Keewatin group is principally volcanic in origin. Basalt, andesite, rhyolite, quartz porphyry, and ash rocks are all present. Banded iron formation is the chief sedimentary material. Most of these rocks, including the iron formation, are older than the granite batholiths and are greatly metamorphosed, becoming sheared to chlorite and sericite schists or, when near granite contacts, recrystallized into hornblende schists. Some, however, are massive, and less closely folded and may be younger than the granite.

West Shiningtree Area.—The Keewatin in West Shiningtree district is goldbearing, and, therefore, of special interest. Structurally it is separable into an older, closely-folded and highly metamorphosed portion; and a younger, less-folded one of massive rocks which overlies the former. The older part consists largely of basic rocks ranging from diabase to fine-grained decomposed greenstone. Mica andesite, decomposed porphyry containing feldspar crystals, and ash rock are also present but in small amount. The greenstone is also cut by quartz porphyry dykes. A single exposure of iron formation was found in the lake east or Saville lake. A rusty-weathering green carbonate schist, closely resembling similar rocks found at Larder and Opasatika lakes, was seen at the north end of Stewart lake and on the Gosselin claim near the north boundary of Asquith. All these formations appear to have been closely folded for the iron formation stands on edge, striking nearly north-south, and the igneous members have been sheared more or less to chloritic and sericitic schists. Near the granite contact, in Asquith and Connaught townships, a glistening black hornblende gneiss has been developed from basic varieties by contact metamorphic action.

A small amount of sedimentary matter, other than iron formation, is associated with the igneous formations of this older, folded group. Two exposures were found of a conglomerate which, so far as could be seen, dips steeply, forming a narrow north-south band. It consists of subangular and rounded pebbles of grey porphyry and other igneous materials in a grey schistose cement. Contacts with adjacent igneous rocks were hidden by drift. On Michiwakenda lake several isolated exposures were seen of a black slate which is locally banded with magnetite. In one case at least, this slate stands on edge though it is not schistose. It is possible that these sediments occur more extensively in the northern part of Churchill township and may belong to a Huronian series older than the Cobalt series.

These folded rocks are overlain near West Shiningtree and Wasabika lakes by a comparatively undisturbed flow of hornblende andesite, the extrusive nature of which is abundantly indicated by an ellipsoidal structure, amygdaloidal cavities, flow lines, and a notable variability in grain. A pale grey rhyolite associated with the andesite appears to bear a similar relation to the older schists. Both andesite and rhyolite are, for the greater part, massive, and the areal distribution of the former indicates comparatively little folding. Nevertheless they contain local sheared zones, usually less than 100 feet across and from northwest-southeast to east-west in course, in which the original massive andesite or rhyolite has been converted into a highly fissile chlorite or sericitic schist. These zones are of some interest, as they appear to have afforded easy circulation to slate and gold-bearing solutions.

Laurentian.

The term Laurentian is applied here in its broad sense to all granites and gneisses which intrude the Keewatin, but are older than the Huronian Cobalt series. Such rocks form a much larger part of the peneplanated basement beneath the Cobalt series than do the Keewatin schists. They underlie the Huronian near the Nipissing-Sudbury boundary, appearing through it in patches, and are exposed continuously over 1,000 square miles between Opickinimika river and the western border of sheet No. 139. Such portions of this area as were examined consist of hornblende, granite and gneiss, aplite and pegmatite, representing variations of one intrusive mass.

Huronian.

The sediments that overlie the Keewatin and Laurentian unconformably consist of a lower series (Cobalt series) of conglomerate, greywacke, quartzite, and banded slate of continental deposition and an upper series (Lorraine series) of quartzite, arkose, chert, and quartz conglomerate that were laid down under water. In their present eroded state they vary in total thickness from almost nothing to 1,000 feet. The strata of both series are concordant, and only gently folded except in a few localities, notably along the Canadian Northern railway, where they are greatly disturbed.

Several contacts between the Lorraine quartzite and older greywacke were seen in Lampman township that show but faint evidence of unconformity. The quartzite lies directly upon a somewhat irregular greywacke surface. There is no basal conglomerate in the quartzite, but tongues and contorted pieces of greywacke project a few inches upward into it as if the greywacke had been plastic when the sand now represented by the quartzite was deposited upon it.

Keweenawan (?).

The Huronian and older groups are intruded by diabase dykes and sills similar to those in Timiskaming and Montreal River districts, and presumably of Keweenawan age. As in those districts, the dykes are confined largely to the Keewatin and Laurentian; the sills to the Huronian beneath which or along the bedding planes of which they have been injected.

Pleistocene.

Boulder clay overlies the Pre-Cambrian rocks over most of the district as a thin sheet, but in places forming ridges. In Ogilvie, Browning, and Unwin townships, also near Meteor, Shoofly, and Oshawong lakes extensive plains of imperfectly stratified sand replace the boulder clay. The surface of these plains is even, but not level enough to imply lacustrine deposition. It is broken by occasional gravel ridges representing eskers, and is also pitted with kettle-holes, many of which now contain lakes. The sand, as revealed along the Canadian Northern Ontario railway, which crosses the second plain mentioned, is strongly cross-bedded and convexly stratified, indicating stream deposition. Some temporary ponding of glacial streams probably occurred during the formation of these sand plains, but the streams themselves appear to have played the most important part in their deposition.

Economic Geology.

Gold.

West Shiningtree District.

Gold was found during June, 1911, in portions of Asquith and adjoining townships, or what is now better known as West Shiningtree district. For over a year past unusually active prospecting has been conducted in this and neighbouring Keewatin areas as a result of the encouraging developments in Porcupine district, which lies 70 miles farther north. A party of prospectors from Sudbury visited West Shiningtree lake late in 1910, and, although no gold was found, the numerous quartz veins seen in the Keewatin schists were thought to be worthy of further examination. It was revisited for this purpose early in the spring of 1911. It is difficult to say when gold was first found, for some of the earlier "discoveries" were premature efforts to arouse public interest. Probably some was obtained in June, but high-grade ore was not found until early in August. This discovery was made near Milepost 3, on the north boundary of Asquith township, by Messrs. Gosselin, Speed, and Frith, and caused a rush of prospectors to West Shiningtree lake, from Sudbury, Gowganda, and other points. On August 19, Mr. L. Jefferson found free gold on Wasabika lake, thus extending attention to McMurchy township. When the writer left this area on August 19, gold had been found in three places, and since then at least three other discoveries have been made. Very little surface exploration had been performed upon any of the properties.

The accompanying map of West Shiningtree district shows that district to be underlain principally by Keewatin rocks with intrusive granites to the south. Also, as stated in the preceding geological description, the older Keewatin formations around West Shiningtree and Wasabika lakes are overlain by a volcanic sheet of hornblende andesite. This andesite contains an unusual number of quartz veins, some of which carry native gold. Indeed, all the gold bearing veins known to the writer lie within this formation.

There are two somewhat different modes of occurrence. In some cases gold occurs in quartz veins that occupy distinct fissures in the andesite. So very little work has been done toward tracing these veins that no true estimate can be made of their extent. However, they are nearly vertical, from a few inches to over 20 feet wide, and traceable for distances up to 200 feet. Some are irregular and short. They consist of white quartz containing occasional small patches of white carbonate, which weathers to a rusty limonite powder. Small aggregates of tourmaline occur in the quartz. Pyrite grains are disseminated through this gangue material in varying amounts and are also present in the wall-rock. Flakes and irregular particles of gold $\frac{1}{8}$ of an inch or less in diameter occur abundantly in places, though other parts of the same veins show no visible gold. At the surface gold particles are occasionally found together with limonitic rust in small cavities produced apparently by the weathering out of pyrite grains. In other cases gold is found in vertical sheared zones in the andesite. These are from a few feet to 100 feet wide and strike between northwest-southeast and east-west. They consist of a highly schistose phase of the andesite through which are distributed a great number of small lenses and veinlets of bluish or white quartz that follow the planes of schistosity. Both schist and quartz are more heavily impregnated with pyrite than are the large veins. Gold in fine particles is obtained by crushing and panning this material, and is said to occur in the schist as well as in the quartz stringers.

Gosselin Claims.—This property lies on either side of the Asquith-Churchill boundary, a few chains east of Milepost 3. The small area containing most of the veins is underlain chiefly by andesite, though sheared rhyolite, green carbonate schist, and schistose greenstone are also present. Just east of the little stream which runs from the lakelet on the township line of Speed lake, a large vein traceable through the drift-covering for 100 feet in a southeasterly direction has been stripped in one place for a width of 20 feet without discovering the west wall. Across the stream and 200 feet west of this vein is a second, apparently about 4 feet wide, which can be followed southward for 200 feet. A little south of this second vein there are several smaller ones whose arrangement and dimensions could not be determined owing to the drift-covering. So far as the scanty exposures indicate, the small veins are more richly mineralized with pyrite than the large ones. Good specimens of gold-bearing quartz were obtained from a 2 foot vein which had been exposed for a distance of 8 feet. Gold was not visible in either of the large veins, though its presence was indicated by assays.

Jefferson Claim.—This claim covers a high fire-swept knob of andesite on the east shore of Wasabika lake, McMurchy township. The andesite is massive and cut by a number of small quartz veins. In one 18 inch vein that could be traced northwestward for 40 feet particles of gold were found at the surface as well as in many of the fragments of quartz that were broken off and examined.

Moore and MacDonald Claims.—Just north of MacDonald lake, Messrs. H. Moore and H. MacDonald have staked claims on a sheared zone in the andesite formation. More work had been performed upon this property than any of the others examined, hence the schistose zone, which varies in width between 10 and 40 feet, could be traced for 550 feet from east to west. The schist is traversed along its strike by an interrupted series of small quartz stringers. Both quartz and schist are impregnated with pyrite. No gold could be seen in any of the samples examined, but by crushing and panning a mixed sample of quartz and schist a considerable "tail" of fine particles was collected. A sample collected by the writer and assayed by Mr. H. Leverin, of the Mines Branch, Department of Mines, yielded a value of 40 cents per ton.

Peterson Claim.—This property probably represents a westward continuation of the sheared zone in Moore and MacDonald's claims.

A short distance south of here another shear zone of the same appearance was being opened by Mr. R. Cryderman, but so far as known no gold had been found.

Maguire Claim.—The Maguire property, situated on the south side of West Shiningtree lake, was not discovered until the writer had left this district, and consequently was not examined. From descriptions obtained, however, gold appears to occur in an east-west shear-zone similar to that seen in the claims just described.

Considering the drift-covered nature of West Shiningtree area and the limited amount of surface work already done, a surprising number of veins and mineralized zones have been found. It is to be expected, therefore, that other veins will be discovered during the exploration of these now known. It is also likely that some which are already known to be wide or have been traced without perceptible diminution in width for 200 feet or more, will prove persistent in length. But, though trenching and stripping may reveal bodies of sufficient size to encourage underground exploration, yet it will possibly prove them to be poorer in values than expected. Specimens carrying visible amounts of gold that have been taken from rich pockets have circulated more readily than specimens from lean portions of the same veins. Assay returns from a number of samples range from 40 cents up to $15 per ton. These results are little more than qualitative, for, in the present unexplored state of the veins, only approximate average samples are obtainable; nevertheless, they probably indicate within reasonable limits the general richness of mineralization in this area.

Meteor Lake Area.

As early as 1897 placer gold was found in the stratified sand around Meteor lake, and the headwaters of Wanapitei river. An unsuccessful attempt to wash the sand and gravel on Meteor lake was made by the Onaping Mining Company. The gold values were found to be too low, the individual colours very fine and difficult to collect, and the country too flat to afford natural washing facilities, consequently the camp buildings and machinery were abandoned. Gold is widely distributed in this area and probably also in the sand plain that covers parts of Ogilvie, Browning, and Unwin townships, but not richly enough to be profitably extracted.

Silver.

Calcite veins of the same type as the silver-cobalt veins of Gowganda and Cobalt districts are associated with remnants of quartz diabase sills that occur at intervals throughout the district. But, with few exceptions, they are too poorly mineralized to be economically important, and are interesting only in showing how persistently silver-cobalt deposits accompany the diabase. Most of the discoveries were made in 1909, since which time prospecting for silver in this district has steadily declined and has now almost ceased, except near Shiningtree lake.

Shiningtree Area.

Shiningtree mineralized area lies east of Shiningtree lake in Leonard township. The known veins are confined to about 4 square miles of a diabase sill that overlies Keewatin and Huronian rocks. A considerable number occupy wide and persistent fissures, frequently in parallel N.-S. series, and a few contain silver. Silver was first discovered in May 1909, since when exploration has continued steadily. At present it is known to occur on four different properties and underground exploration has been commenced upon one of these.

Neelands Claim.—This property was described by the writer in the Summary Report of the Geological Survey for 1910. There has been no further development.

Saville Exploration Company's Claims.—An account of this property was also given in the Summary Report for 1910.

Archibald Claim.—The diabase underlying this property is traversed by a group of three parallel north-south veins, the outermost of which are 80 feet apart. They vary in width from 1 to 3 inches and are stripped for distances varying from 60 to 160 feet in length. Small flakes of silver can be seen at two points along the most easterly one, and a little specularite, chalcopyrite, and cobalt bloom occur in all three.

Caswell Claims.—A similar group of parallel, but less regular veins, striking N. 15° E., intersect the diabase of this property. When visited in August a vertical shaft had been sunk 92 feet beside one of the veins, at the surface of which a little native silver had been found. It was proposed, when a depth of 108 feet had been reached, to drift east and west at the 100 foot level in search of the veins. The working plant consists of a small hoist and one steam-drill.

Rosie Creek Area.

Rosie Creek area includes adjacent portions of Unwin and Browning townships on either side of Rosie creek, a small tributary of Wanapitei river. It consists of a flat sand plain above which rise occasional hills of Lorraine quartzite or of diabase. The diabase hills represent portions of a sill which rests upon nearly flat-lying quartzite or upon Laurentian granite. This area was prospected actively during 1909 and the early part of 1910, but is now almost deserted. The veins that have been found, though of good size, are crooked and contain a somewhat atypical mineral assemblage. Silver has not been recorded except in traces determined by assays. Smaltite and cobalt bloom occur, but chalcopyrite and galena are more common, and slender prisms of stibnite are present in one vein.

Other Localities.

Numerous veins have been found in a diabase sill 250 feet thick which overlies Keewatin and Huronian formations in the township of North Williams. Near the south end of this township a small quantity of silver was found at the surface of a vein on property owned by the Exploration Syndicate Company, but test pitting proved it to be discontinuous.

An 18 inch vein carrying large masses of galena occurs in diabase near the middle of Hodgetts township.

The diabase forming one of the islands in Welcome lake contains a vein of barite.

GEOLOGY OF LAKE SIMCOE AREA, ONTARIO, BRECHIN[1] AND KIRKFIELD[2] SHEETS.

(*W. A. Johnston.*)

INTRODUCTION

The field work of the past season was a continuation of the topographical and geological mapping of a portion of the Lake Simcoe district, Ontario, on a scale of 1 mile to 1 inch. Topographical relief is shown on the maps by contours at intervals of 20 feet. Intermediate contours, or 10 foot contours, are also used in areas where there is very little relief or for the purpose of showing small features of special significance, *e.g.*, beach ridges, etc.

Field work lasted from May 30 until November 10, in which work R. L. Junkin and C. Freeman assisted and rendered efficient service.

A few days in August were spent by the writer in company with Mr. P. E. Raymond, invertebrate palæontologist of this Survey, in an examination of some of the sections of the lower Ordovician in the Brechin and Kirkfield areas. Collections of fossils were made which have been determined by Mr. Raymond, and the partial results of his work are incorporated in this report.

LOCATION AND AREA.

The topographical field work of the past season consisted chiefly of the sketching of the Brechin and Kirkfield map-areas, both of which were completed. The Brechin map-area is bounded by latitudes 44° 30′ and 44° 45′ and longitudes 79° 00′ and 79° 15′, and includes a land area of about 190 square miles. The Kirkfield map-area is bounded by latitudes 44° 30′ and 44° 45′ and longitudes 78° 45′ and 79° 00′, and includes a land area of about 170 square miles.

GENERAL CHARACTER OF THE DISTRICT.

Within the limits of Brechin and Kirkfield areas the maximum relief is about 400 feet. Flat-lying Ordovician limestones occupy the greater portion of the district and are generally well exposed in the central and northern portions of the area. In the southern part the solid rock is in greater part concealed by drift. A strip along the northern border, having an area of about 40 square miles, is underlain by Pre-Cambrian rocks having comparatively little drift-covering. Near the contact of the limestones and crystalline rocks an escarpment is generally well developed, which varies in height from a few feet to upwards of 100 feet. The limestones have a gentle dip varying from 15 to 30 feet per mile towards the southwest. They are rarely faulted, but the dip is sometimes varied by low undulations or folds.

[1] Formerly Mud Lake sheet.
[2] Formerly Balsam Lake sheet.

General Geology.

TABLE OF FORMATIONS.

Recent	Humus, sand dunes, marls, etc.
Pleistocene	Raised beaches, fluviatile and lacustrine sands, gravels and clays. Glacial clays, boulder clays and sands: fluvio-glacial sands and gravels. Boulder clay.
Ordovician Kirkfield limestone (group) (Trenton)?	Upper member (unknown). Prasopora beds. Crinoid beds. Dalmanella beds.
Black River (group)?	Coboconk limestone, Columnaria beds. Upper Lowville (Birdseye) limestone. Lower Lowville limestone, Beatricea beds. Basal series of sandstone, shales, etc.
Pre-Cambrian	

DESCRIPTION OF FORMATIONS.

Ordovician.

Black River (group)—

1. Basal Series of sandstones, shales, etc.—

Resting unconformably on the Pre-Cambrian crystalline rocks in the Simcoe district, Ontario, as a basal series consisting of coarse calcareous sandstone or arkose passing upward into red and green shales with intercalated lenses or thin beds of sandstone, and occasionally thin beds of fine-grained limestone. The thickness of this series varies and the beds are frequently absent on the sides and tops of ridges or domes of the crystalline rocks, where the limestones are seen to rest directly on the old floor. The sandstone and shales are best developed in basins between ridges of the crystalline rocks where they occasionally have a maximum thickness of about 40 feet. They are local in character and derivation, and evidently represent the old soil covering of the Pre-Cambrian rocks somewhat sorted, rearranged, and recemented, and it seems probable that they represent the initial near-shore deposit of the next succeeding formation.

2. Lower Lowville (Beatricea beds).—The red and green shales pass upwards into impure magnesian limestones which on fresh fracture are greenish-grey in colour and weather yellowish-brown. They are characterized by numbers of drusy cavities, occasional quartz grains and crystals of pyrite or limonite, and are generally barren of fossils. They are only a few feet in thickness, and are followed by 6 to 10 feet of fossiliferous blue-grey to dove-coloured limestone characterized by an abundance of a species of Beatricea. These beds somewhat resemble in physical character the typical fine-grained "Birdseye" limestone, but are less compact in texture and weather to a shaly mass. They are overlain by from 7 to 10 feet of unfossiliferous magnesian limestone very similar to the beds which immediately underlie them. A small collection of fossils from the Beatricea beds, as exposed on the west side of Lake Couchiching, Ont., was obtained last year, and the fossils were determined by Mr. E. O. Ulrich, of the United States Geological Survey, as belonging to the lower middle Lowville. One of the best localities in the district where these beds are exposed is about 2 miles south of Dartmoor post-office, on lots 16 and 17, concession I, of Dalton township, and on lot 25, concession VI, of Carden township. A larger collection of fossils was made at this locality the past summer and they have been determined

by Mr. P. E. Raymond of this Survey. Following is the list of fossils, with Mr. Raymond's comments on their occurrence:—

"Near lot 25, concession VI, Carden, Ont., W. A. Johnston and P. E. Raymond, collectors.

Beatricea cf. B. *gracilis*, Ulrich.
Beatricea, sp. ind.
Tetradium halysitoides.
Cyclocystoides halli, Billings.
Rafinesquina minnesotensis, Winchell.
Strophomena incurvata (Shepard), small variety.
Zygospira recurvirostris, Hall.
Ctenodonta nasuta (Hall).
Cyrtodonta huronensis, Billings.
C. subtruncata, (Hall).
Sphenolium, sp. ind.
Raphistomina lapicida (Salter).
Lophospira bicincta (Hall).
L. perangulata (Hall).
Orthoceras amplicameratum, Hall.
O. multicameratum, Hall.
Loxoceras allumettense (Billings).
Isotelus gigas, Dekay.
Onchometopus simplex, Raymond and Narroway
Bumastus indeterminatus (Walcott).
Bathyurus johnstoni, Raymond.
Pterygometopus callicephalus (Hall).
Leperditia fabulites, Conrad."

"This fauna is peculiar in many ways, and, were its position not definitely fixed by the simple stratigraphy of the region, it would not be easy to place it. The facies is distinctly Lowville, although *Orthoceras multicameratum* is the only typical Lowville fossil present. *Cyclocystoides* and *Bumastus indeterminatus* have not previously been found below the Leray-Black River, while *Onchometopus simplex, Bathyurus johnstoni*, the small form of *Strophomena incurvata*, and several ostracods not enumerated above, occur at exactly this same horizon, just below the typical Lowville, near Clayton, New York, and at Ottawa. The *Tetradium* is not fasciculate like *T. cellulosum*, but grows in a loose form, very much like that of *Halysites*. Some of the larger masses had, on weathered surfaces, much the same appearance as similar broken up colonies of *Tetradium syringoporoides*."

3. Upper Lowville (Birdseye) limestone.—The Beatricea beds are overlain by about 20 feet of fine-grained even-bedded dove-coloured limestone characterized by *Bathyurus extans* and in the upper portion of a great abundance of *Tetradium cellulosum*. At the top are a few feet of coarser-grained dark coloured limestone, and in the section exposed in the quarry at Coboconk, Ont., Mr. Raymond considers that the line between the Lowville formation and the next succeeding formation, which was named the Coboconk formation and correlated with the Leray formation of the New York State geologists in last year's Summary Report, should be drawn about 9 feet above the fine-grained beds, as the *Tetradium cellulosum* still appears in these beds.

4. Coboconk limestone, Columnaria beds, correlated with the Leray limestone of New York State geologists.

Good sections showing the total thickness of the Coboconk limestone are rare in the district. One of the best localities is about 2 miles south of Dalrymple post-office.

The beds consist of dark grey, generally coarse-grained, rubbly limestone in thick beds having a total thickness of about 35 feet. The upper portion is characterized by a great abundance of chert, while the lower half contains comparatively little chert but the fossils are generally silicified throughout the formation where exposed on the surface. The following fossils were collected from the upper cherty beds.

"Lot 12, concession III, Carden, Ont. W. A. Johnston, collector.

Stromatocerium rugosum, Hall.
Stromatocerium, undescribed.
Beatricea cf. *B. gracilis*, Ulrich.
Beatricea, sp. ind.
Receptaculites occidentalis, Salter.
Columnaria halli, Nicholson.
Calapœcia canadensis, Billings.
Streptelasma profundum (Owen).
Rhynchotrema inæquivalve (Castelnau).
Orthis tricenaria, Conrad.
Rafinesquina alternata (Emmons).
Strophomena incurvata (Shepard).
Bellerophon charon, Billings.
Holopea nereis, Billings.
Maclurites logani, Salter.
Hormotoma gracilis (Hall).
Hormoceras tenuifilum, Hall.

"This is a typical Leray-Black River assemblage, but the collection is so small that it probably does not properly represent the fauna. *Columnaria halli*, *Calapœcia canadensis*, and the *Hormoceras* are looked upon as the characteristic fossils, as all the others are found in later beds."

On the north end of Grand island in Balsam lake a few feet of coarse-grained, light grey limestone in thin beds are exposed which are very fossiliferous. On account of the isolated character of the exposure it is difficult to say what the stratigraphical relations of the beds are, but they would appear to underlie the Crinoid beds, as these beds are exposed on the west side of the island dipping slightly towards the southwest. The following collection of fossils was made at this locality.

"North end Grand island, Balsam lake, Ontario. W. A. Johnston, collector.

Solenopora compacta (Billings).
Orthis tricenaria, Conrad.
Dalmanella testudinaria (Dalman).
Plectambonites sericeus (Sowerby).
Rhynchotrema inæquivalve (Castelnau).
Rafinesquina alternata (Emmons).
Clionychia, sp. ind.
Cyrtodonta obtusa (Hall).
Ctenodonta nasuta (Hall).
Holopea nereis, Billings.
H. excelsa, Ulrich and Scofield.
H. rotunda, Ulrich and Scofield.
H. appressa, Ulrich and Scofield.
Bellerophon charon, Billings.
Salpingostoma, sp. ind.
Eccyliomphalus undulatus (Hall)
Subulites elongatus, Conrad.

Cyrtospira parvula (Billings).
Scenella, sp. ind.
Liospira americana (Billings).
L. progne (Billings).
Lophospira conradana, Ulrich and Scofield.
L. bicincta (Hall).
Cyclonema, sp. ind.
Cycloceras lesueuri (Clarke).
Bathyurus spiniger (Hall).
Isotelus gigas, Dekay.
Bumastus milleri (Billings).
Pterygometopus callicephalus (Hall).
Ceraurus pleurexanthemus, Green."

"This fauna is totally unlike any other that has been reported from the district. *Bathyurus spiniger* is usually restricted to the Lowville and Leray-Black river, but the specimens from this locality differ from the typical form in having a much longer and straighter spine on the pygidium, and it may prove to be a new species. The large gastropod element in the fauna also suggests the Leray-Black river, or the lower part of the Trenton, many of the species being common at Paquette rapids on the Ottawa."

Kirkfield limestone (group). (Trenton.)—

1. Dalmanella beds.—The thick cherty beds at the top of the Coboconk limestone are followed by about 20 feet of thinly bedded limestones characterized by an abundance of a species of Dalmanella. Some of the beds in the upper portion have a peculiar yellowish or rusty weathering and are overlaid by about 8 feet of thicker-bedded, more compact, light grey limestone, which is followed by about 20 feet of thinly-bedded grey limestones with shaly partings. It is difficult to draw any sharp dividing line between these beds and the crinoid beds which immediately overlie them, and good exposures showing this portion of the section are rare. In the following list of fossils the first three lots are from the lower thinly-bedded limestones, and the latter, which were collected from the dumps along the Trent canal below the Kirkfield lift-lock, are probably from the upper and middle portions of the Dalmanella beds. As stated in last year's Summary Report, these beds are considered by Mr. E. O. Ulrich to be equivalent to the upper part of the Decorah shale of Iowa and Minnesota.

"Lot 22, concession VIII, Carden, Ont. W. A. Johnston, collector.

Girvanella, sp. ind.
Receptaculites occidentalis, Salter.
Streptelasma profundum (Owen).
Dalmanella testudinaria (Dalma).
Rafinesquina alternata (Emmons).
Strophomena incurvata (Shepard).
Plectambonites sericeus (Sowerby).
Sinuites, sp. ind.
Hormotoma gracilis (Hall).
Bumastus milleri (Billings).

Lot 23, concession VIII, Carden, Ont.—
Solenopora compacta (Billings).
Streptelasma profundum (Owen).

Orthis tricenaria, Conrad.
Strophomena, sp. ind.
Hormotoma gracilis (Hall).
Leperditia fabulites, Conrad.

Lot 10, concession III, Carden, Ont—
Receptaculites occidentalis, Salter.
Stenaster salteria, Billings.
Orthis tricenaria, Conrad.
Dalmanella testudinaria (Dalma).
Isotelus gigas, Dekay.

Kirkfield lift-lock. Strata below lock. W. A. Johnston and P. E. Raymond, collectors.

Receptaculites occidentalis, Salter.
Columnaria halli, Nicholson.
Carabocrinus vancortlandti, Billings.
Stenaster salteri, Billings.
Orthis tricenaria, Conrad.
Dalmanella testudinaria (Dalma).
Platystrophia lynx (Eichwald), uniplicate variety.
Rafinesquina alternata (Emmons).
Strophomena incurvata (Shepard).
Zygospira, sp. ind.
Pholidops trentonensis, Hall.
Maclurites logani, Salter.
Phragmolites, sp. ind.
Bathyurus ingalli, Raymond.
Thaleops ovata, Conrad.
Bumastus milleri (Billings).
Pterygonetopus, sp. ind.
Encrinurus vigilans, Hall.
Leperditia fabulites, Conrad."

"The first three lists indicate the fossils which are commonly found in the strata immediately above the cherty beds at the top of the Coboconk limestone. The fossils are usually silicified, and a variety of *Dalmanella testudinaria* is exceedingly abundant. The fossils from the Kirkfield lift-lock were collected from the dump at the sides of the canal, and there appears to be a mixture of the faunas of this lowest bed and the next younger strata."

At Fenelon Falls, Ont., a very good section is exposed, showing at the base on the north side of the river below the locks 8 to 10 feet of thickly-bedded, compact, grey limestone followed by about 25 feet of thinly-bedded limestone characterized on weathered surfaces by a great abundance of black silicified Dalmanellas. Along the south shore of Cameron lake, about a mile west of the town, a few feet of similar beds are exposed in contact with the Pre-Cambrian crystalline rocks. The following fossils were collected from these two localities:—

"Fenelon Falls, Ont. Lowest beds in section below locks. W. A. Johnston and P. E. Raymond, collectors.

Solenopora compacta (Billings).
Stromatocerium rugosum, Hall.
Receptaculites occidentalis, Salter.
Streptelasma profundum, Owen.

Orthis tricenaria, Conrad.
Dalmanella testudinaria (Dalman).
Rhynchotrema inæquivalve (Castelnau).
Rafinesquina alternata (Emmons).
Ctenodonta nasuta (Hall).
C. levata (Hall).
Subulites elongatus, Conrad.
Hormotoma gracilis (Hall).
Lophospira bicincta (Hall).
Isotelus gigas, Dekay.
Calymmena senaria, Conrad."

"This fauna indicates that the beds from which they came are those immediately above the top of the Coboconk limestone. The species listed below were collected above the locks, near the contact of the limestone with the granite. They indicate the same horizon, and the inference is that the Coboconk is absent here.

Receptaculites occidentalis, Salter.
Streptelasma profundum, Owen.
Rafinesquina alternata (Emmons).
Strophomena incurvata (Shepard)."

2. Crinoid beds.—Along the Trent canal above the Kirkfield lift-lock the Dalmanella beds are overlain by about 30 feet of grey limestones generally somewhat thicker bedded, with black shaly partings containing great numbers of crinoids and cystids. The contact between the Dalmanella beds and the Crinoid beds is not well defined, and as most of the fossils from this locality have been collected from the dumps beside the canal it is difficult to say from what beds they come.

"Trent canal, 2 miles north of Kirkfield. W. A. Johnston and P. E. Raymond, collectors.

Lingula canadensis, Billings.
L. philomela, Billings.
Glossina trentonensis, Hall.
Trematis ottawaensis, Billings.
Camarella volborthi, Billings.
Orthis tricenaria, Conrad.
Dalmanella testudinaria (Dalman).
Dinorthis pectinella (Emmons).
Platystrophia lynx (Eichwald).
Rhynchotrema inæquivalve (Castelnau).
Plectambonites sericeus (Sowerby).
Strophomena incurvata (Shepard).
Phragmolites compressus, Conrad.
Oxydiscus, sp. ind.
Subulites elongatus, Conrad.
Hormotoma gracilis (Hall).
Isotelus gigas, Dekay.
Isoteloides homalnotoides (Walcott).
Bumastus bellevillensis, Raymond and Narraway.
Pterygometopus callicephalus (Hall)."

"Nearly all the collecting at this locality has been with the object of obtaining echinoderms, and the rest of the fauna is very imperfectly known. The echinoderms have been listed by Mr. Frank Springer in Memoir 15—P, of the Geological Survey.

The fauna is very similar to that found in strata at the same horizon in the Trenton in Hull, Quebec, and in the Curdsville limestone of Kentucky. The presence of *Bathyurus, Bumastus, Camarella volborthi, Orthis tricenaria,* and *Strophomena incurvata* in this fauna indicate a relation to the Black River.

At Fenelon Falls, Ont., in the section exposed on the north side of the river below the locks, the Dalmanella beds are overlain by about 30 feet of limestone closely resembling in physical character the crinoid beds along the Trent canal above the Kirkfield lift-lock. The top beds are exposed on the flat just in front of the Kawaitha House where they are followed by 3 feet of the Prasopera beds. The following fossils were collected from the crinoid beds at this locality:—

"Fenelon Falls, Ont. Just below the locks. P. E. Raymond, collector.

Cupulocrinus jewetti (Billings).
Unidentified crinoids.
Crania, sp. ind.
Pholidops trentonensis, Hall.
Dalmanella testudinaria (Dalman).
Dinorthis needsi, Winchell and Schuchert.
Plectambonites sericeus (Sowerby).
Zygospira recurvirostris, Hall.
Strophomena incurvata (Shepard).
Subulites elongatus, Conrad.
Hormotoma bellicincta (Hall).
Isotelus gigas, Dekay.
Bumastus bellevillensis, Raymond and Narraway.
Ceraurus pleurexanthemus, Green."

"This fauna indicates the same horizon as the previous one."

3. Prasopora beds.—At Fenelon Falls, Ont., the crinoid beds are followed by about 18 feet of thin shaly limestones characterized by an abundance of Prasopora. Along the Trent canal above the Kirkfield lift-lock and near the stone-crusher a few feet of similar strata are exposed at the top of the crinoid beds. In a cutting on the Grand Trunk railway, 2½ miles south of Brechin, Ont., about 8 feet of thinly-bedded limestone with clay partings is exposed. This outcrop is an isolated one, but, as calculated from the dips, the beds should be about from 25 to 35 feet above the base of the Prasopora beds. The following fossils were collected from these three localities:—

"Fenelon Falls, Ont. Thin, shaly strata above locks. P. E. Raymond, collector.

Agelacrinites billingsi, Chapman.
Prasopora, 2 or 3 species.
Dalmanella testudinaria (Dalman).
Hebertella bellarugosa (Conrad).
Rhynchotrema inæquivalva (Castelnau).
Plectambonites sericeus (Sowerby).
Subulites elongatus, Conrad.
Ceraurus pleurexanthemus, Green."

"Trent canal. 2 miles north of Kirkfield, Ont. Thin shaly layers near the stone-crusher. W. A. Johnston and P. E. Raymond, collectors.

Prasopora, several species.
Dalmanella testudinaria (Dalman).
Platystrophia lynx (Eichwald).
Rhynchotrema inæquivalve (Castelnau)."

"Cutting on Grand Trunk railway, 2½ miles south of Brechin, Ont. W. A. Johnston and P. E. Raymond, collectors.

Licrophycus Ottawaensis, Billings.
Ischadites, sp. ind.
Dendrocrinus acutidactylus, Billings.
Lichenocrinus crateriformis, Hall.
Agelacrinites billingsi, Chapman.
Prasopora, several species.
Dalmanella testudinaria (Dalman).
Plectorthis plicatella, Hall.
Dinorthis meedsi, Winchell and Schuchert.
Strophomena emaciata, Winchell and Schuchert.
Rafinesquina alternata (Emmons).
Rhynchoterma inæquivalve (Castelnau).
Pholidops trentonensis, Hall.
Plectambonites sericeus (Sowerby).
Fusispira angusta, Ulrich and Scofield.
Hormotoma bellicincta (Hall).
H. gracilis (Hall).
Lophospira medialis, Ulrich and Scofield.
Liospira americana (Billings).
Raphistomina, sp. ind.
Sinuites cancellatus (Hall).
Pterotheca, sp. ind.
Isotelus gigas, Dekay.
Pterygometopus callicephalus (Hall).
Calymmene senaria, Conrad.
Ceraurus pleurexanthemus, Green."

"The fossils enumerated in the first two of these lists came from the very base of the shaly strata characterized by the abundance of *Prasopora*, with the exception of the specimens of *Agelacrinites billingsi* from Fenelon Falls. These specimens came from a layer about 15 feet above the base. The exposure on the railway south of Brechin is an isolated one, but the fauna indicates that the strata belong either to the *Prasopora* zone itself, or else low in the next zone. A very similar fauna is found at Ottawa at the same horizon, a little below the middle of the Trenton."

In the above table of formations the terms Kirkfield limestone group (Trenton) and Black River groups are provisionally adopted, and the dividing line between the two groups are put at the top of the Coboconk limestone on P. E. Raymond's recommendation. Mr. Raymond proposes to take up the question of the nomenclature of these formations in his report on the Ottawa-Cornwall map-area.

PLEISTOCENE DEPOSITS OF SOUTHWESTERN ONTARIO.

(*F. B. Taylor.*)

Areas Studied.

Work was begun at St. Catharines on August 26 and closed at Windsor on November 14, 1911.

The work done this season was in four different areas: (1) In the eastern half of the Niagara peninsula; (2) in the region of the escarpment northward from Orangeville to Georgian bay and thence southwest to the vicinity of Clifford and Harriston; (3) between Milton and Toronto, and (4) around Leamington and Kingsville, in Essex county.

Niagara Peninsula.

The work done in previous years left the mapping of this peninsula incomplete. During the first half of the past season the writer was engaged in detailed work on the Niagara quadrangle in New York, where the topography and general character of the country is substantially the same as on the Canadian side. Certain features found in New York were traced to the bank of the river and their relations afforded strong ground for expecting their continuation westward on the Canadian side. Some of these features had not been observed before, and the three weeks given to this area during the past season were largely devoted to the search for them and to the study and mapping of those found. A little time was also taken for spirit-levelling with a Tesdorpf German pocket-level at four or five localities on the old beaches. At several places gaps in previous observations were filled in and the mapping made more complete.

MORAINES.

The Crystal Beach moraine (the continuation in Canada of the Alden moraine of New York) was found on more detailed study to intersect the shore of Lake Erie at a point about a mile east of Crystal Beach. Thence westward it extends as a very distinct ridge, passing about three-fourths of a mile north of Crystal Beach, and having the main highway on or near its crest through Sherks station and to within about a mile of Gasline. Its front or southward relief is 10 to 15 feet through most of this distance, the back or northward relief being half as much or less. Near Gasline the moraine enters a region of thin drift over limestone and was followed with difficulty, being distinguished chiefly as a belt bearing more crystalline boulders than the average for the surrounding region. The bouldery belt crosses the Welland canal at Humberstone, but appears as a more definite till ridge about 3 miles northwest of Port Colborne, where it rests on the top of the low escarpment of the Onondaga limestone and continues in this relation along the south side of the Wainfleet marsh nearly to Lowbanks. There are no very good sections in Canada showing the composition of this ridge, but there are a number in New York and all show it to be composed of till, not of rock.

The Fort Erie moraine (the continuation in Canada of the Buffalo moraine in New York) is a strong, well-defined till ridge for 7 or 8 miles west of Fort Erie, but beyond that it is very faint in its continuation towards Welland. Its composition is well shown in several sections through it. On Niagara river the whole relief of the ridge above the surrounding plain is seen at Fort Erie and Fort Porter to be composed entirely of till. The rock at both of these places is somewhat below the general level of the plain. Sections on the Welland river and the Welland canal, about 2 miles north of Welland, show no rock in the broad, low ridge. Between Buffalo and Depew there are four or five deep railway cuts through the moraine, where its relief is strong and no rock is disclosed.

The Lundy or Niagara Falls moraine (the continuation in Canada of the Tonawanda moraine of New York) is strong and well defined for several miles west from Lundys Lane, but weakens toward Fonthill. It is also strong southeast to Chippawa, but is quite faint farther east and across Grand island. A few miles east of Tonawanda it becomes quite strong and continues so to the hills south of Alabama village, New York. The clayey composition of the ridge and the absence of rock is well shown where the Welland canal cuts through it a mile north of Port Robinson, at Chippawa, on both sides of Grand island and where it is breached by several small streams farther east. The best section, however, is at Niagara Falls, extending from Falls View to the bluff south of the Dufferin islands. In this interval the Niagara river has cut into the east side beyond the crest, leaving only a part of the front or western slope standing. This is the case at Falls View and the Loretto convent. The cut here goes nearly to bed-rock, far below the base of the moraine, exposing a section of drift over 100 feet deep.

The Stamford or Vinemount moraine (the continuation in Canada of the Lockport moraine of New York) is weak between Queenston Heights and the gravel hills north of Stamford, but from this point southwest and west nearly to De Cou falls it is a well-defined feature. After a gap of about 3 miles at the great break in the escarpment west of De Cou falls, the moraine resumes its strong expression about 2 miles north of Effingham and continues in this character to the vicinity of Hamilton. Until this season the Lockport-Stamford moraine had not been traced west of Lockport in New York nor east of Beamsville in Ontario. Heretofore it was supposed that the Lundy moraine found its westward continuation in the Stamford or Vinemount moraine on the escarpment south of Grimsby, but this is not the case. They are independent throughout, the Stamford following the Lundy as the next later one in the series.

The position and course of the Stamford moraine are quite remarkable. Most of its course is on the escarpment close to its edge, generally less than a mile back. This is the case from Lockport to Queenston and from Camden westward. The heavy beds of the Lockport limestone which form the escarpment dip gently to the south and at many places they rise to a slightly higher level at the escarpment than the general surface of the plain to the south. From this it was thought by some that the ridge standing a little back from the edge was merely a rock ridge veneered with till. But there are several deep cuts through the ridge in New York and also in Ontario that show only glacial till with no bed-rock. The prominent gravel hills north of Stamford lie in the line of this moraine and from this point west of De Cou falls, and then again from Effingham to Camden, the moraine leaves the escarpment and crosses the plain 2 or 3 miles south of it. East of Lockport this moraine leaves the escarpment entirely and runs far to the south of it. There is now no doubt as to its true character: it is a terminal moraine of the Ontario ice lobe, built when the ice barely overtopped the escarpment west of Lockport and rested its front just back of the edge. This, too, is a waterlaid moraine, but has an unusually sharp relief for such a feature.

These four moraines have one rather exceptional characteristic: they are substantially horizontal throughout their extent on this peninsula, and they continue so for some distance eastward into New York. In general, terminal or marginal moraines show a distinct decline in altitude from points on the sides of lobes to their apexes. In this case, however, the basin of Lake Ontario is so deep and so close to the escarpment and to the Erie plain, and it presents such a wide, nearly straight front to the south that the ordinary conditions of an ice lobe did not exist. During the time of these moraines the deep ice mass in the lake basin to the north stood only a little above the level of the escarpment and hence only a relatively thin sheet of ice moved out over the plain. Because the plain is flat and nearly level, the ice found nearly equal facility for forward movement all along the front, and from this circumstance made a series of nearly straight and horizontal moraines.

This fact has an important bearing on the glacial history of the peninsula, for in New York, a short distance east of the Niagara quadrangle, two moraines have been found which are later than the Lockport. The first is the Albion moraine, traced by Mr. Leverett from Rochester to Medina many years ago. This is a strong moraine and extends in good strength to Gasport, but from this place westward the ice front at this time appears to have rested either at the base or against the face of the escarpment. It was traced somewhat doubtfully as far as Lockport, but it has not been identified with certainty in Ontario.

The other was first traced this season and may be called the Carlton moraine. It was followed from Troutberg westward through Carlton, and in this interval and for some distance west of Carlton is a splendid example of the waterlaid form of moraine. But it grows weak toward the west and is represented in the Niagara quadrangle and in Ontario by only a few very faint and fragmentary features. In New York it lies 1 to 2 miles back from the Lake Ontario shore, but in the eastern half of the Niagara peninsula of Ontario the features that probably belong to it are 3 or 4 miles back. This moraine is below the Iroquois beach and is the first oue to be found in that relation.

Both of these moraines are horizontal in the parts traced, and considering the horizontal attitude in this area of the four earlier moraines of this series, it is practically certain that these two are also horizontal in the parts where they are too faint for continuous tracing. A moraine is usually formed at the edge of the ice at a time of halting, but it is not to be inferred from this that where a moraine becomes too faint in some intervals to be traced, the ice-front did not halt in those intervals. It is more probable in such cases that other influences caused the moraine to be faint or to become obscured. It is believed, therefore, that a complete inventory of the moraines of the eastern half of the Niagara peninsula should include the four moraines observed and clearly traced, and also the two later moraines whose existence here is inferred mainly from observations in New York rather than from the few faint evidences seen within this district. This makes six moraines in all—six halts of the ice-front during the recession of the Ontario ice-lobe across the eastern half of the peninsula.

In the western part of the peninsula three distinct moraines lying south of the Stamford diverge southeastward from the vicinity of Ancaster and are traceable quite clearly into the eastern part of the township of Glanford. These seem to correspond perfectly with the southern three beaches in the eastern half. The Crystal Beach moraine has not been traced between Lowbanks and Glanford, and the same is true of the Fort Erie and Lundy beaches between Fonthill and Glanford. The topographic contour maps and also observations made at two or three points indicate that all these moraines in this interval lose their relief by broadening and flattening to such an extent that they cease to be visible to the eye as ridges, but are low, nearly flat but continuous clay divides that control the drainage. Some further field work is needed in these intervals. In Haldimand county, in the southwestern part of the peninsula, one or two earlier moraines may possibly be found lying south of the Crystal Beach moraine, but that area has not yet been fully studied.

BEACHES.

Points on the Lundy beach were measured by spirit level near Stamford, Lundys Lane, Fort Erie, Port Colborne, and Lowbanks, and on the Fort Erie beach at the last three places named. Only a little new mapping was done on these beaches. The details of the Iroquois beach were studied between Queenston and Beamsville. A submerged and modified beach found north of Lockport, New York, 32 feet below the Iroquois, has not yet been identified in Ontario.

DRUMLINS.

Two rather small, low, but well-formed drumlins were found about 3 miles south of Chippawa and several other fainter, less perfect ones a little farther south near Black creek. Their axes all run northeast to southwest in harmony with others east of the Niagara river.

THE ESCARPMENT AREA.

Earlier mapping had been carried northward from Lake Erie and along the escarpment to the vicinity of Orangeville, where the work was resumed on September 15. The studies this year were carried northward along the escarpment to the brow of "the mountain" 5 or 6 miles west of Collingwood and thence westward, first in a broader belt to the vicinity of Markdale and Durham and then southwestward in a narrower belt to the vicinity of Harriston and Clifford in northwestern Wellington county.

In this belt parts of three moraines were traced and a small fragment of a fourth was found. The associated lines of glacial drainage, as well as other features, and the general characters and qualities of tho drift were also studied. The most remarkable moraines and drainage lines were found in the townships of Mono and Mulmur in Dufferin county, and these townships, so far as examined, were studied in rather more detail than the rest of the belt.

MORAINES ON THE EAST SIDE OF THE HIGHLANDS.

Three strong moraines were traced across Mono and part way into Mulmur township. The earliest or western one lies generally on or a little back (west) of the escarpment; the second lies 2 or 3 miles farther east and down the slope, while the third lies about 2 miles east of the second and along the lower part of the slope. They run like steps along the slope, the second one being 150 to 200 feet below the first and the third the same distance below the second. The first one is the northward continuation of the Paris moraine, traced in the region south from Orangeville in 1899, and the second one is the northward continuation of the Galt moraine. Tho southward continuation or correlative of the third moraine has not yet been determined with certainty.

At the north end of the highland three strong and well developed moraines turn sharp angles north-northwestward to the southwestward courses on the mountain west and southwest of Collingwood. The Paris moraiue was traced continuously from Orangeville to its angle 3 miles west of Singhampton. The Galt moraine was traced continuously to the north side of Mulmur township, but from this point to Rob Roy it was seen only from the hill above. From Rob Roy to its very acute augle east and northeast of Gibraltar it was examined more closely. The third moraine was not traced between the south part of Mulmur township and the mountain west of Collingwood, but its turning point is 1½ miles east of Banks. The turning points of these three moraines were carefully mapped, for they mark the extreme re-entrant of the ice-front at three successive stages of retreat, and show where the great ice mass in the basin of Lake Huron united with the mass in the Lake Simcoe basin. This angle is quite acute, especially in the second and third moraines.

GLACIAL DRAINAGE ON THE EAST SIDE.

The ice-border drainage channels and gravel terrace deposits associated with the moraines south of the angles, especially with the first and second, are truly remarkable. Their branchings and positions at successively lower levels are quite complex, but they connect perfectly with those previously mapped south of Orangeville. Some of the fluvial gravel terraces are up to or above the general crest of the second moraine, where the ice-front stood when they were being made. Chalmers, Spencer, Hunter, and other early students of this region mistook some of these terraces for old marine or lake shores. In some places their exposed position suggests this origin, but close examination shows no wave-made features. Instead of these, there is a complete set of fluvial forms due to large rivers flowing southward along the front of the ice-mass, and alternating between erosional and depositional phases of action. All the features seen are fully explained by this agency. Some of the fluvial gravel terraces in Mono and Mulmur townships are very strong, bulky features. If it were permissible to attribute them to wave-action it is evident that only prolonged and very powerful waves could have done such a work, and if this were the case strong evidence of wave-action ought to be found on adjacent parts of the escarpment front at or near the same levels. But instead of this, the gravels pass down stream (southward) into large eroded channels in protected positions behind morainic ridges and knolls. These same ridges and knolls of easily eroded boulder clay stand in the same exposed position as the gravel terraces, and yet show no sign whatever of wave-action. The whole set of phenomena are clearly products of large temporary rivers flowing along the edge of the ice-mass and are not shore-line forms.

At one place, about 2 miles west of Elder, there is a "fossil cataract" of no mean size. It is about 70 feet high and the gorge below it is well defined and a fourth of a mile long. It recalls the larger features of the same kind associated with the great river channels on the hills south of Syracuse, New York.

MORAINES ON THE WEST SIDE OF THE HIGHLANDS.

From their turning points on the mountain the three moraines take courses converging slightly toward the southwest. They keep these courses to the axis of the Beaver River valley at Eugenia and Flesherton. This deep and beautiful valley, opening into the highland from the north, produced a moderate lobation of the ice-front at the time of the first or Paris moraine, a sharper lobe at the time of the second or Galt moraine, and a still more pointed one at the time of the third moraine. Moraine fragments near the valley bottom at Kimberly appear to belong to a fourth moraine and mark the terminus of a narrow ice-tongue. A few miles west of this valley a well-defined secondary re-entrant marks the union of this smaller lobe with the main ice-lobe of the Lake Huron basin. The second and third moraines were not traced beyond this re-entrant this season, but the first or Paris moraine was traced from the angle northeast of Irish lake directly southwest past Bunessan and Holstein to the south fork of the Saugeen river at Glen Eden and thence westward to the vicinity of Clifford. Beyond this it appears to turn southwest and probably, though not yet certainly, finds continuation in a moraine which was previously traced from the south up to Seaforth.

GLACIAL DRAINAGE ON THE WEST SIDE.

The border-drainage features associated with the ice-front at the time of these three moraines are very pronounced west of the main re-entrant as well as east of it.

The Beaver Valley ice-lobe was, of course, caused by the marked depression of this valley. At the time of the first moraine this valley was filled to its southern extremity by the ice. No lake or depression of any size remained south of the lobe-front. On this account the large river which flowed southwest along the front of the ice from the direction of Singhampton deposited only a moderate amount of gravel in passing the front of the Beaver Valley lobe south of Ceylon. But at the time of the second and third moraines there was a distinct basin in front of the lobe and it was filled with a remarkable deposit of gravels. These lie chiefly between Flesherton and Eugenia, spreading both to the east and west from the axis of the valley. These gravels are the "Artemesia gravels" of the early investigators of this region. They were deposited during the time of the second and perhaps partly of the third moraines by large, rapidly-flowing rivers which came from the northeast from the vicinities of Rob Roy, Gibraltar, and Banks. Their eroded beds are well defined and easily followed. The small lake was entirely filled and obliterated by the gravels. Near the valley axis the deposit appeared to be quite deep, and it is finer and more sandy on the west side. In the re-entrant west of Flesherton and southwestward from Irish lake the eroded glacial river channels are well developed, but are gradually replaced toward the southwest by gravel deposits, which are quite extensive in front of the broad ice-lobe which had its apex near Glen Eden. Farther west eroded channels again take the place of gravel deposition. There are also great gravel terraces at Durham and east and south of this place.

The Highland Plain: Drumlins and Eskers.

The Highland plain enclosed on the east, north, and west sides, between Orangeville and Glen Eden, by the first or Paris moraine, was not fully explored, but was found to be a gently-rolling plain, carrying many drumlins, mostly small and more or less imperfect in form. The ground between the drumlins is mostly swampy. Several remarkably long and well-developed eskers or hogback ridges also occur in this region. They run in more or less winding, serpentine courses from northwest to southeast, and the parts observed extend across the plain outside of the Paris moraine. One extends southeast from Glen Eden to Riverstown, but was not traced farther; another extends east from Glen Eden, passing 2 miles north of Mount Forest, and thence southeast to the central part of West Luther township, beyond which it has not yet been traced. This one is very large. Another appears first in broken form at Priceville and 2 miles west of Ceylon, but about 4 miles south of Ceylon becomes a single ridge and was traced southeast to Brice hill in central Proton township. It is said to extend several miles farther. A fragment of another was observed near Shrigley, in the northern part of Melancthon township, with the same course, northwest to southeast.

These ridges are composed of sand and gravel—usually horizontally bedded fine sand in the lower parts, with a thick capping of coarse gravel and pebbles on top. The top is usually narrow and the sides as steep as the material will stand. The ridges are usually more or less broken and discontinuous and sometimes show double or multiple ridges. Irregularities of form are thoroughly characteristic of them. They sometimes expand into a knot or cluster of kames, or they terminate in such a cluster or in a delta fan. Knots most frequently occur where the eskers intersect moraines. The esker that passes a little north of Mount Forest is the longest one so far found in this region.

The eskers mentioned appear to mark the course of rivers flowing from northwest to southeast through a thin and nearly stagnant ice-mass which covered the central highland at that stage of retreat which immediately preceded the uncovering of the central nunatak or island-in-ice described in the writer's summary report for 1908.

The drumlins on the west side of the highland between Markdale and Durham are larger and higher than those of the central plain, and their axes trend from northwest to southeast.

Area between Milton and Toronto.

A few days near the close of the season were spent in studying the features around Milton and between there and Toronto. These included two waterlaid moraines of moderate strength, with a possible third fainter one. From a point about 3 miles west of Milton a well-defined moraiue was traced northward, passing just east of Stewartown and west of Norval. It seems probable that this moraine extends on northeast so as to connect with the Oak Ridges moraine near Bond lake.

Another somewhat fainter moraine was found at Ash, 6 or 7 miles southeast of Milton. It takes a course a little east of north to the valley of Credit river, just south of Meadowvale. Here it turns sharply to the east for about 4 miles and then as sharply to the north again, crossing the Etobicoke west of Elmbank. It is distinct and fairly strong to this point, but was not traced farther.

Another moraine of this series, observed in 1899, runs north just east of Cheltenham and turns gradually to the northeast. These three moraines belong to a system made by ice moving westward and northwestward out of the basin of Lake Ontario.

Area near Leamington and Kingsville.

The last few days were spent in studying the region around Leamington, especially between Leamington and Kingsville and northwest of Leamington. The only land in Essex county that rises above an altitude of 640 feet above sea-level is a broad low hill lying west and northwest of Leamington. This hill is composed in part of stony till or boulder clay and largely also of gravel. Its summit rises to an altitude of about 740 feet above the sea. At this level it is crowned by a heavy beach ridge or bar of gravel—the Belmore or Whittlesey beach, being here in the area of horizontality and having the same altitude as in adjacent parts in Michigan and Ohio. Below this beach, at successively lower levels, are the Arkona, Forest, or Warren, Grassmere, and Elkton beaches, and all, excepting the last, forming contours around this hill. The Grassmere beach forms a contour at a distance of 2 to 3 miles from the top of the hill, but also sends out bars to the northeast and northwest, in each case extending along the crest of a broad, low drift ridge which is probably a waterlaid moraine. One of these, an irregular, sandy belt, was observed for 2 or 3 miles northeast from Wigle, and the other, a much better formed gravel ridge, runs northwest through Cottam to Essex.

The hill appears to have been morainic, for the till is quite bouldery, which is an unusual quality for this region. The western side of the hill was heavily cut by wave-action and presents a well-defined bluff or sea cliff at the back of the Arkona beach. The top of the hill appears to have been cut away at the Whittlesey stage, and spits were then formed running southeast and northeast from the south and north ends respectively, while a depression along the east side was filled in by a deep deposit of gravel at the higher stages. The original shape of the hill was evidently greatly changed by wave-action, as the lake waters fell through their successive stages.

A bouldery belt with occasional low knolls runs west from this hill past Kingsville and Harrow towards Amherstburg. This is probably a water-laid moraine. A broad, low clay ridge also runs northwest to Windsor and is probably the southeastward continuation of the Detroit interlobate moraine. The original morainic hill, lying mainly north of Ruthven, was probably somewhat of the nature of a water-laid interlobate deposit. But the related moraines are not yet fully made out.

THE DEVONIAN OF SOUTHWESTERN ONTARIO.

(*Clinton R. Stauffer.*)

General Statement.

Work on the Devonian of southwestern Ontario, which was definitely undertaken in 1910, has been continued in more detail during the season just past (1911). A considerable portion of the time was spent in collecting palæontological material and in making a careful stratigraphic study of the more important outcrops. Many of the corals contained in the Devonian formations are large and are firmly embedded in the rock; hence it is impossible to form collections of good material from every locality where they occur. To make the identifications more certain, reference books on these organisms were carried into the field and determinations made on the spot. This method was supplemented by making collections of more fragmentary specimens which have been shipped to the Geological Laboratory of the School of Mining, Kingston, and will form the subject of a considerable portion of next summer's investigation.

Formational Divisions.

Classification.

The classification adopted by Logan,[1] and taken over by him from the New York State reports, is now pretty generally known by the inhabitants of the regions in which these formations outcrop and is firmly rooted in the geological literature of both the Dominion and Provincial surveys. It seems, therefore, that no radical changes should be made in the usage of these terms unless an increase in knowledge of the deposits should demand it. Logan's wisdom in adopting the classification becomes more and more apparent with increased study of the Canadian deposits. It is quite true, however, as pointed out by him, that the Ontario divisions are not the exact equivalents of those bearing the same names in New York state, though the differences are chiefly those incident to distance rather than to the occurrence of marked unconformities. The aid of the drill has brought to light a very considerable amount of knowledge which was not available in 1863. Hence it is not a matter of surprise to find that the once supposed differences are growing constantly smaller, and, therefore, it has become necessary to introduce into the old classification the names of formations not then known to exist in Canada. On the basis of present knowledge the classification of the Devonian, in the region here under discussion, stands as follows:—

Devonian	Upper	Portage and Chemung beds. Genesee shale.
	Middle	Hamilton beds. Marcellus shale. Onondaga limestone. Oriskany sandstone.
	Lower	Wanting (possibly represented, in part, by the upper Monroe).

[1] Geology of Canada, 1863, p. 20.

Beds of Doubtful Age.

Owing to the interest which has recently been kindled in the deposits immediately underlying the Onondaga limestone of extreme southwestern Ontario and adjacent territory, it becomes necessary to discuss these, to some extent, at this point. The Onondaga limestone is commonly the lowest recognized Devonian formation in Ontario, although considerable remnants of the Oriskany sandstone are frequent in Welland and Haldimand counties. Throughout the remainder of the Devonian-covered area of Ontario and portions of adjacent states, small quantities of sand are common at the base of the Onondaga limestone. This basal Onondaga shows further signs of the Devonian transgression in that it is frequently a distinct conglomerate. At Buffalo, where the merest trace occurs, this arenaceous material has long since been referred to the Oriskany sandstone. This is probably the true horizon, since, when traced westward, it passes into definite deposits of sandstone carrying the typical Oriskany fauna. Farther to the westward the Buffalo condition seems to be restored and to be maintained throughout the remainder of Ontario and continued into Michigan and Ohio.

Near Fort Erie the Devonian deposits rest on the eroded surface of the Cobleskill limestone. As this contact is followed westward the underlying beds vary in age from slightly younger to slightly older until, finally, the beds of this horizon disappear entirely at a point about midway between Springvale and Boston. At Beachville, near Woodstock, where this contact next appears, a remarkable transformation, in lithology at least, has taken place in the underlying strata. Instead of the argillaceous and dolomitic limestones, a very pure limestone occurs and in it is found a fauna of corals, brachiopods, pelecypods, and gastropods seemingly unlike anything found farther to the east. This is the fauna of the "Anderdon beds"[1] of the Detroit River region, and is common at various places to the northward. This association of species is markedly Devonian in many of the aspects. There are often present numerous corals belonging to the same genera as those which occur in the Onondaga limestone, while the brachiopods and even the Mollusca are remarkably similar to forms belonging in that same Devonian formation. In the quarries near Amherstburg the "Anderdon beds" are especially fossiliferous, while overlying them unconformably, and with traces of the Oriskany (?) band, are the massive layers of limestone typical of the basal Onondaga of the Michigan and Ohio basins. Also, at the Stony Island "Dry Cut" in the Detroit river there is another association of very similar species occurring somewhat more than 100 feet below the highest rocks there exposed and—since the Sylvania sandstone probably overlies all of these—as much as 400 feet below the unconformity at the base of the Onondaga limestone. A study of these lower faunas shows that they are not Onondaga and resemble much less the Oriskany. Indeed they lie below the probable Oriskany horizon, while the top beds of the "Anderdon" show the effects of the erosion which marks the lower Devonian interval over much of Ontario. A comparison of these faunas with the Helderbergian of New York shows that there is little in common between them—less, indeed, than they have in common with the Onondaga. It seems safe, therefore, to conclude that these lower faunas are not Helderbergian, as that series is at present known. But that they contain certain elements ancestral to portions of the Onondaga fauna, is quite certain. Perhaps they represent faunas contemporaneous with the Helderbergian,[2] which lived in an interior sea wholly separate from that to the east. Such a sea might have had an outlet to the northward along the same route by which certain elements of the Onondaga fauna later found entrance to the Ontario and Michigan regions. But it should also be kept in mind that there are certain Devonian characters detectable in the Cobleskill fauna and even in earlier formations. The

[1] Mich. Geol. and Biol. Surv. Pub. 2, Geol. Ser. 1, 1910, pp. 42-47.
[2] See Ulrich, E. O., Bull. Geol. Soc. Am. Vol. xxii, 1910, p. 28.

occurrence of some of the same brachiopods among the corals of the "Anderdon beds" at Amherstburg, Beachville, Kincardine, etc., as those which occur among probable Cobleskill corals in the upper Monroe at Sandusky, Ohio, leads one to suspect that this fauna belongs properly in the Silurian, as at present constituted, and where Grabau and Sherzer have placed it.[1] Such, in the present study of the Devonian of Ontario, is the provisional disposition made of these fossiliferous deposits, lying below the Oriskany (?) horizon.

Definitions of Devonian Formational Units.

Oriskany Sandstone.

Tho Oriskany sandstone is the lowest true Devonian formation in Ontario. It consists of heavily bedded, coarse-grained, white to yellowish sandstones lying unconformably on the Silurian. In places absent, in others it varies in thickness from paper-thin to 25 feet and carries the pure Oriskany fauna unmingled with later forms. Evidences of this formation exist from Fort Erie westward nearly to Hagersville, but the arenaceous deposits and scattered bodies of infiltrated sand found beyond that point cannot be definitely assigned to the same formation.

Onondaga Limestone.

This is the "Corniferous" limestone of the older reports. The name "Corniferous" refers to the cherty (flinty) character of the rock and was applied, in New York state, to deposits which later proved to be a portion of the same formation that had previously been called Onondaga limestone. It seems better, therefore, to adopt the correct term in this work, and especially since it is more appropriate to the Canadian deposits. The Onondaga limestone is probably the most variable of all the Devonian deposits of the Province. The basal portion, which rests unconformably on either the Oriskany sandstone or beds of greater age, is often conglomeratic. This conglomerate is made up of pebbles derived from the underlying limestone, and mingled with them are sometimes considerable quantities of sand. This latter may have been derived from the destruction of areas of Oriskany sandstone during the advance of the Onondaga sea. In the vicinity of Springvale this sand becomes so abundant as to locally form a deposit resembling the true Oriskany sandstone, but is much younger in age as evidenced by its Onondaga fauna. In the eastern and extreme northern outcrops the lower 30 feet or more of the Onondaga is a thin, unevenly bedded, cherty, grey limestone carrying a fauna composed largely of brachiopods. Overlying this is 15 feet, more or less, of a relatively pure, thick-bedded, crystalline, grey limestone with partings of greenish shale and full of corals. This, in turn, is overlain by somewhat more than 10 feet of very cherty, dark bluish-black limestone with numerous corals, and passing upward into about 30 feet of very cherty, thinly bedded, grey limestone poor in fossils of any kind. The outcrops of Welland county are not so connected that the entire thickness of the formation can be obtained, but the indications are that it is about 100 feet. To the westward the central purer portion of the formation increases in thickness, at the expense of both the lower and upper cherty parts, and thus passes into the typical Onondaga of Michigan and Ohio. At some of the northern outcrops of this formation, especially in Bruce county, the rock is a most astonishing mass of corals and hydrozoans unlike anything else in the Province.

Marcellus Shale.

In western Norfolk and eastern Elgin counties well records show from 10 to 30 feet of a black bituminous shale immediately overlying the Onondaga limestone.

[1] Mich. Geol. and Biol. Surv. Pub. 2, Geol. Ser. 1, 1910, pp. 217-223.

This shale is covered by from 200 to 280 feet of glacial drift, so that it cannot be definitely determined at the present time. However, its position in the geological scale strongly suggests its Marcellus age. And then in the high banks of drift at Port Stanley are good sized pieces of well-preserved black shale carrying the Marcellus fauna. If these blocks of shale were derived from the bed-rock to the northeast, as is almost certain, there can be no further question as to the age of the deposit of black shale there reached by the drill.

Hamilton Beds.

The Hamilton beds are made up of grey limestones and soft, blue shales. There are commonly three persistent limestones—a lower, middle, and upper—recognized in well sections, and it is the lower limestone that comes in direct contact with the Onondaga as the Marcellus shale pinches out to the westward. This lower limestone, as its fauna shows, is the northward extension of the Delaware limestone of Ohio, and hence may represent, in part, the Marcellus shale lying farther to the east. The total thickness of the Hamilton beds ranges about 300 feet, although greater thicknesses are sometimes encountered.

Genesee Shale.

This formation consists of a bituminous, fissile, black shale similar to that of the same formation to the south and east. As an evidence of the life which existed during the time of its deposition and of the conditions under which deposition took place, this shale contains carbonized plant stems and leaves, an abundance of the spore cases of certain plants, a Lingula, and the occasional bones of large fishes. The Genesee shale lies immediately on top of the upper limestone of the Hamilton beds, and forms a very good outcrop at Kettle point, where the most striking feature is the large spherical concretions projecting from the shale. The thickness of these shales is not definitely known, but some well records indicate as much as 185 feet.

Portage and Chemung Beds.

In a few of the well records, especially in Moore township, 20 to 50 feet of greenish shales and sandstones make their appearance on top of the black shales of the Genesee, and sometimes even interstratified with the upper layers of that formation. These cannot be definitely separated into two formations. nor have they been directly observed, but they probably belong to the horizon of the New York Portage and Chemung beds.

New Industries Connected with the Devonian Formations.

The economic importance of the Devonian has been indicated in a previous summary report.[1] However, the use of these formations, in a commercial way, is constantly increasing. New quarries, to obtain the limestone for crushing purposes, have been opened at one place and a large new cement mill has been recently installed at another. Moreover, the sandstone belonging to the Oriskany is again receiving attention. A large, well-built mill has been located on the site of the DeCew quarry, where this rock will be crushed for glass and sand-blast sand. This new industry promises to be an important one.

[1] Summary Report of the Geological Survey for the year 1910 (1911), p. 195.

KEWAGAMA LAKE MAP-AREA, PONTIAC AND ABITIBI, QUEBEC.

(*Morley E. Wilson.*)

Introductory

The past season was spent by the writer in continuation of the geological investigations commenced the previous year in the vicinity of Lake Abitibi, Pontiac county, Quebec. During the summer of 1910 an area to the south of Lake Abitibi and adjacent to the Interprovincial Boundary was examined and mapped. During the summer of 1911 this work was continued to the eastward as far as the Kinojevis and Nawapitechin rivers. The region thus investigated, in conjunction with the area to the south of the Kinojevis river, examined by Dr. J. A. Bancroft for the Quebec Department of Mines, will permit of the publication of a geological map extending from the Interprovincial Boundary to Kewagama lake and from the National Transcontinental railway to the Rainboth-Blouin base-line, or expressed in geographical terms from longitude 79° 30′ 56″ to longitude 78° 15′, and latitude 48° 50′ to latitude 48° 8′ 22″.

During the past season the writer was assisted in the field by Messrs. E. M. Burwash, L. E. Dagenais, J. S. Stewart, and C. P. Sills, all of whom rendered efficient service in carrying on the work.

Previous Work.

During the summer of 1901, Mr. J. F. E. Johnston made a geological reconnaissance along some of the waterways of the region which he described in the Summary Report of the Survey for that year. The district was again visited in 1906 by Mr. W. J. Wilson in the course of a preliminary examination of the country along the National Transcontinental railway. Mr. Wilson's observations were published in brief in the Summary Report for 1906 and again in greater detail in Memoir No. 4, "A Geological Reconnaissance along the line of the National Transcontinental railway in western Quebec."

General Character of the District.

topography.

Physiographically this region belongs to the great Pre-Cambrian plateau province which occupies nearly the whole of the northern part of the Province of Quebec. It has a general elevation ranging from 900 to 1,100 feet above sea-level, with hills and ridges rising here and there to heights of 500 to 700 feet above the surrounding country. As was pointed out in the Summary Report for 1910, these elevated districts constitute what may be described as a rocky hill country in contrast with the clay flats which surround them. They present all the typical topographic features characteristic of rock surfaces which have suffered continental glaciation. The clay belt on the other hand possesses a uniformly flat surface underlain by stratified clay, and might be described in physiographic terms as a structural plain in the incipient stages of dissection.

Lakes are generally very numerous throughout the Pre-Cambrian region of northern Ontario and Quebec, and this district is no exception. They occur chiefly, however, in the rocky hill country. As a rule the lakes are not very large, although two of them, Lake Makamik and Lake of Islands, have areas of 18 and 14 square miles, respectively. Lake Lois, one of the most picturesque lakes in the region, is 12 miles long but is very narrow, its maximum width being less than 2 miles. There are three other lakes of the long, narrow type which are over 5 miles in length. These are Lakes Kajakanikamak, Kekeko, and Kinojevis.

The drainage of the region is about equally divided between the St. Lawrence and the James Bay basins, so that the height of land passes almost through the centre of the area examined, but with a much more sinuous course than is shown on existing maps. The streams on the south side of the St. Lawrence-Hudson Bay divide find their way into the Kinojevis river and thence to the upper Ottawa. The drainage on the James Bay slope, with the exception of a few headwater streams flowing into the Harricanaw river, is entirely into Lake Abitibi by way of the Whitefish (Amikatik) river and its tributaries.

MEANS OF ACCESS.

The canoe routes along the upper Ottawa and its tributaries formerly afforded the sole means of access to this region, but the northern part of the district is now more easily accessible by railway from Cochrane, Ont., the junction point of the Timiskaming and Northern Ontario with the National Transcontinental railways. For the southern portion of the region the waterways from Lac des Quinze are yet the best means of communication. There are two roads leading from Lake Timiskaming which may be followed in starting out on these routes, one which leads from Ville Marie to Gillies' farms at the south end of Lac des Quinze, and the other from North Timiskaming to Klock's farm, 15 miles farther north on the same lake. The Kinojevis river may be reached from Lac des Quinze either through Lake Expanse and the upper Ottawa, through Rogers and Crooked lakes or through Barriere, Albee, and Kekeko lakes. The first route requires less portaging, but is more circuitous than the other two.

General Geology.

With the exception of unconsolidated glacial and post-glacial deposits, the rocks of the region are entirely of Pre-Cambrian age, and for the most part belong to the most ancient subdivision of the Pre-Cambrian. In a structural way these Pre-Cambrian rocks divide themselves into two principal classes, to the first of which belongs a basal complex of sedimentary and igneous rocks which has been more or less highly metamorphosed and deformed. The rocks of the second class on the other hand are entirely of sedimentary origin, have been but little deformed, and except for cementation have not been metamorphosed.

In the southern part of the region the prevailing basal rock is a fine-grained mica schist with which is associated some hornblende schist and amphibolite. This group of rocks was formerly[1] called the Pontiac schist, but will now be designated the Pontiac group. In the northern part of the region the rocks of the older complex consist largely of basic and acid volcanics which for purpose of description shall be called the Abitibi group. Both the Pontiac group and the Abitibi group are intruded by batholithic masses of granite and gneiss constituting a third and younger subdivision of the older complex.

The second class of Pre-Cambrian rocks—the Cobalt series—consists of a succession of clastic sediments, conglomerates, greywackes, arkoses, and quartzites with inter-

[1] Summary Report of Geol. Survey 1909, p. 175.
" Geology and Economic Resources of the Larder Lake District, Ont., and adjoining portions of Pontiac county, Que., Memoir 17.

mediate variations which rest in striking structural and erosional unconformity on the denuded and almost baselevelled surface of the older complex. Erosion since Pre-Cambrian times, however, has stripped the greater part of the series from the surface of the ancient peneplane (paleoplane) upon which it was deposited so that it now occurs as small outcrops or as hills and ridges scattered here and there throughout the region.

The rocks thus far described are overlain by a thin mantle of glacial material—gravel, sand, boulders, and boulder clay—deposited from the last Pleistocene ice-sheet. These deposits are in turn overlain by stratified clay laid down from a huge lake which occupied the greater part of this region in post glacial times.

TABLE OF FORMATIONS.

Pleistocene and Recent.	
Post Glacial	Stratified clay and sand.
Glacial	Gravel sand and boulder clay.
Nipissing diabase (Keweenawan?).	
Igneous contact.	
Cobalt series (Huronian).	
Granite and gneiss (Laurentian?).	
Igneous contact.	
Pontiac group (Huronian?).	
Abitibi group * (Keewatin?).	

* Probably composed of more than one series.

It will be observed that in the above table of formations the various series of rocks have been given local names and that with the exception of the Cobalt series they have not been assigned definitely to any of the major subdivisions of the Pre-Cambrian as defined in the Report of the International Geological Committee for the Lake Superior region. This plan was adopted because there was some doubt as to the place occupied by the different series in the general classification.

The fine grained mica schists of the Pontiac group which are probably metamorphosed quartzose sediments are very similar to rocks which elsewhere in the St. Lawrence basin have been called Huronian, and may represent another Huronian series older than the Cobalt series. But, if the Pontiac group be Huronian then the granite and gneiss which intrudes the Pontiac group are also Huronian in age and can no longer be classed as Laurentian. Furthermore, evidence is accumulating[1] which indicates that a Huronian series older than the Cobalt series is present in the region and that the volcanic rocks now called Keewatin may possibly belong in part to this older series. For these reasons it has been thought advisable to substitute local terminology for the general nomenclature and thus avoid unnecessary assumptions and doubtful correlations.

Pontiac Group.

A series of fine grained mica schists occur at the north end of Lake Opasatika which has been previously described in reports on that district. During the past season these rocks were again encountered in the country farther to the east, and are now known to extend continuously in an east-west belt from 10 to 15 miles wide for a distance of at least 50 miles. They are delimited on the south by intrusive granite and gneiss and on the north pass with an apparent transition into sheared arkose and conglomerate. These rocks are in turn followed by the volcanics of the Abitibi group.

[1] Engineering and Mining Journal, Vol. xcii, pp. 645-649. Geology of a portion of Fabre township, Pontiac county, Dept. of Colonization, Mines, and Fisheries, Quebec

Throughout the belt just outlined the Pontiac group is composed almost entirely of a fine grained biotite schist, but in the region examined during the past summer some hornblende schist and amphibolite are also present. These amphibole rocks are exceedingly variable both in texture and composition which gives rise to a most peculiar irregular appearance on the weathered surface. Both the hornblende and biotite schist have a strike trending approximately in an east-west direction, and in general dip steeply to the north away from the intrusive granite and gneiss.

Sheared Conglomerate and Arkose.—If the Pontiac group be studied in transverse section, it may be observed that on passing northward away from the intrusive granite and gneiss the mica schist becomes more massive and that finally outcrops of sheared arkose and conglomerate containing pebbles of granite and rhyolite are reached. This arkose and conglomerate occurs continuously in an east-west belt north of Kinojevis and Kekeko lakes, and was also observed on Kiekkiek lake in the area examined by Bancroft, so that it probably extends along the whole northern border of the Pontiac series. It would, therefore, seem probable that the mica schist, the arkose, and the conglomerate, are in comformable succession, and that the mica schist is simply the metamorphic product resulting from the contact action of the granite and gneiss on the arkose. However, in a region where the rocks have suffered intense metamorphism and are not very well exposed, an unconformity might be present which was not observed, or if observed, was not recognized because obscured by deformation; for this reason alternative possibilities should also be considered.

If it be assumed that the sheared conglomerate and arkose rests unconformably on the Pontiac schist, then these rocks (the conglomerate and arkose) must be either a locally deformed phase of the Cobalt series or a Huronian series older than the Cobalt series infolded with the Pontiac schist. In opposition to the first alternative it may be pointed out that the undisturbed Huronian belonging to the Cobalt series occurs in the Kekeko hills, at a distance of less than 2 miles from this highly sheared and steeply inclined conglomerate and arkose, and that it is improbable that such a change would take place so abruptly. Moreover, if an unconformity exists between the sheared conglomerate and the mica schist, the conglomerate would probably contain fragments of the schist, but no such pebbles or boulders were observed.

It is concluded, therefore, that while the evidence with regard to the stratigraphical position of the sheared conglomerate and arkose is insufficient for a final conclusion, yet such evidence as has been obtained preponderates in favour of their conformable relationship to the Pontiac schist and for this reason they have been placed provisionally in the Pontiac group.

Abitibi Group (Keewatin?).

Throughout the northern part of the region the predominating rocks are volcanic lavas ranging in composition from basalts to rhyolites. The acid and intermediate types are, however, most abundant. Unlike the Keewatin (?) greenstones which occur farther to the south, these rocks are commonly grey or greenish-grey in colour and might be more appropriately described as greystones. There are associated with these volcanics some ferruginous dolomite and dolomitic sericite schist which are also included in the Abitibi group.

In a region where the rocks, on the whole, are not very well exposed, it is not always possible to ascertain the stratigraphical and structural relationship of the lava flows of the Abitibi group, but in places their attitude and trend can be recognized partly from their change in texture from centre to margin and partly from the occurrence of the spheroidal and amygdaloidal structures at their surface. When the spheroidal structure was present the spheroidal masses of lava were observed in place to be flattened on one side, giving rise to what the writer described in the field as a "bun" structure. This flattening was, probably, caused by the flowage of the spheroids of lava under their own weight. The flattening would, therefore, occur on the under side of the spheroid, and affords a criterion for distinguishing the top and bottom of the lava flows. The volcanics of the Abitibi group have been generally folded into vertical or nearly vertical position, the strike varying from northwest and southeast to east and west.

Relationship to the Pontiac Group.—Since the Abitibi group and the Pontiac group are areally separate from one another, their relationship can only be inferred from their general distribution or by comparison with other regions. If the Pontiac group be Huronian, older than the Cobalt series, and the Abitibi group be Keewatin—as has been generally assumed—then the Abitibi group would be older than the Pontiac group. On the other hand, the distribution of the Pontiac group in a narrow belt intervening for a distance of 50 miles between the Abitibi group and the batholithic granite and gneiss suggests that the occurrence of the schist in this relationship is not a mere coincidence, but that the Pontiac group is stratigraphically below the Abitibi volcanics and has been tilted up into its present attitude by the intrusion of the granite batholiths. This evidence, however, is insufficient to warrant a positive conclusion, so that the relationship of the Pontiac group to the Abitibi group must for the present remain an unsettled problem.

Granite and Gneiss.

Both the schists of the Pontiac group and the volcanics of the Abitibi group are intruded by batholithic masses of granite and gneiss, ranging in size from small isolated intrusions 3 to 10 miles or less in diameter to a huge massive of which only a marginal portion intruding the Pontiac group on the south occurs within the confines of the region examined. The smaller batholithic masses occur in the northern part of the region and are in igneous contact with the Abitibi volcanics. Since there are probably granites of varying age present in the region it cannot be assumed that these masses are connected with the larger southern batholith, although such may be the case. Both hornblende and biotite granites and gneisses are represented in these intrusives, but the hornblende varieties are most common in the northern batholiths, whereas biotite granite and gneiss predominate in the southern massive.

The intrusion of the rocks of the Pontiac group and the volcanics of the Abitibi group by these batholiths was accompanied by the usual contact phenomena which characterize such magmatic invasions. The junction of the southern batholith and the Pontiac group is marked by a contact zone, several miles wide, on which dykes and irregular masses of granite, aplite, and pegmatite intrude the schist, increasing in size and numbers towards the south until finally only isolated blocks of schist are observed. The blocks, however, with few exceptions, maintain the same attitude and strike as the schist farther north, showing that they have not been tilted from their original positions. The smaller batholiths are filled along their margin with angular, subangular, and rounded blocks of the Abitibi volcanics with which are associated hornblende rocks and "schlieren" of hornblende granite, so that there appears to be a complete gradation from blocks which are undoubtedly greenstone or greystone of the Abitibi group to "schlieren" of hornblende granite. It is, therefore, more probable that the hornblende variations in the granite have been formed by the assimilation of the Abitibi volcanics rather than by differentiation from the granite magma.

Cobalt Series.

Huronian strata belonging to the Cobalt series was observed in this region in only two or possibly three localities. As these rocks commonly occur, however, as small remnants lying here and there on the truncated surface of the Abitibi volcanics, it is probable that there are other small occurrences in the region which were not observed. The Cobalt series has its greatest development in Boischatel township, where conglomerate and arkose occur in the Kekeko hills, having a vertical thickness of 700 feet. Conglomerate similar to that of the Cobalt series was also observed in Dexter township, about 3 miles north of Lake Kajakanikamak. On some of the islands in Lake Kajakanikamak a rock occurs associated with rhyolite and andesite of the Abitibi group, which appears to pass gradationally into the volcanics and cannot be distinguished from them except for the presence of grains of quartz. This, when examined microscopically, was found to be an arkose, but it is doubtful whether this arkose belongs to the Cobalt series, for unlike the typical arkose of that series its feldspar grains have been highly corroded and sericitized.

Origin of the Cobalt Series.—The origin of the conglomerates, greywackes, and arkoses of the Cobalt series was discussed at length in a recent report on the Larder Lake district, Ont., and adjoining portion of Pontiac county, Que., in which it was concluded that the greater part of the conglomerate of the series was of glacial origin, and that the stratified greywacke, arkose, and quartzite represented inter-glacial or post-glacial deposits of fluviatile or lacustrine origin. The strongest evidence in support of these conclusions was obtained during the past summer at the east end of the Kekeko hills, where scratched and faceted pebbles were obtained from the conglomerate.

Nipissing Diabase.

The Nipissing diabase is not extensively developed in this region since it was observed in only a few localities. It occurs as narrow dykes—usually less than 200 feet in width, intruding the rocks of the older basement complex. Its correlation with the Post Huronian Nipissing diabase is, therefore, based solely on its lithological similarity not only in mineralogical composition but in its fresh unaltered character to the diabase which in this district intrudes the Huronian.

Pleistocene and Recent.

The rock surfaces in this region where exposed to view present the usual smoothly eroded and striated appearence which results from glacial denudation. The greater part of the surface of Pre-Cambrian rocks of the region are, however, hidden beneath a thick mantle of glacial and post glacial deposits.

The lowermost Pleistocene deposits consist of sand, gravel, and boulders, which are partly glacial and partly fluvioglacial in origin. The fluvioglacial deposits are roughly stratified and usually take the form of kames. In a few localities elongated, narrow ridges of a similar character occur which are probably eskers.

Throughout the larger part of the region the older Pleistocene deposits are overlain by stratified clay and sand, sediments, which are evidently of lacustrine origin. The stratified clay is uniformly bedded in layers averaging about one-half inch in thickness, the beds being separated as a rule by a thin layer of calcium carbonate. Locally the stratified clay becomes arenaceous, and in these places a bed may contain two or three subsidiary layers due to an increase in sand content. The stratified sands never exceed a few feet in thickness and always overlie the stratified clay. They appear to be confined to the vicinity of glacial and fluvioglacial deposits in which sand is abundant.

It is believed that these uniformly stratified Pleistocene deposits were laid down from a huge lake which occupied this region in post-glacial times. This lake was evidently connected with the Timiskaming basin during a considerable part of its history, for the stratified clay was observed on the height of land in Launay and Trécesson townships, at an elevation of 1,074 feet above sea-level, and from that point has been traced continuously along the Nawapitechin and Kinojevis rivers and southward to the stratified clay north of Lake Timiskaming.

If it be assumed that each bed in the stratified clay represents the deposition of a single season, then by counting the number of beds an estimate of the length of time the lake occupied the district can be obtained. Since the maximum number of beds observed in the cuts along the National Transcontinental railway was only 250, the post-glacial lake—if each bed is an annual deposit—was of very temporary duration in this region.

The surface of some of the Pleistocene sand areas in Trécesson township has been subject to wind action and presents a typical sand dune appearance. Some of these dunes have been very recently formed, for in one locality where a forest fire had removed the vegetation, several birch and banksian pine have been partly buried in sand.

Economic Geology.

Gold.

Quartz veins are common everywhere in the region, but are most extensively developed in the rocks of the Abitibi group.

On the north side of the Kinojevis river, near the Cascade rapids (Manneville township), an east-west belt of dolomitic sericite schist occurs which is intersected by numerous veinlets and veins of quartz. Some of the veins are from 4 to 10 feet in width and in one place a huge lens of quartz about 30 feet wide has been formed. The occurrence of these veins and irregular masses of quartz in dolomitic sericite schist is strikingly similar to the veins and quartz lenses of the Porcupine district, but assays of samples taken from all of the larger developments of quartz were made by Mr. Leverin of the Mines Branch of this department, and in every case returned no gold whatever.

Some very irregular veins of quartz occur in a shear zone in greenstone on an island at the north end of Lake Agotawekami from which it was reported assays of $20 per ton had been obtained. An average sample of this quartz taken by the writer, and assayed by Mr. Leverin of the Mines Branch, however, was found to contain no gold.

A large number of quartz veins cutting sericite schist, greenstone, and ferruginous dolomite have been staked in the vicinity of the National Transcontinental railway, but the assays of samples from these veins have never exceeded $1 or $2 per ton.

While it is evident from the above results that an auriferous quartz deposit of commercial value has not, as yet, been discovered in this region, it must also be remembered that the country has not been prospected except in a very superficial way. Geologically the region is very similar to the Porcupine district, and with the transportation facilities now afforded by the National Transcontinental railway, is probably one of the most promising fields for the prospector in northern Ontario and Quebec.

Copper.

A large number of the quartz veins of the region contain chalcopyrite, but no deposit of this mineral was observed which was of sufficient dimensions for commercial mining operations.

Molybdenite.

The pegmatite and aplite occurring in the contact zone between the Pontiac group and the granite and gneiss contains molybdenite in a number of localities in this region. These occurrences, however, are all small, and are not at all comparable in extent to the deposits of this mineral occurring in the vicinity of Kewagama lake.

CERTAIN MICA, GRAPHITE, AND APATITE DEPOSITS OF THE OTTAWA VALLEY, AND AN OCCURRENCE OF EOZOON CANADENSE.

(*John Stansfield.*)

Introductory.

During the season of 1911, work was carried on in the region immediately north of the Ottawa river, in the townships of Hull and Buckingham, and the Seignory of La Petite Nation. An examination of certain typical mines of the region was undertaken, the Gemmill mine at Cantley being taken as an illustrative mica deposit, the Walker mine and Dominion Graphite Company's mine near Buckingham as illustrative of the occurrence of graphite, and the Emerald mine at Glenalmond of apatite. A small area at Côte St. Pierre illustrates the occurrence of Eozoon Canadense.

Topographical and geological work was carried on simultaneously, no contouring being done. Detailed large scale maps were made in each area. The method employed was transit and stadia traversing, in some cases details heing filled in hy compass and tape traverses. At Cantley one area 330 × 400 yards, and another 400 × 400 yards were mapped for publication on the scale of 200 feet = 1 inch, and the road running from Kirk Ferry through Cantley and back to Kirk Ferry, was surveyed for puhlication on a scale of 2,000 feet = 1 inch. At the Walker mine an area of about 1½ square miles was mapped for publication on a scale of 400 feet = 1 inch. At the Dominion Graphite Company's mine an area of 800 × 800 yards, at the Emerald mine one of 970 × 1,100 yards, were mapped for publication on the scale of 200 feet = 1 inch, and at Côte St. Pierre another area 490 × 800 yards was mapped for publication on a scale of 400 feet = 1 inch. In addition telemeter traverses were run connecting the Walker and Emerald mines with the post-office at Buckingham, and connecting the Côte St. Pierre locality with the Ottawa river at Papineauville.

Assistance was rendered by Messrs. C. C. Galloway in topography, and Mr. G. H. Gilchrist in topography and geology, the place of the latter being taken by Mr. W. S. McCann, from the beginning of August to the end of the season. Great kindness was shown to the party hy the Dominion Graphite Company.

History and Previous Exploration.

In 1873, Mr. H. G. Vennor visited and reported on the graphite and apatite deposits of the Lièvre River valley, including the Emerald mine. In 1876, he surveyed an area including the graphite and apatite deposits of Buckingham township.

In 1877, Dr. J. B. Harrington visited several apatite and mica occurrences and reported on the minerals found in association with these deposits.

In 1883, Mr. J. F. Torrance visited and reported on the apatite deposits of Quebec, including those of the Lièvre River valley.

In 1897, Mr. A. A. Cole surveyed the Walker mine and other graphite deposits in the township of Buckingham.

In 1899, Dr. R. W. Ells reported on those parts of Ontario and Quebec included in the Grenville sheet, and in the same year Mr. A. Osann studied the geology of the areas surveyed this summer, with the exception of the Dominion Graphite Company's mine.

That part of the Lièvre River valley in which occur the graphite and apatite deposits examined, was reported on in 1905 by Prof. E. Haycock.

General Geology.

TABLE OF FORMATIONS.

The rock formations developed in the region have been subdivided in accordance with the following table:—

II. Quaternary.—Marine-glacial clay (Leda clay) and sands.

I. Pre-Cambrian—

3. Igneous intrusives—
   - *3c*. Trap dykes.
   - *3b*. Gabbros and pegmatites of the mineral deposits.
   - *3a*. Older pegmatite veins.
2. Grenville series.
1. Ottawa gneiss.

The Ottawa gneiss is seen at Cantley, at several points along the north road of the main traverse, and on the east hill of the Gemmill mine. It is a reddish gneiss of the composition of a granite, or in some cases of a syenite. Gneissic structure may be well developed or only broadly suggested. Syenitic gneiss is abundantly developed in the Walker Mine area; a dark-coloured biotite-gneiss occurs in the same area, and also on the road between the Walker mine and Buckingham.

The Grenville series is more abundantly developed than the Ottawa gneiss in the area examined, constituting the major portions of the outcrops. It includes impure crystalline limestones, quartzites, garnet-gneisses, sillimanite-gneisses, and black-weathering gneisses rich in pyrites whose exact nature is not yet determined. The graphite deposits examined are found closely associated with members of the Grenville series, most often with limestones.

Older Pegmatites.—The Ottawa gneiss and Grenville series in all areas visited are cut by very many pegmatite dykes, their development being not so marked in the limestones as in rocks of other types. These pegmatites often carry tourmaline, as is especially the case in the Cantley district. They are classified as of one general age, older than the gabbros and associated pegmatites, because members of the gabbro group cut these pegmatites at Cantley, and because of the general absence of pegmatites of this type cutting the gabbros and associated rock types.

Gabbros and Pegmatites of the Mineral Deposits.—The gabbros have been described by Osann as being all hypersthene-gabbros, enstatite-gabbros, scapolite-gabbros, or normal gabbros with the exception of the gabbro at the Dominion Graphite Company's mine. These rocks lack gneissic structures and form relatively small bodies. The pegmatites of this group are later than gabbros, since included blocks of the latter in the former are frequently met with at the Emerald mine. At the Dominion Graphite Company's mine the "blue quartz veins" are the representatives of this group.

In some rare cases these pegmatites are younger than the ore-deposits.

Trap Dykes.—Two diabase dykes between 30 and 40 feet wide occur near the Buckingham-Glenalmond road. One is found on the Emerald Mine hill, striking 86° E. of N. The other is about halfway between Buckingham and Glenalmond, and strikes 71° E. of N. They dip vertically and belong to a family of dykes developed in the region of the Lièvre and Gatineau rivers and which can often be traced across country for many miles. Others of these dykes occur in and round the town of Buckingham, *e.g.*, opposite the vicarage and just north of the Alexandra Hotel, and also just to the west of the bridge over the Lièvre.

QUATERNARY: MARINE-GLACIAL CLAYS AND SANDS.

The clays fill in the lower depressions between the hills of Pre-Cambrian rocks. The clay at a few points shows stratification, individual bands being, as a rule, ¼ inch in thickness. At one or two points marine fossils are met with in the clay. They are:—

Saxicava rugosa.
Astarte cf. Laurentiana.

Both forms are met with on the left bank of the Gatineau river, 400 yards below the falls at Kirk Ferry. The Astarte is found at Gow's farm at the Gemmill mine, and also on the road from Buckingham to the Walker mine, near the cheese-factory.

The sands occur, covering a considerable area, as a thin capping above the clay, and are unfossiliferous. They are found at points all along the north bank of the Ottawa river, and in the valleys of its tributaries.

Economic Geology.

MICA.

The Gemmill Mine.

The deposits at the Gemmill mine, situated on lot 10, range XII, of the township of Hull, and also known as Gow's, the Vavasour or Nellis's mine, occur on two hills, known as the East and the West hills, which are separated by a clay-filled hollow. The mica occurs in veins which cut gabbro, gneiss, and pegmatite alike. The vein-walls are clear-cut in the pegmatite and gneiss, but wavy in the gabbro, constancy of thickness being associated with the former types of country rock and "bulging" with the latter. The veins constitute a system with a general parallel development. The whole of East hill is cut by veins, usually about 15 feet apart, whilst on West hill they are developed chiefly on the southern face, with a few at the northeast corner. The veins of East hill have a gentle curve, the strike varying from N. 68° E. at the northeast corner to N. 23° E. at the southwest corner. The dips vary between 37° and 87° to the southeast, and are for the most part high (between 60° and 75°). On West hill the strikes vary from N. 45° E. on the western face to N. 78° E. at the southwest corner, the majority being close to N. 65° E., whilst the dips are high, ranging from 68° to the southeast to vertical. On the northeast corner of the hill a few veins occur, which have not been opened, the strikes varying from N. 29° E. to N. 49° E.; the dip, obtained in only one case, was 75° to the southeast. The thickness of the veins varies from almost nothing up to 15 feet, a common width being about 6 feet. Veins very often pinch out to 1 foot or less at the surface, widening out a few feet below the surface.

The chief minerals of the veins are, in the order of deposition, pyroxene, phlogopite, apatite, and calcite. Parallel banding is well developed, the pyroxene occurring in a dark green comb on each wall, with bands of phlogopite, and in the centre a mixture of apatite and calcite in varying proportions. The calcite is best developed on East hill, being sparingly present or absent in the veins of West hill. The apatite is most commonly green, the red variety being occasionally seen on East hill, whilst it is more typical of West hill than the green variety. Other minerals found include fluorite, quartz, and actinolite, but these are uncommon, at any rate so far as present exposures are concerned.

The phlogopite bands vary in width from 1 inch to 1 foot, or even more. As a rule the mica is arranged with the cleavage planes parallel to the walls of the vein.

The mica has a rough hexagonal shape in the case of the larger masses, the shape being more perfect in the case of the smaller forms, especially in those found completely embedded in calcite. The mica reaches 2½ and even 3 feet across in the rough state, such masses yielding large cuts. For the most part the mica yields cuts comparable in size with the original crystal, but occasionally it is found to be flawed and much cracked, having been subjected to movement or differential pressure subsequent to its formation. In such a case the mica is worthless for cuts of any size.

In a few cases the veins occur on fault planes along which movement of a few feet took place before the formation of the veins.

Actual mining is not being carried on at present, but prospecting is being kept up. Several new veins have recently been found on West hill and openings are usually made on them to a depth of a few feet only, but often yield large masses of mica for a small expenditure of labour. The mica can be dug out near the surface or loosened by small charges of dynamite. Only that mica close to the surface is useless, owing to the action of the weather. For a considerable time no sales have been made, working for stock being the present policy of the owner of the mine. As a result the warehouse is filled with prepared mica, and picked phosphate is lying on the dumps. The mine was first worked in 1878, and was formerly worked for phosphate. Mining was more actively carried on, several shafts being sunk on East hill. The shafts were sunk on the veins, the deepest one reaching a depth of 160 feet, a drift along the vein from it reaching a length of 190 feet. The shafts are now practically abandoned. When first operated the mica was dumped as waste, fortunately in one place, and free from other material, and is now being utilized for scrap mica.

GRAPHITE

In both the areas mapped and in several other occurrences of graphite visited the graphite deposits were found to be closely connected with bodies of intrusive igneous rocks. In some cases the ore is found as a band at the junction of the igneous intrusive with the intruded rock, in other cases as an impregnation of the intruded rock close to the igneous contact, and in others as an impregnation of the igneous rock itself. This association of graphite ore and igneous rocks was found in all but a few small exposures, which owing to lack of time were not so thoroughly studied as the more important bodies constituting the ore-shoots, and in all probability closer study of these few cases would disclose igneous rocks in close association. The country rock is either a pyritic-micaceous gneiss, which previous observers have determined to be sillimanite-gneiss, or limestone. The types of igneous rock with which the ore-bodies are associated are two in number, a gabbro (hypersthene-gabbro of Osann), and a pegmatitic representative of the gabbro.

Walker Mine.

Lots 20 and 22, range VIII, township of Buckingham.

At the Main pit the ore is an impregnation of gabbro, limestone, and gneiss, situated on the underside of an almost flat sheet of igneous rock. The working is now filled with water and close examination of the ore-body is impossible. The mine was worked by underhand stoping from time to time between 1890 and 1896, when the mill was permanently closed down. The graphite was separated from the crushed ore by a wet process.

The openings of the Nelly's Pit group and the openings between this point and the Main pit are much overgrown and do not appear to have been carried beyond the shallow pits of the prospecting stage. These openings are on clean veins of columnar graphite, which vary in width from ¼ inch to 4 inches. Examples occur of veins cutting pegmatite, cutting gabbro, and limestone, and following a gabbro-pegmatite contact. Large sphenes about the size of a walnut are associated with the ore in these pits.

In addition, pegmatites are occasionally met with in other parts of the district which carry graphite throughout their mass.

Dominion Graphite Company's Mine.

Lot 20, range V, township of Buckingham.

Pit 1.—Here the ore-body has the form of a shoot whose dimensions at the surface are 60 feet × 30 feet. The central mass of this ore-shoot is a mixture of graphite and calcite, the edges consisting of impregnated gabbro. The ore-body splits to the south into four tongues or veins of impregnated gabbro. On the east the mass is cut by a highly quartzose vein, of the type locally called "blue quartz vein." This type of vein is probably an acid representative of the later stages of the gabbro intrusion. It is found to be composed of quartz with a very subordinate amount of hornblende. The northern extension of the shoot was not exposed at the time the mine was examined. The ore-body is worked by underhand stoping. The graphite is usually amorphous, occasionally the columnar variety being met with in small amount. Apatite in nests up to the size of a hen's egg was found in the graphite ore. Pyrite veins cutting the ore are often met with, sometimes massive, sometimes with a honeycomb structure, with the development of crystal forms.

Pit 2.—The ore-body is a very richly impregnated band from 3 inches to 1 foot in thickness, on the upper side of a "blue quartz vein." The immediately adjacent country rock is limestone above and gneiss below. This body appears to be small and was nearly worked out at the time of examination, though the same type of deposit is indicated in small openings along the upper surface of the same dyke to the south. A small vein of gypsum was found associated with the ore-body.

Pit 3 (Swamp Pit).—Here rocks of the gabbro and pegmatite types occur. At the time of examination ore-bodies only a few inches thick on the west side of a gabbro dyke and on the west side of a pegmatite dyke were exposed. Development work has since been carried on at this pit and an ore-body has been exposed which promises to be an important supply.

Pit 4—Contains a small exposure of graphitic gneiss a few inches thick, overlain by a dark-coloured limestone bearing a striking resemblance to a spherulitic rock. No important work had been carried on at this pit when visited.

Work has been carried on at this mine during the past summer. The mill was erected in the winter of 1910-1. The mill, which is built on the slope of a hill to make use of gravity in the handling of the ore in the various stages of the extraction, is one of the most up-to-date in the country, and is designed to treat 200 tons of ore per day. The ore is roasted in kilns, passed through crushers, the graphite flattened into flakes and separated in the dry way by means of revolving bolts.

Employment is found for 80 to 100 men, some difficulty being experienced in obtaining sufficient labour.

APATITE.

Emerald Mine.

Lots 18 and 19, ranges XI and XII, township of Buckingham. The occurrence of apatite at the Emerald mine is very similar to that at the Gemmill mine, the two most striking differences being that at the Emerald mine mica is only met with in veins round the rim of the hill, and sulphides are present in the ore. Pyrite is much the more common sulphide, pyrrhotite being a good deal rarer. Of other minerals found mention may be made of actinolite and tourmaline; the latter not being found in situ its relation to the apatite is not clear. Pyroxenes embedded in calcite are met with, sometimes with a rim of uralite round the pyroxene.

In the centre of the hill the apatite occurs in large masses rather than veins. They are in reality widened veins and send off smaller veins into the country rock, which is here a gabbro. The main mass of the filling, now removed, was apatite; but from small patches left on the walls of the openings the green apatite and pink calcite are seen to occur in exactly the same way as at Cantley. The maximum width of the largest of these pockets is 50 feet. Instances of this pockety occurrence of the ore are known as Murray's, Watt's, and Boilleau pits.

Veins cut gabbro, pegmatite, and gneiss indifferently, there being again a tendency to departure from rectilinear bounding surfaces when gabbro is the country rock. Outside the gabbro area the veins are narrower and show good parallel banding, often with excellent comb structure. A large number of openings have been made in the area included in the sheet and a number of shafts and winzes sunk, and several drifts have been run into the hill for the purpose of striking ore-bodies, or for draining the workings. In all cases the shafts appear to have been sunk to a shallow depth only, before being abandoned, 50 feet being about the maximum. The mine was most actively operated in the early eighties, when it was one of the three largest producers of apatite in Quebec.

AN OCCURRENCE OF EOZOON CANADENSE AT COTE ST. PIERRE.

Subsequent to the discovery of Eozoon in specimens from Burgess, Ont., and the finding in 1858 of other specimens at Grand Calumet, Que., by Mr. McMullen of the Geological Survey, Eozoon was reported from a number of Canadian localities. Mr. J. Lowe found it at Côte St. Pierre and made collections from this localities. between 1863 and 1866. In 1875 Mr. T. C. Weston made collections for Sir J. W. Dawson under the auspices of the Geological Survey. This locality has yielded some of the best specimens of Eozoon.

The area mapped is situated about 10 miles north of Papineauville. The southern edge of a mass of gabbro is exposed, its margin being overlain by glacial clay and sand. A small area of limestone is included in the exposure, and a few minor outcrops of quartzitic gneiss also occur.

The limestone is altered along its contact with the gabbro for a width of 150 to 200 feet. The chief minerals produced are diopside and tremolite. The former is predominant close to the contact and is developed to a far greater extent than the tremolite, which is found at a greater distance from the intrusion. Beyond the zone where tremolite occus is the Eozoon band, consisting of serpentine and calcite with the well-known pseudo-organic structure. The Eozoon was exposed at only one point and only a very small area was seen. It is at this point that small veins of asbestos cut the rock, which caused an opening to be made some thirty years ago in an attempt to work the asbestos.

Exposures in the contact-metamorphic zone are not good, so that an attempt to map the extent and zones of the metamorphism met with small success.

GEOLOGY OF ORFORD MAP-AREA, QUEBEC, SOUTHERN PART OF "SERPENTINE BELT," BOLTON TOWNSHIP.

(Robert Harvie.)

Introductory.

In accordance with the instructions of the Director, the writer was occupied during the past field season in the mapping and geological examination of the serpentine belt of southern Quebec, in continuation of the work which has been progressing for three seasons under Mr. J. A. Dresser.

As this was the writer's first work with the unusual types of rocks here found, progress has naturally been slow, and this slight acquaintance has further limited his comparison of this district with other portions of the belt. For the same reason the generalized account of the geology given below is largely based on the work of Mr. Dresser.

Before beginning the regular work and in order to become somewhat familiar with working conditions, two days were spent in studying the chrome iron and asbestos mines at Thetford and Black Lake. Work in the field was commenced at Eastman on June 8, and closed at Knowlton Landing on October 10. In order to establish a proper connexion with Mr. Dresser's work of the previous year, Mr. J. J. O'Neill, his assistant on that occasion, was attached to the party for the first week. Mr. Alex. MacLean and Mr. A. Mailhiot acted as assistants until September 9, and I am indebted to them for thoroughly efficient and enthusiastic services. Mr. MacLean's intimate knowledge of other parts of the belt, gained with Mr. Dresser, was especially helpful to the writer. I also wish to thank Mr. N. S. Parker, of Eastman, for placing at our disposal his accurate and detailed information concerning the prospects, mineral locations, and other features of the district.

Location.

The serpentine belt lies in that part of the Province of Quebec southeast of the River St. Lawrence, and runs in a northeasterly direction approximately parallel to that river from within Vermont to Gaspé. The portion examined in last season's work includes parts of Bolton and Brome townships of Brome county. This district lies south of the Canadian Pacific Railway line from Montreal to Sherbrooke, north of the boundary of Vermont, and immediately west of Lake Memphremagog.

Previous Work.

The first accounts of the general geology of the district were by Sir Wm. Logan in the early reports of the Geological Survey, and these he later compiled and included in his Geology of Canada in 1863. Logan believed in the sedimentary origin of the serpentines, and his work and intended map on the scale of 4 miles to 1 inch were prepared with that in mind. The publication of the map was, however, delayed (for one reason or another), and in the meantime Dr. Selwyn, who had succeeded Logan as Director of the Survey, questioned this origin. Finally in 1882 it was proved by microscopic examination that the serpentines were of undoubted igneous origin, and it was definitely decided to revise Logan's work before publication. The revision was entrusted to Dr. R. W. Ells, whose reports and maps on the various districts traversed by the serpentine belt were issued in the Annual Volumes of the Geological Survey for the years 1886, 1887, and 1894. In order to meet economic needs, a special report on the copper-bearing rocks, by Mr. Dresser, was issued by the Geological Survey in 1907 as Publication No. 974.

Object and Progress of the Present Investigation.

Since the first shipment, about 1876, the production of asbestos in Quebec has steadily increased until now it has an annual value of over two and a half million dollars, placing the Eastern Townships near the top in order of importance of the mineral districts of Canada. In view of this economic importance of the serpentine belt, with which asbestos, copper, chrome iron, talc, and other valuable minerals are associated, the present investigation was commenced in order to obtain more complete information concerning its real distribution, geological structure, and economic resources. The field work was begun by Mr. Dresser in 1907 and continued in 1909 and 1910, his reports of progress being included in the Summary Reports of the Geological Survey for those years. His report for 1909 gives briefly a very satisfactory account of the principal geological features of the belt. A preliminary report on the district between the Chaudière and St. Francis rivers is now ready for the press.

Summary and Conclusions.

The serpentine belt which Mr. Dresser has been tracing and examining in a general southwesterly direction from East Broughton, is found to continue through the district examined this year to the boundary line of Vermont. Although called the serpentine belt, the area occupied by serpentine is a relatively small proportion, but the predominant economic importance of these areas is sufficient reason for the application of this name to the belt as a whole. In Bolton and Potton townships the serpentine continues to be of minor areal importance, but on the other hand, as contrasted with districts to the northeast, its economic importance is reversed since the copper deposits associated with the other related types of rocks—diabase and porphyrite, have already given a large production in the past, while the asbestos deposits of the serpentine have not got beyond the early stages of prospecting.

Trial shipments have been made of chrome iron, talc, and iron ores, but with unsatisfactory results.

General Character of the District.

The district lies just within the border of the Appalachian mountain system, and the topography as a whole partakes of the features usually found to characterize that region. In general the country is traversed in a northeasterly direction by numerous parallel ridges and valleys. Locally the western border of the district is formed by the mountains of the Sutton Mountain anticline, many of the peaks probably averaging 1,800 feet above sea-level. Adjoining this range to the east is the strongly marked valley of the Missisquoi river, ranging in altitude from 675 to 800 feet. The next ridge to the east is from 3 to 4 miles wide with an average elevation of 1,100 feet. The serpentine belt intrusions are found chiefly along this ridge and compose the highest mountains of the immediate vicinity, three of them rising to over 2,000 feet. The next important depression is occupied by Lake Memphremagog with an elevation of 690 feet. The influence of the topography is well shown by the location of the railways, a good example being the Canadian Pacific Railway's line from Montreal to Newport, the excessive detours shown thereon being simply an expression of the difficulty of finding a suitable grade in a direction across the trend of the hills and valleys.

General Geology.

The outstanding feature of the geological structure of the Eastern Townships is the existence of three main anticlines composed of ancient sediments and volcanics, between which are synclinal troughs underlain by younger sediments. In a broad way the anticlines are expressed as ridges and the synclines as valleys, the reason for this probably being found in the kind of underlying rock. The anticlines, to a large extent at least, are composed of volcanics considered to be of Pre-Cambrian age. Flanking the volcanics are arranged various sedimentary formations in ascending geological order towards the axes of the synclines. In the succession are represented the Cambrian, Ordovician, Silurian, and Devonian. The serpentine belt includes a series of intrusives occurring chiefly along the eastern slope of the Sutton Mountain or westernmost anticline.

TABLE OF FORMATIONS.

Quaternary	Sand, gravel, and clay.
Devonian ?	Shaly limestone, serpentine, peridotite, pyroxenite, gabbro, diabase, granite, aplite, alkaline rocks of the Monteregian type.
Silurian	Shale and limestones.
Ordovician Farnham Series	Graphitic argillite and limestone conglomerate.
Cambrian	Greywacke, purple and green slates; red marble, schistose grey quartzites.
Pre-Cambrian—Sutton Mountain series	Porphyries and greenstones.

DESCRIPTION OF FORMATIONS.

Pre-Cambrian.

Sutton Mountain Series.—The rocks of the porphyry-greenstone series are probably the only ones older than Cambrian. In the early geological work in the district the volcanics were mistaken for sediments owing to their being much squeezed and folded and thus having had the features commonly associated with igneous rocks almost entirely removed. The porphyries are well shown on the railway line between Eastman and South Stukely, while the greenstones are well exposed near Foster.

Cambrian.

The rocks belonging to this system comprise an extensive development of a grey usually schistose quartzite with smaller amounts of greywacke, green and purple slates, and a few bands of a red marble. These are found chiefly in the valley of the Missisquoi, the best exposed section being found just south of Eastman.

The correlation of the so-called Cambrian and Pre-Cambrian has never been definitely established. Apparently these terms were first of all given on the basis of broad generalizations, and have been accepted since simply for lack of more exact information.

Ordovician.

Farnham Series.—The black slates which are the principal rocks of this series have been correlated with the lower Trenton. In most places the entire formation has been metamorphosed to such an extent as to completely remove all signs of its original bedding, and at the same time cause the production of secondary minerals. The correlation is made on the determination of fossils collected at Castle Brook west of Magog, from which locality the formation has been traced laterally for many miles.

Silurian.

The Silurian system is of relatively small extent in the district, but it furnishes important evidence as to the age of the serpentine series. The northern half of Lake Memphremagog lies in a synclinal trough of Silurian measures whose age as previously determined has been chiefly based on a few species of not very characteristic corals. However, the discovery of a new fossil locality at Knowlton Landing containing a much wider range of species has given an opportunity for a much more decisive determination. Mr. P. E. Raymond has kindly made the following preliminary report on a collection of some 300 pounds of fossiliferous material.

"The following species were determined:—

Dalmanites lunatus, Lambert; abundant.
Dalmanites, sp. ind.; probably new; common.
Calymene, sp. ind.; rare.
Bronteus pompilius, Billings; rare.
Ceratocephala, cf. *C. goniata,* Warder; rare.
Chonetes, sp. ind.; rare.
Coelidium, sp. ind.; rare.
Operculum of gastropod, like that referred to *Oriostoma* by Kindle.
Orthoceratites, indeterminable; common.

"Trilobites form the most important part of this collection. The specimens of cephala and pygidia are numerous, and though distorted, fairly well preserved. The most common one is very similar to *Dalmanites pleuroptyx,* Green, but differs from that species in having fewer rings on the axial lobe of the pygidium and fewer ribs on the pleural lobes. It is, therefore, referred to Lambert's species, described from the Silurian at Littleton, New Hampshire (Bull. Geol. Soc. America, Vol. XV, p. 480, 1904.) The other species of *Dalmanites,* represented only by pygidia, is characterized by its rounded outline, the absence of a caudal spine, and the few (about 10-13) rings and ribs (8-9) on the pygidium. The presence in this fauna of a *Calymene* and a *Ceratocephala* of the type of *C. goniata* indicate the middle Silurian age of the strata at this locality.

"The fossils from a second locality, a little higher in the section, are mostly indeterminable. The pygidium of a species of *Encrinurus* was recognized, and some of the *Orthoceratites* are identical with those in the lower beds."

"The strata at a third locality on the other limb of the syncline are full of badly squeezed brachiopods, none of which could be recognized with certainty. The most common shell is a rhynchonelloid, possibly a *Wilsonia.* Two or three specimens appeared to be *Atrypa nodostriata,* Hall, and another looked like *Leptaena rhomboidalis.* With these was a large and well-preserved specimen of *Favosites gothlandicus,* Lamarck."

Devonian.

Two outliers of rocks which have been referred to the Devonian are found at Knowlton Landing and Owls Head on the west side of Lake Memphremagog, and as far as is known rest conformably on the middle Silurian. The diabase which accompanied the intrusion of the serpentine alters the middle Silurian strata in the vicinity of Knowlton Landing, and since the outlier of Devonian rests conformably on the middle Silurian at that point, it is thus considered probable that the intrusion of the serpentine rocks in this vicinity took place after the deposition of this representative of the Devonian. The highly altered and squeezed character of the serpentine and, also to a limited extent, of the Monteregian rocks, observed chiefly in Shefford and Brome mountains to the west, indicates that they were intruded before the cessation of folding to which this, in common with other portions of the Appalachian system district, has been subjected. This movement is considered to have been complete in Carboniferous times, and thus gives a younger limit to the age of these sediments. It would seem very probable that they are late Devonian in age since this was a period of great igneous activity in the Appalachian uplift, especially in the Hudson valley north of New York.

The Serpentine Belt.

The rocks of the serpentine belt are—serpentine, peridotite, pyroxenite, gabbro, diabase, granite, and aplite. The previous work of Mr. Dresser has indicated that these different rock types are, in the main, parts of one consanguineous intrusion, having separated from one another during the process of cooling. In the case of intruded sheets examples are commonly found showing peridotite in the lower portion and on ascending, a zone of pyroxenite, then gabbro, and finally diabase. Where the intrusions form stocks or plugs, the types are found to be arranged in the same order from the centre outwards, as is found in the sheets from the base upwards. The granite and aplite, which represent the most extreme acid phases of the process of differentiation, have generally been intruded a little later than the other rocks. The serpentine is an alteration phase of the peridotite and all gradations are found between a pure serpentine and only slightly altered peridotite. The district examined this year was noteworthy on account of the predominance of the diabase end of the series.

Alkaline Rocks.

On the St. Lawrence plain to the west of this district there are a number of residual hills of intrusive igneous rocks which have received the name of Monteregian hills from the best known representative, Mount Royal, at Montreal. Dykes of rocks belonging to these intrusions are found in many places quite distant from any of the large masses. They are readily recognized on account of being composed of minerals of an unusual alkaline composition.

An exposure of these rocks is found in a cutting on the Canadian Pacific railway near Orford pond, about 2 miles from Eastman. The rocks represented are camptonite, nordmarkite, and monzonite. At the Huntingdon mine a camptonite dyke cuts both the serpentine and the ore-bearing schistose diabase. In a cut on the railway, ¾ of a mile south of Bolton Centre, a deeply weathered dyke of tinguaite cuts the Cambrian schists. Numerous other dykes of this class have been found at Lake Memphremagog and have been described in minute detail by Marsters.[1]

Quaternary.

The superficial deposits, more especially in the valley of the Missisquoi, consist chiefly of sands and gravels deposited on the retreat of the ice-sheet and almost unmodified since. On a small scale splendid examples may be found of outwash sand-plains, kames, and terminal and lateral moraines. Bolton pass. which cuts across the Sutton Mountain anticline, shows very evident glacial action, and what was probably a good-sized englacial stream discharged easterly through this pass into the Missisquoi, building the sand-plain in the vicinity of South Bolton village.

[1] V. F. Marsters, Amer. Geologist, July, 1895.

ECONOMIC GEOLOGY.

COPPER.

Huntingdon and Ives Mines.

The copper mining industry in this district was in its most flourishing condition about 1870 while copper was selling at about 20 cents per pound, at which time both the Ives and Huntingdon mines near Eastman were vigorously worked, seemingly at good profit. The extreme decline in the price of copper soon after this date caused the gradual abandonment of these mines as soon as the known bodies of ore had been worked out. The ore of the Huntingdon mine is said to have contained from 7 to 10 per cent of copper and that of the Ives mine from 10 to 14. While no specific information can be found as to the output of these mines, it is known that for the three years 1869 to 1871 the total production of Quebec from five mines was 27,082 tons of ore valued at $333,817. It is not improbable that half of this was from the Huntingdon and Ives mines. About 1890 the Nicols Chemical Company reopened the Huntingdon mine, but apparently their prospecting was unrewarded, since after having done a lot of expensive work they closed down again. During the past summer Mr. N. S. Parker, while prospecting on the surface at the Ives mine, uncovered a promising looking outcrop of ore, but the lateral extent has not been proved and it may be that in depth the ore was stoped out by the former workings. It may be mentioned here that there are large dumps containing low grade ore at both these mines, which under present improved conditions it might be profitable to concentrate, especially in view of their favourable situation.

Lake Memphremagog Mine.

This is situated on the northwest slope of Hogsback mountain, not far from Knowlton Landing. According to the estimate of Dr. A. W. G. Wilson,[1] of the Mines Branch, the amount of ore as shown by the present workings will not be more than 20,000 tons, with a copper content probably less than 2 per cent. A quantity of ore reported to be as much as 500 tons, shipped in 1907, is the total production to date.

On lot 1, range IX, of Bolton, at Eastman village, a shaft about 15 feet deep, on one wall shows a small vein with a lens of ore about 1 foot thick containing chalcopyrite, sphalerite, and pyrite. Owing to a fault the vein is not continuous across the pit.

Prospect pits on lots 24 and 25, of range VII, of Bolton, sunk recently, do not show any valuable ore-bodies.

CHROME IRON ORE.

Chrome iron ore has been found and prospected on lots 9 and 13, of range VII, and 26 of VI, of Bolton. All these showings are small, and the only production has been one shipment of 27 tons in 1896 from lot 9, of range VII.

IRON ORE.

On lot 9, of range X, of Bolton, there is a series of lenses of hematite and quartz, occurring in a fine-grained basic igneous rock near its contact with quartzite. The largest body is about 40 feet long and 7 feet wide at the surface, but at the bottom of a pit 70 feet deep it is said to be 18 feet wide. The lenses outcrop for about 100 yards and are then covered by soil. In places the hematite is quite pure and of the specular variety, in other places it is intimately mixed with the quartz, and in some places,

[1] Summary Report of the Mines Branch, Dept. of Mines, 1909, p. 71.

chlorite. Copper stains are commonly found in fissures in the ore. The mining rights belong to John McDougall & Co., of Drummondville (now included in the Canada Iron Corporation, Ltd.), who mined a trial shipment of 200 tons in 1903.

ASBESTOS.

Although a large number of pits and other openings have been made in search of asbestos, nowhere has this been found of good enough grade to warrant serious mining operations. The most promising prospect is on lot 9, of range VII, of Bolton, but even there the fibre is harsh and not over half an inch in length, while the deposit is of unknown and possibly limited extent. The openings already made are in a poor location since they are close to the upper contact of the serpentine body, which position has been shown by Mr. Dresser's previous work to be usually an unfavourable place for the development of asbestos. The owners or promoters of this property had evidently once thought well enough of it to start building a mill, but did not get farther than laying the foundations.

TALC.

Deposits of talc are found on lots 26, range II, 24, range VI, and 24, range VII, of Bolton, and on 28, range V, of Potton. Excepting the first mentioned, all of these are very impure and dark-coloured, containing numerous crystals of magnesium carbonate. From lot 24, range VI, of Bolton, 300 tons, valued at $1,800, were shipped in 1871.

The deposit on lot 26, range II, of Bolton, which was only recently discovered by the owner, Geo. R. Pibus, is the most promising of these prospects. A pit 15 feet deep shows schistose talc 7 feet wide, and the band is found along the strike in pits 75 and 375 feet distant. The talc, although not perfectly pure, appears to have a sufficiently good colour, and the body is probably large enough to be mined economically. The deposit is 5 miles from South Bolton station, and connected therewith by a good road with favourable grade

BELŒIL AND ROUGEMONT MOUNTAINS, QUEBEC

(*J. J. O'Neill.*)

Introduction.

The first two weeks of the season were spent with Mr. R. Harvie in continuing Mr. Dresser's work on the serpentine belt. The remaining three and a half months were devoted to the study of the two mountains, Belœil and Rougemont, with the purpose of completing the work on the Monteregian province.

After the field work had been completed, a number of duplicate sets of the principal rock types from Belœil, Rougemont, and Mount Johnson were collected; to procure which it was found necessary to engage blasters to secure fresh specimens.

The contour map of this district, lately issued by the Department of Militia, enlarged to a scale of 4 inches to 1 mile, was used as a basis for geology.

The field-work was carried on alone, except for temporary assistance in surveying contacts.

Location and Size.

The Monteregian province is made up of eight volcanic intrusions of alkalic magma in the form of laccoliths or volcanic necks, situated in the southwestern part of the Province of Quebec, and extending from Mount Royal at Montreal, to Shefford mountain, nearly 50 miles due east.

Mount Royal, St. Bruno, Belœil, Rougemont, Yamaska, and Shefford mountains are spaced at from 5 to 15 miles apart along the west-east line; Mount Johnson is 6 miles south of Rougemont, Brome mountain is 2 miles south of Shefford.

The areas of these mountains range from 0·422 square miles in the case of Mount Johnson, to 30 square miles, in the case of Brome, which is more than three times as large as Shefford, the next largest.

Topography.

The Monteregian hills stand up in striking contrast to the low-lying plain of Palæozoic strata, known as the St. Lawrence lowlands, which extends from the Laurentian highlands on the northwest to the Appalachian province on the southeast, with a width of about 80 miles at Montreal.

The plain is deeply mantled with glacial drift, and the subdued character of the hills, with their crag and tail profiles, points also to the profound glaciation which has affected the whole of eastern Canada.

Terraces surrounding many of the hills are the result of the sea invasion following the retreat of the ice, and sand and gravel deposits on Mount Royal show that the water rose relatively to 493 feet at least, and, not improbably, to 560 feet.[1]

Most of the Monteregian hills enclose one or more lakes in basins gouged out by the ice, and these form the natural reservoirs for the water-supply of the surrounding villages.

The drainage of the Belœil-Rougemont region is effected by the rivers Richelieu and Yamaska, which flow northward through the drift and are tributary to the St. Lawrence.

[1] Goldthwait, J. W., Raised Beaches of Southern Quebec: Summary Report for 1910, Geological Survey, 1911, p. 226.

Belœil Mountain.

Belœil mountain rises to a height of 1,375 feet above sea-level, or 1,275 feet above the plain. Near the south end of the mountain there is a lake about a fourth of a mile square, with a maximum depth of about 40 feet, at an elevation of 535 feet. This lake occupies the bottom of a wide basin gouged out of the mountain by the ice.

Belœil is the product of two intrusions, an earlier one of essexite which forms the western half of the mountain, followed by nephelite-porphyry which contains fragments of the essexite and occupies the eastern half of the mountain. There are also many dykes of complementary nature representing at least two stages of intrusion.

The dykes seem to radiate from the essexite magma and to cut through it in many places. None were observed cutting the porphyry nor seeming to come from it directly. Two sheets of tinguaite, 4 feet to 6 feet in thickness, come off from the eastern side of the mountain, presumably from the porphyry.

The intrusions seem to have taken place without any disturbance in position of the sedimentary beds, and the relation of the igneous rocks, together with the relatively thick zone of rocks strongly altered by contact metamorphism, and the fact that the magma is coarse-grained right to the contact, point to the intrusion as having been progressive through the same channel; in other words a volcanic neck.

Rougemont Mountain.

Rougemont mountain rises to 1,275 feet above sea-level, or about 1,150 feet above the plain. It is heavily timbered, and the extensive covering of drift permits of few exposures of the underlying rock. The exposures are mostly decomposed to a depth varying from a few inches to several feet.

There are two small lakes contained in this mountain, one at the north end at an elevation of 800 feet, and the other at an elevation of 500 feet, near the south end.

An essexite varying in texture, and perhaps in composition, within short distances, seems to be the only intrusion forming the mountain. The rock is very high in ferro-magnesian minerals and in many places weathering produces a regular gossan. There are also a few dykes which indicate the latter phases of activity.

The igneous rock at the borders of the intrusion is more or less filled with masses of hornstone fragments for a width up to 200 feet in places. No disturbance of the surrounding sedimentary beds seems to have taken place, and the same contact phenomena occur as at Belœil. It would seem then that Rougemont is also of the nature of a volcanic neck.

Economic Geology.

Enclosed within Belœil mountain are three areas of limestone and marble. The two areas exposed on the hills to the east and north of the lake are coarsely crystalline and streaky marble, covering an area of about 4 acres. The surface material crumbles easily due to the action of weathering, but that lower down is probably more compact.

At the third exposure, at the northeast end of the mountain, two old lime-kilns are situated which have been long out of use. The rock here seems to be on the margin of the intrusion with bedding nearly vertical. It is exposed on both sides of a swampy depression, between the hornstone collar to the north and the porphyry hill to the south. It is about 500 feet in length and probably 150 feet in breadth. The portion exposed nearest the porphyry is a fine-grained, compact, whitish marble containing dark streaks of impurities. but on the opposite side of the depression the exposure seems to be a calcareous conglomerate in which the pebbles are rarely larger than peas, and there are thin shaly layers showing the bedding planes.

Close examination was made for fossils, but without success. Dr. F. D. Adams has shown the author a memorandum from Dr. Ells that fossils of the Devonian age have been found in this occurrence.

It would seem that the marble present in the mountain is well worth proving and testing for its value for decorative purposes.

RECORDS OF POST-GLACIAL CHANGES OF LEVEL IN QUEBEC AND NEW BRUNSWICK.

(*J. W. Goldthwait.*)

Introductory.

About six weeks were spent in July and August, 1911, by the writer and two assistants, in southeastern Quebec and eastern New Brunswick. The investigation of raised beaches and other marine deposits of the post-glacial epoch, as reported a year ago, was continued, from Matane on the lower St. Lawrence, eastward around the Gaspé peninsula to Chaleur bay, and thence southward down the coast of New Brunswick to Amherst, Nova Scotia. Measurements of altitude of these elevated beaches were made at a number of localities. A special effort was made to trace the Micmac terrace and sea-cliff[1] outward from the lower St. Lawrence to the gulf, with a view to the correlation of the relatively recent uplift it records, with recent changes of level along the gulf coast. Special attention was placed, also, upon supposed evidences of modern subsidence on the New Brunswick coast. In this connexion observations were made on the distribution of plants of fresh-water and salt-water types, in districts where progressive subsidence or elevation has been suspected; and borings were made at many places to determine the depth of peat bogs and to gather other facts which might aid in settling the disputed question of modern stability of the coast.

Co-operation with the Shaler Memorial Investigation.

A few weeks before entering the field, and with the approval of the Director, the writer conferred with Professor Douglas Wilson Johnson, of Harvard University, and arranged the details of a plan for co-operation between the Geological Survey and the Shaler Memorial party, which was already engaged in a comprehensive study of the evidences of modern subsidence along the Atlantic coast, both in this country and in Scandinavia. The advantages of this co-operation to the Survey are both direct and indirect. Professor Johnson will prepare for a forthcoming memoir a chapter on the modern stability or instability of the coast of Quebec, New Brunswick, and Prince Edward Island, in which his own observations and those of the present writer will be set forth and discussed, in the light of the newly collected evidence from the whole field. Indirectly, the Survey has gained, through the more critical and intelligent search for evidences of modern subsidence which the writer has been enabled to make as a result of Professor Johnson's suggestions. The question of present rising or sinking of the coast has a peculiar interest, since it must take account of changes witnessed by those who have dwelt long near the shore. In some localities the rights of property owners on the seaboard have rested upon the correct answer to the question, whether the coast, in the last few centuries, has been rising or sinking, or perfectly stable. In view of these human aspects of the question, Professor Johnson's contribution to the subject will very distinctly add to the value of the forthcoming report.

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[1] This name was given last year to a remarkably strong and continuous terrace and sea-cliff which stands about 20 feet above mean sea-level, in the region between Quebec and Matane. See 'The twenty-foot terrace and sea-cliff of the lower St. Lawrence'. American Journal of Science, Vol. xxxii, 1911, pp. 291-317.

A second conference with Professor Johnson was held in Quebec, on November 18 and 19, in order to discuss on the ground several questions raised by the strong development, uniform height, and fresh appearance of the Micmac shoreline, which forms a connecting link between the evidences of the early post-glacial uplifts of the coast and those of modern elevation or subsidence. The conference led also to a more definite conception of the origin of certain non-marine terraces which lie between the city of Quebec and Ste. Anne-de-Beaupre.

Records of the Champlain Submergence.

In 1910, the upper limit of marine submergence was found to decline very steadily from about 630 feet at Quebec to less than 200 feet at Matane. Observations during the present season in the same district, including old localities which were revisited and an examination of new ones, strengthen that correlation. In one instance only, has a correction of last season's data seemed necessary—namely, at Matane. There, although the highest distinct beach stands at 174 feet, as reported last year, the washed sands extend farther, to the foot of a rather persistent bluff, at 218 feet, which harmonizes better with determinations of the upper marine limit at localities both to the east and to the west, than did the 174 foot measurement. As a supplement and amendment to the data given in last year's summary, therefore, the upper marine limit at the following places is here recorded:—

St. Joachim.—Rolled gravels up to 560-570 feet (aneroid).
L'Islet.—Highest of a series of strong beaches, 520 feet ± (aneroid).
Priceville.—Delta of Grand Métis river, 270 feet ±.
Matane.—Upper limit of sands at foot of bluff, 218 feet.

The observations of raised beaches from Matane eastward to Ste. Anne-des-Monts, including not only barometric measurements but the results of more precise levelling at several places, extend this water-plane 50 miles farther east. It appears to continue the same uniform descent east of Matane which it holds to all the way from the city of Quebec, reaching an altitude of approximately 150 feet at Sainte Anne-des-Monts. The new data from this district are as follows:—

Ste. Félicité.—Wide, gravelly terrace, 204 feet.
Grand-Mechin.—Top of extensive delta, 175 feet.
Cape Chat.—Short spit of shingle back of the mountain, 156 feet.
Ste. Anne-des-Monts.—Two miles west of village, pocket beach, highest of a group, 150 feet.
Ste. Anne-des-Monts.—Two miles east of village. Gravelly beach, highest discovered on favourable slope, 137 feet.

The figures given above, unlike the other measurements, refer to the last high-tide mark on the beach, instead of mean tide-level. They are, therefore, subject to a correction of a few feet. All are measurements made with German pocket-level and rod.

An unlooked for feature which complicates the task of correlating the beaches of this more easterly district with those west of Matane, is the presence along this north Gaspé shore of marine terraces and delta deposits at altitudes much higher than the water-plane referred to in the preceding paragraphs. The topographic strength of these higher shorelines is extraordinary, and thus quite unlike the beaches farther up the lower St. Lawrence, excepting, of course, the Micmac shoreline, which is always conspicuous. At one particularly exposed headland near Capucins, the most typical cobblestone beach which I have seen anywhere east of

Covey hill was found, at an altitude of 273 feet above high tide, or fully 100 feet above the water-plane which has been traced down the estuary from Quebec.

The reason for these higher marine terraces and beaches can at present only be conjectured. While a local bulge in the upwarped water-plane is not impossible, no other facts have been found which might support that view; moreover, as already stated, the highest shoreline from Quebec to Matane seems to be traceable all the way out to Ste. Anne, in terraces and deltas which harmonize with that plane. A more satisfactory theory is that the Gaspé peninsula bears a record of earlier and deeper submergence than the lower St. Lawrence coast possesses, because of an earlier disappearance of the ice-cap from it than from the latter shore. As Chalmers has said,[1] glacial drift covers the upland, near the shore, as far east as Ste. Anne-des-Monts, although not far beyond there the presence of residual soils and certain details of topography indicate that the coast did not suffer glaciation. Further than this, little is known about the glaciation, and more especially the de-glaciation of the Gaspé coast. In view of the probability that the whole lower St. Lawrence region was glaciated from the south, rather than from the Laurentides, it seems not unlikely that this great peninsula had a glacial history somewhat independent of the region to the west. Whatever that history may be, it is still well concealed by a forested wilderness of mountains. With the few facts now available, the theory of a relatively early de-glaciation of the north Gaspé coast can only be regarded as a working hypothesis.

As reported a year ago,[2] the elevated beaches between Quebec and Matane seem to be about alike in weakness of topographic expression, at all levels except the Micmac shoreline, 20 feet above the sea, which is a very conspicuous terrace and sea-cliff. The conclusion that was drawn last year, that "the coast seems to have emerged steadily from the very first," developing beaches among which none particularly excel in strength, seems to be contradicted by facts from the Gaspé coast, east of Matane; for there is at least one very strongly marked terrace and sea-cliff, intermediate in height between the Micmac shoreline and the one which lies on the plane of the "highest" beach of the Quebec district. This shelf and cliff, while naturally less sharp and fresh than the later Micmac shore, closely rivals it as a record of long continued wave-work on a stationary or subsiding coast. An observer in this field would scarcely hesitate to conclude that the post-glacial emergence of the north Gaspé coast was not steady, but subject to one or two interruptions.

It was my expectation, after reading the literature of the district, and following the raised beaches down the lower St. Lawrence, that the coast of Chaleur bay would furnish equally good records of wave-work and marine sedimentation, and at altitudes not far different from those of the neighbouring portion of the St. Lawrence, that is, from 150 to 200 feet. It was, therefore, both a surprise and a disappointment to find at all places visited between Campbellton and Gaspé basin no acceptable evidence whatever of wave-work above the altitude of 75 feet; and even below that, only faint records of it. At Gaspé basin, Port Daniel, and other places, there are gravel deposits with horizontal surfaces, which, while not records of wave-work, appear to signify at least conditions of submergence of the coast by the sea, to the depth of 50 to 75 feet, during which deltas formed at the mouths of the largest rivers, and some smoothing of the shallower portions of the shore took place. At Port Daniel the remnants of a delta deposit and faint beaches agree in fixing the upper marine limit at about 70 feet. On the equally favourable slopes above this altitude, only a sheet of the red boulder clay, containing striated stones, covers the ledges. At Grand river, the limit of submergence, similarly marked, is close to 50 feet. Dr. John M. Clarke, Director of the Geological Survey of New York state, has

[1] R. M. Chalmers. Surface geology of eastern Quebec; in Summary Report of the Director, Geological Survey, Canada, 1904, pp. 250-263.
[2] Geological Survey, Canada, Summary Report of the Director, 1910, p. 228.

kindly furnished me with detailed information concerning fossil-bearing beach deposits near New Richmond, which indicate former marine conditions at levels well below the 70 foot mark.

It is as difficult to account for the slight amount of post-glacial submergence of the east and south coasts of Gaspé as it is to explain the extraordinarily deep submergence of the north coast. On the south side, as on the north, there is nothing, apparently, to support the theory of local departure from that regularity in upwarping which is clearly registered by the beaches between Quebec and Matane. On the other hand, the faint and uncertain records of the Chaleur Bay coast agree fairly well in fixing the upper limit at about 70 feet. It seems likely that the Chaleur Bay district was covered by ice longer than the lower St. Lawrence, so that by the time the ice-cap disappeared from it the coast had risen all but about 70 feet of the net amount. This hypothesis is supported by the occurrence of many kames, especially near the mouths of the large rivers, as noted in detail by Chalmers.[1] These kames rise ordinarily to a height of 150 to 200 feet, and possess steep ice-contact slopes, as if they had accumulated in recesses against tongues of ice which were tributary to a large glacier in Chaleur bay, for some time after the ice-cover had gone from off the lowland coast of the St. Lawrence. The exposure of these kames is such that their steep ice-contact slopes would have been greatly flattened by the waves if the ice had not remained around them while the coast emerged from the sea. The satisfactory settlement of this question, like that raised in the discussion of the phenomena of the north Gaspé coast, must await a very thorough exploration and investigation of the glacial geology of the rugged wilderness from which the Restigouche, Cascapedia, and other glaciers seem to have issued.

Near Bathurst a well-defined upper limit to beach deposits was found at the altitude noted by Chalmers—viz., 195 feet. At Caraquet, likewise, the figures given for the upper marine limit, 138 feet, seem correct. Near Newcastle, search revealed no very strong mark of wave-work at the upper edge of the submerged zone; but the best one found, a gravelly spit at the mouth of the Bartibog river, was found to be 152 feet above high tide, instead of 125 to 150 feet, as Chalmers has put it.[2]

South of Newcastle, no satisfactory evidences of submergence at altitudes comparable to those already noted could be found, although localities described by Chalmers were visited, and an effort was made to determine the upper marine limit. Near Berry Mills station, and a few miles east of it, at the base of Indian mountain, morainic hillocks and kames were seen, which seem to possess nothing unusual, either in form or in structure, to mark them as of marine origin. The extensive sand-covered plain just west of Moncton, up to 100 feet or more, is probably a wave-swept feature; but no good place at which to measure the upper limit of this was found. At Shediac, and at Amherst, Nova Scotia, the evidence of submergence, likewise, was rather clear on the lower ground, where sands are extensive and deep; but distinct shoreline topography seems to be absent. Observations at St. John and Pennfield, New Brunswick, support Chalmers' statements concerning an upper marine limit there of about 225 feet.

The Micmac Shoreline.

The conspicuous terrace and sea-cliff, reported a year ago as extending with little interruption from the city of Quebec at least as far as Ste. Anne-de-Beaupré on the north side, and from Lévis at least as far as Matane on the south side of the

[1] R. M. Chalmers. Surface geology of northern New Brunswick and southeastern Quebec. Geological Survey, Canada, Annual Report, 1886, Part M, pp. 22-27.

[2] R. M. Chalmers. Surface geology of eastern New Brunswick, northwestern Nova Scotia, and a portion of Prince Edward Island, Geological Survey, Canada, Annual Report. Vol. VII, 1895, p. 23, Part M.

St. Lawrence, was again studied, and was traced with ease from Matane to Ste. Anne-des-Monts. This carries the Micmac shoreline fully 275 miles down the estuary. The same wonderful strength, and the same uniformity of altitude which characterize the terrace and cliff west of Matane, characterize it here, on the north Gaspé coast. Along the 25 mile stretch of bold, almost mountainous coast between Grand-Mechin and Ste. Anne, where great headlands like Cape Chat alternate with gently concave re-entrants behind which the upland rises less precipitously, the Micmac shelf extends with remarkable persistency. At the capes, it becomes narrow, but seldom disappears. When one considers the steep declivity of this coast, and the vigorous wave work which is going on there, it is surprising that a narrow shelf like this has not been completely cut away since its elevation from the sea. One is almost compelled to regard the emergence of the Micmac shelf as of very recent date. While the outer portion of the shelf, which is still under water, is much narrower along this bold coast than off the gentler upland west of Matane, it is sufficient menace to navigation to discourage, if not to prevent small freight steamers from making landings at the docks. Freight and passengers are transferred to small sail boats, a hundred yards or so off-shore. The largest rivers, like the smallest, enter the sea across ledges and reefs of rocks, having entrenched themselves but imperfectly beneath the surface of the Micmac terrace since its uplift. Still more striking as an indication of the recency of the post-Micmac uplift is the fact that the small streams, where they pass out through the Micmac sea-cliff to the terrace, come with abrupt descent, over cascades or falls. The larger rivers, like the Rimouski, Matane, and Ste. Anne rivers, have worn back their over-steepened channels very considerably, yet they, too, retain enough of the heritage of this recent rejuvenation to yield water-power for the great lumber mills around which the larger towns have grown up.

After discovering that this shoreline extended without change of strength or altitude from Quebec to Ste. Anne-des-Monts, 275 miles, I expected that it would be found at Gaspé basin, only a little more than 100 miles farther east. Owing to lack of time for a continuous journey by carriage along this difficult stretch of coast, and to the fact that the next steamer for Gaspé basin was not to leave until a week later, we returned to Matane and proceeded by rail to Campbellton, N.B., and thence to Dalhousie, where we began a search for elevated beaches along the north side of Chaleur bay, with Gaspé basin as the final goal. No trace of the Micmac shelf and cliff was found at Campbellton, Dalhousie, Carleton, nor, in fact, at any point on Chaleur bay. High cliffs of fresh rock are everywhere being cut back by the sea, and the platform below slopes off rapidly under water, allowing boats to come close in shore. This condition becomes more impressive eastward, as one passes out from Chaleur bay and around the east end of the Gaspé peninsula. A continuous wall of red and grey rocks, rising vertically from the water's edge, affords no hope of discovering any trace of a Micmac shelf and cliff. Even in the protected re-entrants, the cliffs are freshly cut and naked. The picturesque rock at Percé and the high capes beyond bear testimony only to the incessant attack of the sea on a coast which has certainly not been rising in recent times. While this coast may have been perfectly stationary during the period when the Micmac terrace was rising from out of the lower St. Lawrence, one is constantly tempted to adopt the view that subsidence, rather than stability has been the condition here for a long time—the cliff recession is so impressive, where crags stand 500 feet above the water, and at the same time, because the depth of water on the submerged shelf beyond is considerable.

To determine where the Micmac shelf disappears, in its course down the lower St. Lawrence, plans for the last week of the field season were changed, so as to allow the writer to take the trip from Gaspé basin, on the steamer "*Gaspesien*" around the cape, and along the north Gaspé shore, past Fox river, Grande-Vallée, and Ste. Anne-des-Monts. Fortunately, the trip was by daylight from Gaspé basin as far as Mont Louis; and fine weather allowed the boat to keep very close in-shore. The details of cliff and beach could thus be seen almost as well as from a moving carriage, though with the obvious disadvantage that no opportunity was given to set foot on the land—especially since the landings are accomplished by transfer to sail-boats, as already mentioned. From Cape Gaspé as far as Pointe Séche not a sign of a dry shelf at the foot of the precipitous cliffs was seen. Here, however, the cliff was observed to be turf-covered, and on the beach at the base were seen many fish houses, reached by long flights of steps from the houses which stand perched on the edge of the bluff. At Cloridorme, again, a line of fish houses was observed, strung along the foot of turf-covered cliffs, apparently out of reach of the storm-waves. In this re-entrant there seems to be no active recession of the cliffs, although the shelf, as well as I could judge, stands but little above the level of the sea. Similar suggestions of a low, narrow shelf appear at a number of points between here and Cape Magdalen. From the lighthouse at that point a very distinct terrace extends westward along the shore for fully a mile—to all appearances like the Micmac terrace along the coast west of Ste. Anne-des-Monts. From this series of observations, I am inclined to believe that the Micmac shoreline descends to sea-level somewhere in the vicinity of Pointe Séche, and that everywhere east and south from there it is submerged and destroyed. That the old shoreline should disappear, as it seems to do, within a distance of 75 miles from Ste. Anne, after continuing without change of altitude for 275 miles, is certainly surprising; but possibly the change in direction of the coast beyond Ste. Anne swings the line of observation into an oblique position with respect to isobases to which it has up to that point been parallel. If so, the isobases for the Micmac shoreline run almost at right angles to the isobases for the "highest" beach of the lower St. Lawrence.

Modern Instability of the Coast.

In the last two or three years, the question of present upward or downward movement of the coast has received renewed attention, chiefly as a result of studies of salt-marsh structure by plant physiologists.[1] The discovery last year of the Micmac terrace, but slightly, and apparently recently elevated from the sea, suggested the desirability of a closer study of the modern shoreline of the Maritime Provinces, in order to sift the so-called evidences of modern subsidence, both botanical and physiographic. As indicated in the opening paragraphs of this report, a considerable share of our time was devoted to this work, the results of which will be presented in detail in a later paper, and will be discussed by Professor D. W. Johnson, in their relation to his own researches, both in North America and Europe.

As regards the lower St. Lawrence, the physiographic and botanical evidence suggest that the Micmac terrace is still slowly rising from the sea. The marshy shore, hardly scarred by the waves, the slight amount of intrenchment of stream and river channels where they cross the terrace, and the shortness of the gorges which they have cut back from the face of the Micmac cliffs—all these convey the impression that the elevation of the coast is still in progress. Had it ceased even a few centuries ago, one would expect to find the waves trimming back the shore more distinctly, and the streams better adjusted to the new base-level. If subsidence had set in since the elevation of the Micmac terrace, and were now in progress, the wave-cutting should be even more distinct, and the streams should possess channels deep enough at their mouths to admit small boats to enter without danger. The mixed salt and fresh water vegetation of the high-tide zone of the Micmac terrace supports

[1] C. A. Davis. Salt marsh formation near Boston, and its geological significance. Economic Geology, Vol. V, 1910.
W. F. Ganong. The vegetation of the Bay of Fundy salt and dyked marshes; an ecological study. Botanical Gazette, Vol. XXXVI, 1903, pp. 161-186, 280-302, 349-367, 429-455.

the view that emergence is still going on. Convincing proof of it, however, is yet to be found.

A variety of evidence has been adduced from New Brunswick to prove that the coast of that Province is now sinking beneath the sea. So far as I was able to find and test this evidence, it is questionable if not indeed fictitious. While, locally, there are signs of an increase in the height of the high-tide surface, killing trees which stand near the border of salt marshes, such cases are rare, and in some instances of uncertain value. The general absence of a dead fringe of forest trees around the edges of the salt marshes, in northeastern New Brunswick, is, indeed, rather an indication that no rapid subsidence is now in progress. Freshwater peat bogs reported to reach depths considerably below high-tide level, appear from soundings made this season to go down no farther than mean low tide. If the close approach to that limit is as general as the measurements in certain typical bogs suggest that it is, we have in these peat deposits reason for a belief in present stability rather than in present subsidence; for sphagnum and other peat-building plants might accumulate in basins whose floors extended to mean-tide level, and whose waters, consequently, were fresh, while they might not, under ordinary conditions, accumulate in deeper basins because of brackish or salty conditions. Modern subsidence, if continued for several centuries, should have lowered such bog floors to greater depths than that to which our borings indicate they extend. An instrumental survey of the beaches of Grande Plaine, on Miscou island, which are known from the presence of walrus bones to be a few centuries old, supports the opinion expressed some time ago by Chalmers, that these beaches record stable conditions of land and sea at the present time.

PLACER GOLD ON MEULE CREEK, SEIGNIORY OF RIGAUD-VAUDREUIL, QUEBEC.

(*Joseph Keele.*)

Introduction.

Placer gold mining was carried on in the Chaudière River valley during many years, the most active period of mining operations being included between the years 1863 to 1878. The Chaudière river is a northwesterly-flowing tributary of the St. Lawrence, heading near the Quebec-Maine boundary and joining the St. Lawrence not far above Quebec city. The gold-bearing territory, known as the Beauce gold district, borders the middle third of the river valley. Some of the ground was very rich, the Gilbert river, one of the principal tributaries of the Chaudière, for example, yielded nearly $2,000,000 in coarse gold in a distance of 2 miles, the gold being taken out principally by open-cut work. Much of the ground in the district though it carried good pay could not be profitably worked by individual miners, on account of the great thickness of over-burden lying on bed-rock—where mostly all the gold was found—the presence of underground water, and the large size of the boulders frequently encountered in the workings. Mining operations, however, were carried on until 1896, but were mostly unprofitable during this later period.

Recently a Montreal syndicate operating under the name of the Champs d'Or cie Rigaud-Vaudreuil, have acquired the mining rights on the territory known as the seigniory of Rigaud-Vaudreuil, comprising an area of 70,000 acres, and covering a great portion of the Chaudière valley and its tributaries, including Gilbert river. Prospecting was begun early in 1910 on Gilbert river, River des Plantes, Bras river, and Meule creek, using Keystone and Empire drills for piercing the gravels. As the prospects and water supply were favourable on Meule creek, the work of installing an hydraulic plant was begun there during the winter of 1910-11.

Only a few days were spent by the writer in this field, so that the following descriptions are incomplete.

A summary of the former mining operations carried on in this region was published by the Geological Survey in 1898.[1]

Geographical and Geological Sketch.

The region that includes the gold fields is a dissected plateau lying northeast of the more hilly portion of southern Quebec, and has a general elevation of 1,200 to 1,500 feet above sea-level.

The Chaudière river traverses the region in a northwesterly direction; it occupies a valley of considerable dimensions, and carries the drainage of the gold district into the St. Lawrence river, its mouth being about 8 miles above the city of Quebec.

The valley is underlain principally by grey and reddish Ordovician slates. These slates are penetrated by narrow bands of basic igneous rocks, which recur at intervals of one-half to 1 mile.

The wider parts of the valley occur where the comparatively soft slates have been eroded by the river, and the contractions are formed where the harder igneous bands project as spurs from each side of the valley walls. The valley is apparently an ancient one, as the river for the greater portion of its course flows without change

[1] Chalmers, R. Surface geology and auriferous deposits of southeastern Quebec.

in grade over hard and soft rocks alike. A mantle of unconsolidated material principally of glacial origin, is nearly everywhere present.

The valley of the Chaudière is rather thickly settled, and all the bottom lands and much of the side slopes are cultivated. Fairly extensive tracts of mixed timber still exist in the small tributary valleys, and on the upland, a quantity of pulp wood being produced annually from them.

The Quebec Central railway crosses the valley of the Chaudière at Valley junction, situated 43 miles southeast of Lévis, the railway's terminal point on the St. Lawrence. A branch line of this railway extends up the valley of the Chaudière from Valley junction for a distance of 56 miles.

The only mining now being done is on Meule creek, a tributary of Mill river, which enters the Chaudière opposite the village of Beauceville, 12 miles south of Valley junction.

The prevailing bed-rock seen in the creeks is composed of dark grey or red slates of Ordovician age. The cleavage of the slates is the most pronounced structure of these rocks, and is parallel to the bedding planes. The beds are also traversed, irregularly, by numerous joint planes at various angles to the cleavage. On weathering, the rock breaks down into thin slabs, wedge-shaped fragments, and splinters.

The slates have been disturbed from their original attitude, and the beds are now in a vertical position.

The slate bed-rock is penetrated at intervals by dyke-like sheets of diabase of 100 feet in width or more. These intrusive sheets may have originally been injected as sills between certain beds of the sediments while the latter were in their original horizontal position, the whole being subsequently dislocated until the formation stood on edge, and the intrusive sheets asumed the appearance of dykes. Enclosed within the diabase sheets are bands of quartz porphyry or porphyrite, of irregular width. Whether the porphyrite originated from the same magma as the diabase, or has subsequently eaten its way up through it, could not be determined without more extended observations. Both the diabase and porphyrite have schistose phases, and show considerable alteration in places.

Veins, stringers, and kidneys of quartz are often locally abundant in the intrusive bodies, but are by no means a persistent feature in them. In certain parts of the district, quartz veins are found traversing the slates and other sediments.

A mantle of unconsolidated material, principally of glacial origin, is spread nearly continuously over the region. The thickest deposits of boulder clay appear to occur in the narrow valleys of the tributary streams, while terraces of alluvial sand, gravel, and clay border the main river.

Pre-glacial deposits of sand, gravel, and clay overlying the bed-rock are still preserved on some of the side streams. These pre-glacial beds are of no great thickness, they are overlain by thick deposits of glacial drift, and their presence is only revealed during mining operations.

Mining.

Meule creek is a small stream flowing in a narrow valley of rather steep grade, with heavily timbered side slopes. The gold is mostly all found on bed-rock, so that mining operations involve the removal of the overlying materials, and the hydraulic method is here used for moving these alluviums.

The workings in August, 1911, consisted of an open pit, made on the right limit of the creek, about half a mile above its junction with Mill river. At the time of the writer's visit, the operations preliminary to a clean up were being made after a month of hydraulicking. The plant in use is the first of its kind to be installed in this gold field, so that the results obtained from it are awaited with great interest.

Water for the monitors is obtained from Lake Fortin, a sheet of water which measures 1½ miles, by three-fourths of a mile in its extreme dimensions. A ditch nearly 7 miles long, of which distance about 4.500 feet is flumed, brings the water to a penstock, from which starts a rivetted steel pipe 18 inches in diameter tapering to 15 inches. At a distance of 1,400 feet from the penstock this pipe branches into two 10 inch lines, each 500 feet long, terminating in monitors or giants. One of these giants is used for cutting down the bank of gravel, and the other for driving the gravel through the sluice to the elevator pit, the fall from the penstock to the monitors being 260 feet.

The sluice leading from the hydraulic pit is about 100 feet long, and about 3 feet wide, and is floored with steel rails laid longitudinally.

At the end of the sluice a bucket elevator, equipped with a stacker, has been installed to handle the tailings and to save whatever gold was not caught in the sluice.

The tailings are raised 40 feet by the chain of buckets, each of which has a capacity of 1½ cubic feet. The buckets deliver the tailings into an elevated sluice, and the material is driven through it and stacked by a powerful stream of water supplied by a centrifugal pump electrically driven, having a capacity of 6,000 gallons a minute. Power is supplied from a steam-power house built near the railway station at Beauceville; it is transmitted to the field of operations by a copper transmission line, 8,000 feet long, at a voltage of 2,200, which is reduced by a transformer to 440 volts.

Many large boulders, too heavy to be moved by the giant, become concentrated in the bottom of the pit as hydraulicking proceeds. These are moved to one side and piled with a derrick, the power for this purpose being supplied by a Pelton wheel driven by a water jet.

The timbering of a shaft and drift are revealed at the bottom of the bank at the upstream end of the hydraulic pit. These are the remains of the old workings of Coupal, who operated here on a small scale in 1896.

The overburden is heavy on the south side of the pit as the bank rises on this side and forms the lower part of the valley slope. The section revealed in this bank consists of 1 to 4 feet of yellow gravel and clay lying on bed-rock; above this and showing a fairly distinct unconformity with it, is 25 feet of blue boulder clay. Above the boulder clay is 10 feet or so of slide material, which is an unsorted mass of loamy clay, gravel, and rock fragments which has crept down the valley slopes.

The yellow gravel lying on bed-rock is composed chiefly of fragments of slate and diabase mostly angular, but with some well-rounded pebbles; this material is all in small pieces, none being over 6 to 8 inches in diameter, and all derived from the drainage basin of the creek. These gravels are mixed with a highly plastic, smooth, yellow clay, which is very different in colour and texture to any other clay found in the vicinity, either in the boulder clay or the later stratified clay of the river terraces.

These yellow gravels are probably remnants of pre-glacial or Tertiary accumulations, which, owing to their protected position in the bottom of narrow stream channels, escaped total destruction by the advancing ice-sheet during glacial times.

The boulder clay, which is the direct glacial contribution to the drift, is a mixture of pebbles, chiefly well worn and smooth, of diabase, porphyry, slate, granite, gneiss, and occasional fragments of serpentine. Boulders and blocks up to 3 and 4 feet in diameter are encountered in this deposit, the whole being bonded by a very compact gritty clay. Portions of this deposit do not break down very readily under the stream from the giant and have to be blasted.

The bed-rock surface exposed in the bottom of the pit shows the greater part to be dark grey slates of rather fresh appearance, having their cleavage running in the same direction as the flow of the stream. The slate is well-jointed in a direction across the flow of the stream, but the principal crevices are found in the cleavage planes. The gold is found wedged into these crevices to a depth of a foot or two.

There is a portion of a band of diabase and porphyrite, partly decomposed and crumbling, exposed along the north side of the pit; it forms a tighter bed-rock than the slate, and does not allow the gold to penetrate so far.

The bed-rock surface where cleared up is very uneven, ridges of the harder parts standing up a foot or so above the more weathered portions. The yellow clay was found to have been forced into the larger crevices and had to be removed by hand-picking, as owing to its smooth and sticky qualities the stream from the giant was unable to tear it out.

The hydraulic pit measured about 200 feet long by 100 feet wide, and the area of bed-rock cleaned up after one month's hydraulicking, was about 17,000 square feet. Of this area about one-third was said to have been worked out by Coupal, leaving an area of virgin ground amounting to 11,300 square feet.

The amount of gold recovered from this area is reported to be $7,500, or an equivalent of about 70 cents to the square foot of bed-rock. The amount of dirt moved amounted to 16,600 cubic yards, which would give 45 cents to the cubic yard.

The yellow gravels are said to contain some gold, but there is no doubt that the greater portion is on bed-rock, so that it is obvious that the less overburden to be removed, the more profitable the mining operations.

The black sand resulting from the final washing of the gold consists mostly of grains of magnetite. The quantity of fine gold carried over into these concentrates is so large that it might be worth while to install a small magnetic separator for its recovery.

Origin of the Gold.

The gold so far found on Meule creek is all coarse, and varies in size from nuggets worth $150 to grains about the size of the head of a pin, but a considerable portion is about the size of flaxseed.

The gold is very smooth, many of the particles are flattened, and show signs of wear by prolonged attrition. There are a few rough pieces of gold, some with quartz still adhering to them, but these can be explained on the assumption that they had not been long enough released from a quartz fragment to become worn smooth.

The well worn appearance of the gold is generally supposed to indicate that it had travelled from some far distant source, and had suffered much abrasion from being transported by water in company with the usual alluvial material, but this, however, is not always the case with placer gold, as it may have a local source and still present this worn appearance.

The origin of the gold is obscure, as it seems to have no connexion with the bed-rock on which it lies. Locally the slates contain small cubes of iron pyrite, but no mineralization was observed in the intrusive portions. A large number of assays made from the quartz veins and intrusive rocks of this district, in former years, gave only small quantities of gold or none at all.

Various speculations have been made regarding the origin of the gold of the auriferous gravels. Logan and Hunt, the earliest investigators in the field, believed the original source of the gold to have been the so-called Pre-Cambrian crystalline schists of the district, and that from there the gold was set free during processes of degradation and laid down with the Cambrian and Ordovician sediments to be afterwards concentrated and eventually deposited with the gold-bearing gravels. Other investigators have endeavoured to connect the origin of the gold with that of the dyke-like igneous bodies found traversing the sedimentary strata of the region. Dresser has suggested that the gold of the placer deposits may have been directly derived from the basic igneous rocks (the Pre-Cambrian of Logan and Hunt) with which are associated the numerous copper deposits of the region which carry small values in gold.

An alternative hypothesis is that the gold originally existed in rich bunches of quartz stringers or kidneys in the intrusive rocks, but at a much higher level than where it is now found. These rich quartz kidneys were eroded down, but their gold content was left behind and concentrated in the drainage channels.

Owing to its gravity, coarse gold soon drops out of the current, and remains behind, while every particle of the rocks which originally contained it is eventually carried away.

The horizontal movement of gold lying in such a bed-rock as the creviced slates of Meule creek is very small, the vertical downward movement as erosion proceeds is the principal one.

The gold while passing downward during the various stages of erosion, becomes pinched and flattened in bed-rock cracks, is subjected to all manner of abrasion from the wash gravels, and is probably found now at not more than a few thousand feet in a horizontal direction from its source. But during this time it may also have travelled 1,000 feet or more in a vertical direction, which would be the principal factor in giving the gold the well-worn appearance which it now presents.

Prospecting.

In future operations in this field a considerable portion of the mining costs are to be charged up against prospecting, as the old reports on the district indicate that the ground is "spotted," or in other words that the "leads" or paystreaks are not continuous.

If the gold originated in veins in the intrusive rocks, and if the rich veins were bunched in certain parts of the intrusive, while the greater part of it was barren, then the breaking down of such rocks would give rise to spotted ground. If the gold originated in these intrusive rocks, then the most probable places to repay prospecting would be on the downstream side of these rocks.

The bottoms of the narrow valleys of the tributary streams generally contain the richest concentrations of gold on account of the restricted area in which the gold accumulates.

There is a prevalent opinion that the valley bottom of the Chaudière must contain considerable gold, but this has not been proven, as the few shafts sunk there did not reach bed-rock on account of too much underground water.

The side streams do not contribute very much to the gold values in the main rivers, and in many cases the paystreaks on the tributaries do not reach down to the main valley at all.

All the gold that is liable to be in the main river valley may be restricted to whatever that stream itself has broken down from quartz veins which it traversed in its course.

The amount of gold-bearing veins broken down would probably be much more than those of the side streams, but the area of bed-rock over which the gold would be distributed in the main valley would be large.

Very little gold, only amounting to a few fine colours to the pan, is found in the boulder clay. The paystreak in any stream in the district, if it existed, was always found on bed-rock below a variable thickness of yellow gravel and clay, which are pre-glacial.

The extent and distribution of the yellow gravels throughout the region is unknown. Since they are always covered with a varying thickness of loose overburden, of a widely different character, their presence is only revealed in mining operations or by borings. So far, they have always been found resting on bed-rock, and in some cases they are actually composed of fragments of weathered and rotted bed-rock in situ.

They are generally regarded as being of pre-glacial age for the following reasons: (1) They contain no material having a source outside the drainage basin in which they occur; (2) no foreign material has been found underlying them; (3) they are overlain and sharply divided from deposits of glacial drift, or later stream gravels largely derived from the drift.

During some of the earlier prospecting in this field, the glacial drift was found resting on bed-rock, and, when this occurred, the gold was either absent or did not occur in paying quantities.

Whenever prospecting is carried on by means of the Keystone drill, the yellow gravels may be used as a guide. If hard rock is encountered, without having pierced the yellow gravels, it may probably prove to be a large boulder, and it would then be advisable to move the drill a short distance away.

No benches or rims of bed-rock at a higher elevation than the present streams, and carrying gold-bearing gravels have ever been located. Mr. Wm. P. Lockwood, who spent thirty years in prospecting over a great portion of this district, is of the opinion that no high-level, gold-bearing gravels exist here.

It may be noted in this connexion that remnants of old channels or terraces at high levels on the valley slopes would suffer greatly from erosion during glacial times, and that the gold in the boulder clay may be derived from that source.

Dredging in the wide flats at the mouths of tributary streams is proposed for this district. Before commencing operations of this kind, the ground should be thoroughly prospected with an Empire or other similar make of drill. The principal obstacles to the success of dredging here, will be the presence of large boulders, and the difficulty of recovering a great deal of the gold, if present, from the deeply-creviced bed-rock.

GEOLOGY OF THE MONCTON MAP-AREA, WESTMORLAND AND ALBERT COUNTIES, NEW BRUNSWICK.

(*G. A. Young.*)

Introductory.

Because of the development taking place in the Stony Creek gas and oil field, situated about 8 miles south of Moncton, N. B., the writer was instructed to commence geological field work on an area embracing the petroleum field, and also the city of Moncton on the north, and, on the south, the gypsum quarries of Hillsborough and the oil-shale area of Albert Mines. In order that the origin of the important gypsum deposits of Hillsborough might be more fully treated from a chemical standpoint, Mr. H. E. Kramm was associated with the writer and devoted considerable time to the study of the deposits in the field. During the progress of this special investigation, it became apparent that for the proper solution of various problems raised, it would be desirable that Mr. Kramm visit some of the other gypsum deposits of the Maritime Provinces and, accordingly, with the sanction of the Director, he did. A summary report dealing with the results obtained by Mr. Kramm in his study of the gypsum deposits is appended. The writer, under instructions from the Director, also extended his field of operations beyond the district primarily being studied, and visited a greater part of the area over which the Albert oil-shales are known to outcrop. During the progress of field work, the writer was ably assisted by Mr. M. F. Bancroft.

While in the field, the party received favours from many persons. The writer wishes to acknowledge his particular indebtedness to Mr. M. Lodge, of Moncton, and to Mr. O. P. Boggs and other officials of the Maritime Oilfields Company, and, on behalf of Mr. Kramm, to Mr. C. J. Osman, managing director of the Albert Manufacturing Company.

Location and Area.

The Moncton map-area lies in southern New Brunswick; it is about 18 miles long in a north and south direction, about 12 miles broad in an east and west direction, and embraces a rectangular area of about 230 square miles. The northern boundary of the district lies just north of Moncton, while the southern passes about 5 miles south of Hillsborough; the eastern boundary lies about 2 miles east of Hillsborough, while the western passes just west of the upper waters of the west branch of Turtle creek.

The map-area is traversed from north to south by the Petitcodiac river which empties into Shepody bay, one of the two northeasterly-extending prolongations of the Bay of Fundy. Moncton and Hillsborough, the two chief centres of population of the district, are situated on the Petitcodiac; Hillsborough lying to the south almost in sight of the mouth of the river, while Moncton is situated to the north where the Petitcodiac, after flowing from its source in a general easterly direction, bends sharply and flows southward to the Bay of Fundy.

Previous Work.

The Moncton map-area includes part of two geological map-sheets—No. 1, N.E., Grand Lake Sheet, and No. 4, N.W., Cumberland Coal-field Sheet—both on a scale of 4 miles to 1 inch. The geology of the area represented by the Grand Lake Sheet is described in a report by Messrs. Bailey, Matthew, and Ells in the Report of Progress of the Geological Survey for 1878-79; the geology of the Cumberland coal-field map-area is described in a report by R. W. Ells, forming part E of the Annual Report, Vol. I (new series), of the Geological Survey. Various phases of the geology of the Moncton map-area are treated in Summary Reports of the Geological Survey, in Dawson's Acadian Geology, and elsewhere. Two reports have been issued dealing with the oil-shales of the Moncton map-area and adjoining districts. The first of these, by L. W. Bailey and R. W. Ells, appeared as part of the Report of Progress of the Geological Survey for 1876-77; the second, by the late R. W. Ells, was, in 1910, issued jointly by the Mines Branch and Geological Survey.

Physical Features.

As regards its physical features, the Moncton map-area presents a considerable diversity since within it are portions of two contrasting physiographical provinces. One of these, the Carboniferous Lowland, forms the greater part of the southeastern half of the Province of New Brunswick and extends into Nova Scotia. Over this lowland area, the country seldom rises higher than from 200 to 300 feet above the sea, and for the most part is only gently rolling. The second physiographical province is that which may be called the Caledonia Upland, an elevated tract of country fronting on the Bay of Fundy and stretching northeasterly from near St. John city almost to the mouth of Petitcodiac river. Over considerable portions of this upland, the surface is comparatively level with general elevations of over 1,000 feet above sea-level. These two physiographical provinces were regarded by R. A. Daly as representing, in part, two peneplains: that of Caledonia mountain was supposed to be of Cretaceous age, while the Carboniferous lowland was thought to be of Tertiary age.[1]

In the Moncton map-area, the Carboniferous lowland is best exemplified in the neighbourhood of Moncton where the country is low and broken by gently-rolling slopes whose summits rise from 100 to 300 feet above sea-level. On the other hand, in the extreme south of the map-area, the northern edge of the eastern end of the Caledonia upland is represented by an elevated tract of country whose summit levels rise between 1,000 and 1,300 feet above sea-level. This border portion of the upland is broken and trenched by water courses, and its northern boundary, at many points, is marked by a series of relatively deep, east and west trending valleys.

Viewed from a commanding situation either in the lowland or upland area, the two physiographical provinces seem to be sharply divided from one another. When the country is traversed, however, or when a topographical map of the area is examined, it is found that, in reality, the two types of country merge one into the other. For instance, proceeding southwesterly from the Carboniferous lowland about Moncton, the summit levels of the country rise gradually higher and higher in the form of broad, relatively flat-topped hills penetrated and separated from one another by the valleys of minor streams, until, finally, about 15 miles south of Moncton the rolling top of Caledonia mountain is reached where the general level is about 1,000 feet higher than that of the neighbourhood of Moncton.

General Geology.

General Statement.

The greater part of the Moncton map-area is floored by Carboniferous sediments ranging in age from Millstone Grit or mid-Carboniferous, to very early Carbonifer-

[1]Daly, R. A. The Physiography of Acadia; Harv. Coll., Mus. Comp. Zool., Bull., Vol. XXX, pp. 73-103, 1901.

ous as represented by the Albert series. Some writers have preferred to place the Albert series in the Devonian, but the palæontological evidence[1] favours the assumption that the series is of very early Carboniferous age rather than very late Devonian age. Of these Carboniferous measures, the younger strata, as represented by the Millstone Grit and immediately underlying measures, occur in approximately horizontal, unfaulted attitudes, while the older beds in many places, are faulted and tilted at various angles. The Carboniferous strata comprise a wide range of sedimentary types—conglomerates, sandstones, shales, limestones, and gypsum of varying compositions, colours, etc.—but all are relatively unaltered and in no instance were they observed to be penetrated by igneous bodies.

In the southwestern part of the map-area, over the included part of Caledonia mountain, an entirely different set of rocks outcrop. These appear to be largely of igneous origin, and at many localities have a schistose structure and present other characteristics indicating that they have been greatly modified in attitude and appearance. The original rock types appear to have been mainly volcanic varieties, both massive and fragmental, and both acid and basic, but dyke-like bodies of granite and diabase are also common. The plutonic rocks, as developed in the district, form relatively small bodies, but, to the west of the map-area, within the limits of the Caledonia upland, plutonic rocks—granite, diorite, etc.—have been described as forming large bodies, and true sediments—slates, crystalline limestones, etc.—have been noted at various places.

For the present it is proposed to apply to the rock complex forming Caledonia mountain, the term, Caledonia group. The rock assemblage is undoubtedly older than Carboniferous, and the rocks were deformed before the deposition of the Carboniferous measures, since representatives of the various rock types may be recognized as making up the conglomerates and other coarse detrital rocks of the bordering, in part, overlapping Carboniferous strata. The Caledonia group, in various preceding reports has been classed as belonging to the Pre-Cambrian, but in the present report, it is proposed to return to an older usage and to refer to it as being pre-Carboniferous since it seems not improbable that early Palæozoic sedimentary and igneous rocks may form an integral part of the rock complex.

TABLE OF FORMATIONS.

Carboniferous	Millstone Grit group
	(unconformity)
	Intermediate group
	(unconformity)
	Albert series
	(unconformity)
Pre-Carboniferous	Caledonia group.

(The group names in the above table are provisional only.)

SUMMARY DESCRIPTION OF FORMATIONS.

For various reasons, it seems inadvisable in the case of this report, to enter into a detailed description of the geology of the district except so far as is necessary to give some idea of the conditions under which petroleum and natural gas have been found.

Caledonia Group.

The modes of occurrence and distribution of the various members of the pre-Carboniferous, Caledonia group, do not seem to have had any bearing on the occur-

[1] Lambe, L. M. Palæoniscid Fishes from the Albert Shales of New Brunswick; Canada, Dept. of Mines, Geol. Surv., Memoir No. 3, 1910

rence of crude oil and natural gas in the Carboniferous strata except, that since the rock complex forming Caledonia mountain may have acted as a unit block during periods of folding and faulting, it may thus, in part, have guided the actions of these deforming forces and so, indirectly, influenced the formation or accumulation of the hydro-carbons. The pre-Carboniferous complex of Caledonia mountain appears to represent a part of the rim of the ancient basin in which were deposited the Carboniferous measures of New Brunswick.

Albert Series.

The oldest member of the Carboniferous system in the district is the Albert series, a group of thinly bedded, usually dark coloured slates, calcareous slates, limestones, and sandstones. Enclosed in the above strata, whether or not at more than one general horizon has not yet been determined, are slate beds relatively rich in hydro-carbons and of a distinctive appearance. These, so-called, oil-shales when retorted yield varying amounts of crude oil and nitrogen—about 27 to 56 imperial gallons of crude oil, and about 30 to 112 pounds of ammonium sulphate per ton.[1] In these oil-shales and associated beds, in places, are numerous remains of fishes of the genus palæoniscus.[2] The hydro-carbons of the shales or slates are present, at least partly, in a solid state, forming a substance that in appearance resembles albertite, but, whatever the present state of the hydro-carbons may be, there are grounds for believing that they are essential, original constituents of the shales, that the oil-shales do not represent beds that have been saturated with oil originating outside of the shales and absorbed by them.

Former estimates of the total thickness of the Albert series have given amounts in the neighbourhood of 850 feet or, if certain conglomerates are included in the series, of 1,050 feet. This estimate seems to be too low, for wells lately drilled in this series, in the Stony Creek district, have penetrated a thickness of this strata of 1,800 feet without passing through the Albert measures which it is assumed are there approximately horizontal.

The Albert measures are exposed in a few, relatively small, isolated areas in the southern portion of the Moncton map-area. They outcrop along the flanks of Caledonia mountain in the southwestern corner of the district in the main and tributary valleys of the east and west branches of Turtle creek. The strata are exposed farther east over a small area about Albert Mines in the southeastern part of the map-area; they may also be seen farther north, just south of Stony Creek, for a limited distance along the western bank of the Petitcodiac river; and again, to the southeast of that locality, on the east side of Petitcodiac river in the valley of Downing creek.

The above-mentioned areas of the Albert series belong to a succession of similar areas occurring at intervals over a narrow zone of country, rarely more than 4 miles broad, that passes through the Moncton map-area and extends in an east and west direction for at least 30 miles—from beyond Elgin on the west to past Taylorville on the east. To the west of Elgin, strata occurring in rather widely separated areas have also been recorded as belonging to the Albert series.

The Albert series as exposed in the southwestern area about the head-waters of Turtle creek, has a general northerly dip at angles varying from 5° to 30°. In the Albert Mines area, the strata form a rather tightly compressed anticlinal fold, and in places, are vertical. As exposed along the shore of the Petitcodiac south of Stony Creek, the measures appear to be exposed along a section transverse to a flat anticline. Over the area to the southeast, in Downing Creek valley, the structure is not

[1] Ells, R. W. Bituminous or oil-shales of New Brunswick and Nova Scotia; Part I, p. 17; Canada, Dept. Mines, 1910.

[2] Lambe, L. M. Palæoniscid Fishes from the Albert Shales of New Brunswick; Canada, Dept. Mines, Geol. Surv., Memoir No. 3, 1910.

so apparent; the outcrops there seem to belong to a series of neighbouring, in part separate, areas found to the south and also to the east in the valley of Memramcook river, in which, though in some places the measures form flat anticlines, in others they are faulted and tilted in various directions at comparatively steep angles. West of the Moncton map-area, the Albert series, as exposed at intervals as far west as Elgin, in some places has a gentle dip in a uniform direction while in others, the effects of powerful disturbing forces are apparent.

In connexion with the description of the Albert strata, mention may be made of the occurrence of the substance or mineral, albertite, as found in and adjacent to the limited area of the Albert series exposed at Albert Mines. Albertite, by many authorities classed with the asphalts and supposed to be a solidified form of petroleum, is a black substance, having a conchoidal fracture and a hardness of about 2 on the ordinary scale of hardness. It is easily fusible and readily ignites in an ordinary flame. It is essentially composed of hydrogen and carbon with about 3 per cent of nitrogen, 2 per cent of oxygen, and a trace of sulphur. The mineral occurs filling fissures, usually narrow, not only in the Albert series but in strata of the Millstone Grit and Intermediate groups. Most of the reported occurrences of such veins have been within a radius of a few miles from Albert Mines, but one occurrence, many miles to the westward, has been recorded. The only large vein of albertite ever discovered was found cutting the Albert strata at Albert Mines and has been worked out long since. This vein, it is said, was mined over a distance of about half a mile and to a depth of 1.100 feet or more, beyond which it became too narrow to be profitably worked. The vein was nearly vertical and followed an almost straight course along the general direction of an anticlinal axis in the country rock, but varied in width up to 15 feet and sent apophyses into the adjoining strata.

Intermediate Group.

In certain cases, at least, the areas of Albert series are bounded by faults. In other cases, the strata of this series disappear beneath members of the younger Carboniferous divisions that for convenience in this report are referred to as forming the Intermediate group. This group may be defined as including all the Carboniferous measures between the Albert series and the base of the Millstone Grit group. A final decision concerning the succession and contents of the various divisions forming the Intermediate group has not, as yet, been made. The following statements, therefore, are intended to be only provisional.

The strata of the Intermediate group together with those of the Albert series, floor the narrow zone of country already referred to as stretching for about 30 miles from Taylorville on the east to beyond Elgin on the west, these two points being situated, respectively, east and west of the limits of the Moncton map-area. This zone is bounded on the north and east by the overlapping Millstone Grit group. The southern boundary of the zone, over the greater part of its course, is formed by the pre-Carboniferous complex of Caledonia mountain, but in the east, the area of the Intermediate group is prolonged beyond the limits of the district, first southward and then westward, around the end of Caledonia mountain.

What appears to be the lowest division of the Intermediate group holds as a characteristic member, a considerable thickness of red strata that in composition vary from an argillite to a limestone, are generally of bright brick-red colour but in many places are splotched or banded green, and in many localities lack distinct signs of bedding. With these rocks are associated reddish sandstones and conglomerates and, perhaps, grey and dark grey limestones and siliceous beds. Strata, such as the above, are exposed on Weldon creek and its tributary, Peck creek.

A second division of the Intermediate group, younger than the above, consists of coarse, heavily-bedded conglomerates and sandstones overlain by dark grey, thinly-bedded limestones which in places, as near Hillsborough, are capped by a considerable volume of anhydrite and gypsum.

A third, still younger member of the Intermediate group, is made up essentially of red conglomerates and sandstones succeeded by red and green argillites and argillaceous limestones.

The total thickness of these three divisions must surpass several thousand feet, but at present it seems inadvisable to attempt to give a definite statement regarding their thickness, especially as there is good ground for believing that the various series are only partially represented in the Moncton map-area.

The strata of the Intermediate group, like those of the older Albert series, in places lie with high angles of dip; in other localities they are nearly horizontal, and in such cases different divisions may appear to succeed one another conformably, as if without a break, although there is indirect evidence to indicate that prior to the deposition of each succeeding division, the strata of the immediately underlying division had been eroded in no inconsiderable degree.

Millstone Grit Group.

Younger than the Intermediate group, is an assemblage of strata usually classed as forming the Millstone Grit formation, but which in this report is provisionally considered as forming a group. These measures have already been described as forming the northern and eastern boundary of the zone of the Intermediate group and the Albert series that laps around the pre-Carboniferous rock complex of Caledonia mountain. The Millstone Grit rocks floor the greater part of the Moncton map-area and extend continuously over a large part of New Brunswick.

Unlike either the Intermediate group or the Albert series, the Millstone Grit group seems to represent a period of continuous deposition and, in a striking fashion, the strata seem to have escaped the action of any pronounced earth movements and still lie almost horizontally, the beds forming wide arches whose limbs seldom dip at higher angles than 5° or 10°. The only observed exception to this general horizontal attitude of the measures, was at Dorchester, east of the Moncton map-area, where, over a considerable area, the Millstone Grit beds have an angle of dip of from 15° to 25°.

Although there is every reason for believing that prior to the deposition of the Millstone Grit strata, the older Carboniferous beds were severely eroded, and had passed through periods of at least locally pronounced earth movements, yet at a number of localities there is little or no direct evidence of such having been the case, and at different points the Millstone Grit strata seem to regularly and conformably succeed different divisions of the Intermediate group and even of the Albert series.

The strata of the Millstone Grit group are, in general, of the nature of quartzose sandstones and conglomerates; shales occur, but not nearly so abundantly as the other varieties. Over wide areas, the rocks are uniformly light-coloured, usually light yellow, but in some areas, beds with a more or less pronounced red colour are abundant.

To the writer, it appears that the strata of the Millstone Grit group are naturally divisible into at least two divisions. The higher of these two divisions consists of a quartz conglomerate overlain by a quartz sandstone. Both types of rocks are light-coloured, weathering yellow. The conglomerate is usually crowded with smooth, rounded pebbles of white and variously tinted quartz lying in a sandy, in part, calcareous base. This conglomerate with its distinctive characters, and the overlying sandstones, were noted at various points within the Moncton map-area. The same conglomerate, or a very similar one, has been described as being present at many places over the wide extent of the Carboniferous area of the Maritime Provinces.

Whether in all cases the strata belong to the same horizon is not apparent, but, in the Moncton map-area and adjoining districts, it is believed that the conglomerate always marks the same horizon.

At some places, as at Hopewell cape, the above conglomerate may be seen resting directly on a division of the Intermediate group, but in other cases of which, perhaps, the best examples are found outside the limits of the Moncton map-area, there is interposed between the base of the Millstone Grit quartz conglomerate and the top of the underlying strata of the Intermediate group or the Albert series, as the case may be, an assemblage of sandstones and argillaceous beds that seem to form the lower division of what, in this report, has been termed the Millstone Grit group. This lower division, as developed more particularly in the districts immediately east of the Moncton map-area, seems to occur filling depressions—old valleys formed by the active erosion preceding the Millstone Grit period. The strata of the lower division may be described as having levelled the ancient, pre-Millstone Grit surface preparatory to the laying down in a practically continuous sheet, of the quartz conglomerate of the upper division of the Millstone Grit group.

The lower division of the Millstone Grit group, as above defined, shows a considerable variation in lithological characters. In some places the beds are largely of pale grey, rather fine-grained sandstones with only occasional red beds. In other places, as exposed on Stony creek, the strata comprise quartz conglomerates, coarse and fine, light-coloured sandstones, and red and green argillaceous and calcareous shales.

In the northern half of the Moncton map-area, rock exposures are very scarce and no definite conclusion has yet been reached as to what formations are there represented. A very few outcrops of the characteristic quartz conglomerate of the upper division of the Millstone Grit were seen, but elsewhere were found various reddish sandstones, red shales, and red argillaceous limestones that probably belong either to the lower division (as defined above) of the Millstone Grit group or to a third and higher division overlying the grey quartzose conglomerate, but possibly in part or in whole, may belong to divisions of the Intermediate group.

The thickness of the Millstone Grit group varies. The greatest thickness of the strata of the upper division as found in the territory examined was not above a few hundred feet. The lower division from its mode of occurrence—filling up depressions in the pre-Millstone Grit surface—is wanting in places, in others is very thin, and in other instances may have a thickness of several hundred feet. On the whole, it is not believed that the strata of the Millstone Grit group as developed in the territory under review, anywhere attains a thickness comparable with that found in various districts of Nova Scotia, and that, in general, the Millstone Grit beds form a comparatively thin mantle resting on and covering the variously disturbed and eroded members of the older divisions of the Carboniferous system.

Economic Geology.

Information relative to the important gypsum deposits of Hillsborough is given in the appended report of H. E. Kramm. Accounts of other economic deposits, such as the bog manganese of Dawson Settlement, are deferred to the final report. The possibilities in connexion with the establishment of an oil-shale industry in the region have been dealt with by the late R. W. Ells in a recent report,[1] and need not be more than incidentally referred to in this report. It is proposed, however, to briefly outline some of the main points in connexion with the history and results obtained by various companies that have engaged in the production or search for crude oil and natural gas within the Moncton map-area and adjoining districts.

[1] Ells, R. W. Bituminous or oil-shales of New Brunswick and Nova Scotia; Canada, Dept. of Mines, 1910.

PETROLEUM AND NATURAL GAS.

History of Development.

Some time between 1854 and 1856, Abraham Gesner, at one time provincial geologist of New Brunswick, noticed the oil-shales of the Albert series as exposed in the eastern part of the belt over which they occur and, by retorting them and re-distilling the product, he obtained a burning oil. Following this discovery, a company was organized to work the oil-shales of Taylorville and a refining plant was erected at St. John. Prior to this, however, in 1894, the substance albertite was found filling a large vein in the area of the Albert series at the locality now known as Albert Mines. After the conclusion of a series of law suits, during which the material was adjudged to be a coal, the deposit was actively exploited; and since albertite yielded from 130 to 135 gallons of oil per ton, while the oil-shales of Taylorville only gave about 35 gallons per ton, the enterprise of mining these oil-shales was abandoned. Subsequently, however, shipments of the oil-shales of Taylorville were made, and about 1862, a plant was erected on the upper portion of the east branch of Turtle creek, about 12 miles west of Taylorville, to treat the oil-shales there developed. With the opening up of the great oil-fields of Pennsylvania and elsewhere, practically all attempts at the mining of the oil-shales ceased. Of late years attention has again been attracted to the oil-shales of the Albert series; the previously unknown or unappreciated fact that under suitable treatment the oil-shales are capable of yielding not only crude oil but also sulphate of ammonia, making their economic development a possibility. The mining of albertite, unlike the mining of the oil-shales, proved to be a profitable industry and continued until about 1876, when the deposit, a true fissure-filling deposit and not a coal, was worked out and mining ceased.

The character of the oil-shales and the presence of albertite, together with other phenomena, naturally suggested to such as were acquainted with the region, that crude oil also might be present in the Albert strata. This idea was further strengthened by the fact that over the district lying south of Dover and between the Petitcodiac and Memramcook rivers, the early settlers were frequently annoyed by finding on their farms beds of maltha, in some cases covering acres to a depth of from 1 to 18 inches. These various phenomena being known, some time between 1850 and 1860, certain oil men from Pennsylvania became interested in the district and three shallow wells, the deepest not over 190 feet, were sunk in the Albert series. In each of the three wells small quantities of oil and considerable volumes of gas were found, but owing to lack of money the enterprise was abandoned.

In 1876 or 1877, interest was again aroused in the possibilities of the Dover-Memramcook field, and during the next two or three succeeding seasons, seven wells were drilled at various localities in the district. Six of these wells either started in the Albert rocks or else entered them after passing through a thin cover of younger strata. The seventh well, which proved to be a complete failure, was drilled entirely in strata younger than the Albert series. The wells were drilled to depths of from 1,000 to 1,900 feet, and in all, except the one above mentioned, considerable volumes of gas were found, and in the case of two wells, oil in considerable quantities was obtained, one well yielding at the rate of 20 barrels per day for some three or four days. For financial reasons this enterprise also was abandoned.

In 1901, the New Brunswick Petroleum Company began operations in the Dover-Memramcook district, and in the course of about five years drilled about eighty wells, most of which were located directly on outcrops of the Albert series or penetrated these rocks after passing through a thin cover of overlying strata. Most of the wells drilled were shallow wells sunk only to depths of between 300 and 600 feet, but, in all, the Company pumped from them between 9,000 and 10,000 barrels of oil.

In 1909, the Maritime Oilfields Company, the Company at present operating in the region, entered the field, first drilling a few wells east of the Petitcodiac, but afterwards confining their efforts to a district on the west side of the river just south of Stony Creek. Their first well in the Stony Creek field was drilled to a depth of 1,728 feet, mainly in the Albert series, and yielded oil at the rate of about two barrels per day and gas at the rate of about 300,000 cubic feet per day.

In all the Company has drilled twenty-two wells into the Albert series in the Stony Creek field, three of which were not completed, but all of the remaining nineteen yielded oil or gas. In 1910 the amount of oil pumped from the wells then completed was 1,485 barrels, but no effort has been made to develop the full capacity of the wells as oil producers since the great volumes of gas encountered warrants the treating of the field as a gas field. In the autumn of 1911 the Company had partly completed a pipe-line to Moncton, 8 miles distant, and hoped before the close of the year to be in a position to supply the town with gas fuel.

Figures are not at hand for a reliable estimate of the total amount of gas already available. From seven of the wells the total calculated yield, as derived from measurements made with a Pitot tube, was nearly 4,000,000 cubic feet per day, the closed pressures of the individual wells varying from 20 to 200 pounds per square inch. From the remaining twelve completed wells, varying results were obtained. One well had a closed pressure of 525 pounds, rising in three days' time to 610 pounds, and an estimated flow of 3,695,000 cubic feet per day; a second had a closed pressure of 475 pounds and an estimated flow of 8,893,000 cubic feet per day; and a third had a closed pressure of 560 pounds with an estimated capacity of 6,417,000 cubic feet per day. In these three cases, the volume was estimated from observing the rate of rise of pressure at minute intervals. As regards oil, in the case of one well, 60 barrels accumulated in 20 hours; from another after an interval of 7 days, 87 barrels were pumped; while a third gave an estimated yield of 40 barrels in 25 hours. The above figures have been taken from records furnished by the Company.

Stony Creek Field.

The present developments of the Stony Creek field are confined to an area about 2 miles long by 1½ miles broad, fronting on the west bank of Petitcodiac river and lying between Stony Creek on the north and Weldon Creek and its tributary, Hiram creek, on the south. Between the two creeks the land rises rather rapidly from the level of the tidal river, to a height of about 460 feet above mean tide, then gradually drops in a westerly direction for a vertical distance of about 200 feet to a transverse valley, beyond which it again gradually rises to above 400 feet above sea.

Four of the wells of the Maritime Oilfields Company are on the steep east front of the hill, the remaining nineteen are scattered over the top of the hill, the transverse depression, and beyond on the second rise.

Along the river front, at low water, strata of the Albert series are visible, apparently arranged in a flat anticline whose axis presumably strikes in a westerly direction. To the north, following westerly up Stony creek, are outcrops of gently dipping strata of what are regarded as the lower division of the Millstone Grit group. To the south, in the valleys of several minor streams and in those of Weldon creek and its tributary, Hiram creek, beds belonging to the Intermediate group are exposed; these measures in the neighbourhood of the wells are almost horizontal, a short distance south they are inclined at high angles. The top of the hill and the country to the west are believed to be floored by the upper portion of the Millstone Grit group. Thus the Albert series outcropping along the eastern base of the hill, extends westward into it, as shown by the borings, and is overlain towards the south by strata of the Intermediate group, towards the north by strata of the lower division of the Millstone Grit group, while in the area of the main hill, these two overlying divisions are themselves covered by the upper division of the Millstone Grit. The exposures indicate, in general, that the measures of all the divisions have relatively gentle dips.

The wells stand at elevations varying between 250 feet and 460 feet above sea-level, and in depth they range from 1,200 to 2,060 feet. After passing through a thickness of overlying formations usually amounting to about 350 feet, they enter the Albert series, of which a maximum thickness of 1,800 feet has been penetrated without encountering any signs indicating the approach of the base of the formation.

The strata of the Albert series, as found in the various wells, consist mainly of thinly-bedded, shaly beds, usually black or dark green in colour and varying in composition from an argillite to a limestone. Besides the shaly strata, fine-grained quartzose sandstones are comparatively common, the number of individual sandstone beds in a single well varying between 3 and ·15. In thickness the individual sandstone beds vary from a few feet to 100 feet or more. There is a rather general tendency for the sandstone beds to occur in groups, in a number of instances three such groups separated by intervals of from 150 to 350 feet of shales, being encountered in a single well. The aggregate thickness of a single group of sandstones may rise to 180 feet, but more often lies between 30 and 90 feet. The individual beds of a group of sandstones may be separated by shaly layers varying in thickness all the way from a few feet to 30 or more.

Though slight traces of oil or gas have been found in the shaly beds and, in one instance, in strata overlying the Albert series, the oil and gas are confined, practically, to the sandstone beds in the Albert series. In the case of one well which the drillers recorded as apparently passing through disturbed, broken strata, practically all the sandstones are free from oil or gas. In the producing wells, a small number of sandstone beds do not afford any trace of oil or gas. Usually the number of such dry beds is small in comparison with the total number of sandstone beds in a well; and the dry beds, as a rule, occur towards the top of the well, but such beds are also recorded as occurring beneath others with showings of oil or gas. Usually by far the greater number of the sandstone beds are recorded as at least showing oil or indicating the presence of gas, and in some of the wells, sandstone beds of two different horizons yield large volumes of gas.

In the case of about one-half of the number of the wells, all the sandstone beds (except such as are dry) of each well are recorded on the logs as being either all oil sands or all gas sands. In the remaining cases, oil and gas sands irregularly alternate or they occur in two groups of which, in some wells, the oil sands form the higher group while in others the gas sands form the higher groups.

In two wells, strong flows of salt water were recorded. In one case the salt water was struck near the bottom of the well, being first met in a 12 foot sandstone bed lying 68 feet below an oil sand that, with other immediately overlying sands, yielded oil at the rate of 5 barrels per day. In the second instance, after having passed through two sands, both giving indications of oil, and one giving a small show of gas, a salt water sand was struck at a depth of about 810 feet. This well was continued to a depth of 1,250 feet, and in the additional distance of 440 feet passed through four beds of sandstone with an aggregate thickness of 245 feet, but which were barren of oil or gas except in the case of the lowest bed which was said to give a "show of gas."

At present the study of the logs and samples of drillings of the wells is not sufficiently far advanced to permit of drawing deductions bearing on the general structure of the oil and gas-bearing strata, or on the question of the possible equivalency of the various sandstone beds of the different wells. Possibly, as certain lines of reasoning at least suggest, it may be found that the sandstone beds are of the nature of lenses.

Mode of Origin of Oil and Gas.

A consideration of the question of the possible extension of the area of the field or of the existence of other gas and oil-fields in adjacent regions, inevitably leads to the postulating of some mode of origin and method of accumulation for the crude oil and gas. In the present report it would be inadvisable to write at length on the subject or to review or attempt to weigh the various theories that have been propounded concerning the origin of oil and gas. The writer may only state that to him, the most satisfactory hypothesis concerning the origin of oil and gas in this particular field. is that which premises a common origin for the two and a derivation chiefly or wholly from the destruction of animal remains. It is also believed that world-wide experience has shown that, whatever the reason or reasons may be, oil and gas tend to accumulate near the axis of the anticlines or where sudden changes of dip occur in strata otherwise possessing a uniform dip, although instances are on record where the situation of accumulations of oil and gas seem to bear no reference to the structure of enclosing strata. A third assumption, perhaps involved in the preceding one, is, as experience has shown to be the case in many districts, that individual pools are usually much longer than broad and usually are grouped along rudely parallel straight or curving lines.

In describing the Albert series, the presence of oil-shales, rich in hydrocarbons and carrying numerous fossil fish remains. was pointed out, and it was stated that there were reasons for believing that the hydro-carbons are indigenous to the shales. Such conditions, or such assumed conditions, naturally favour the assumption that in the present case at least, the oil has been derived from organic remains and, probably, principally from animal remains.

Adopting the hypotheses and applying the assumptions made above, the conclusion is reached that the oil-shales proper and the associated dark shales, so characteristic of the Albert series, are the original source of the crude oil and gas now found in the oil and gas sands of the Albert series. In other words, it is concluded that the true home of the oil and gas accumulations is within the Albert series; this conclusion does not negative the possibility of oil or gas pools existing in some places in strata other than the Albert series since it is possible that parting or fracture planes, etc., may in places have afforded a channel whereby the oil or gas may have passed into other strata.

The above statement of conclusions is, perhaps, only a circuitous method of expressing the fact that, in New Brunswick, so far as experience goes, crude oil, natural gas, and oil-shales are confined to the Albert series.

Possible Existence of Other Gas and Oil-fields.

The extension of the Stony Creek oil-field or the finding of other oil-fields in this part of New Brunswick would, for the reasons outlined in the preceding section, depend on the distribution and extent of the Albert series; on whether the oil-shales and allied strata are co-extensive with the Albert series; and on the presence or absence of conditions favourable to the formation of pools.

Until the study of all available information is completed, it would be unwise to attempt to state how far these general conditions appear to be complied with in the case of the areas where the Albert series is actually exposed. It seems permissible, however, to put forward some generalized conclusions dealing with the possibility of oil or gas accumulations existing in regions adjacent to the Stony Creek field, but over which the surface rocks belong to the flat-lying Millstone Grit group and so effectually conceal the underlying strata.

The fact that the Albert series is known to outcrop at intervals over a length of more than 30 miles, and possibly over a much greater distance, and since, though locally closely folded, the strata on the whole have low angles of dip—indicating that through crumpling there has not necessarily been much narrowing of the original width of the basin of the Albert series—it seems not improbable that the strata or remnants of the strata may extend in a northerly direction beneath the covering of younger strata to a much greater width than the present outcrops show.

Furthermore, on the hill known as Lutz mountain lying a few miles north of Moncton, there are exposed tilted strata resembling the Albert series. Though from the lack of good exposures and the lack of fossil evidence it has not been possible to settle beyond doubt that these beds of Lutz mountain do belong to the Albert series, yet they may be held to furnish corroborative evidence indicating that the Albert series does extend at least that far north beneath the covering of Millstone Grit and other formations, and that the basin of the Albert series has a width of at least 25 or 30 miles.

As regards the extension of the Albert series in an east and west direction, the late R. W. Ells has recorded[1] his belief that the Albert series are the equivalents of certain strata exposed as far west as the neighbourhood of St. John city and possibly even farther west. If this correlation holds true it is also equivalent, in some measure, to setting a limit to the extension of the oil region in that direction, for there oil-shales no longer occur in the strata, but that the bituminous strata do extend beyond Elgin is indicated by the report long ago of the finding of small veins of albertite (solidified petroleum?) 30 miles southwest of Elgin. The possibilities of the extension of the Albert series to the east beyond the outcrops in the valley of the Memramcook, the last in this direction, can only be definitely determined by borings, since in that direction the Albert series disappears under a continuous mantle of Millstone Grit and overlying younger strata that extend to Northumberland straits. It would, however, be a rather remarkable coincidence if the eastern limits of the outcrops of the Albert series should also mark the eastern end of the basin of this series. It seems more probable that the Albert series does occur for some considerable distance to the eastward beneath the cover of younger measures.

There thus seems to be good grounds for supposing that the basin of the Albert series extends for at least 50 miles from beyond Elgin on the west to beyond the valley of the Memramcook on the east and, less certainly, that it has a width of at least 25 or 30 miles from the foot of Caledonia mountain northwards. Of course, during the periods of erosion in early Carboniferous time, the Albert series may have been swept away from a considerable part of this area once possibly occupied by it.

Granting that the Albert series was and is still present, though largely concealed, over a region as large or larger than the one rudely outlined above, it does not follow that oil-shales and the associated bituminous beds occur everywhere in the Albert series of this area. Not only may the richer bituminous shales have been removed by erosion from considerable areas, but also since the oil-shales possess rather exceptional characters, it is entirely probable that their distribution is more limited than that of the containing strata. There are indications that in a westerly direction, Elgin approximately marks their limit, for in the western part of the field the quality and amount of the oil-shales seems to decrease. On the other hand, the oil-shales of the Memramcook valley in the easternmost exposures of the Albert series, are as rich in hydro-carbons as any found elsewhere, and, therefore, it seems safe to assume that if the Albert series continues eastward beneath the there continuous covering of Millstone Grit and younger strata, the oil-shales will also extend eastward.

As to what are the conditions necessary for the accumulation of gas and oil in pools, other than the presence of the oil-shales and a suitable reservoir, it is difficult, if not impossible, to state. Doubtless an anticlinal or analogous structure and the absence of unsealed partings, fissures, and fractures, and other channels by which the oil or gas might be dissipated, are also necessary factors.

As to how far these conditions prevail in those areas where though the Albert series may exist it is hidden by younger formations, it seems impossible to say, and positive proof of the presence or absence of oil and gas can only be obtained by drill-

[1] Ells, R. W. Bituminous or oil-shales of New Brunswick and Nova Scotia, Part II, pp. 10-21; Canada, Dept. of Mines, 1910.

ing. The only conclusions of practical value that it seems possible to arrive at are doubtless such as have already suggested themselves to, and have influenced the officials of the Maritime Oilfields Company: (1) The existence of oil and gas having been proved in the Stony Creek field, future development work should first take the form of à carefully planned attempt to develop the full extent of the field; (2) in anticipation of the future exhaustion of this field, exploratory work carried on by drilling should eventually be commenced in an endeavour to locate another field in adjacent regions; in carrying out this exploratory work it would be necessary to sink a certain number of wells, not altogether in the hope that they might produce oil or gas, but in order to obtain a knowledge of the structure and character of the underlying strata. In attempting to extend the limits of the present field and in attempting to find new fields, advantage should be taken of the widely applicable rules that individual fields are usually much longer than broad, and that the individual fields or pools are usually grouped along rudely parallel lines. In the present instance, there is a strong probability that some such policy as the above may be carried out, since all the prospective oil and gas territory of New Brunswick is held under a single control.

GYPSUM OF NEW BRUNSWICK.

(*H. E. Kramm.*)

Introductory.

The writer spent the latter part of June, all of July, and the greater part of August investiagting the origin of the gypsum deposits of New Brunswick.

In all eight weeks were spent in the field, of which three were devoted to a study of the deposits at Hillsborough, two weeks were spent in investigating and mapping the deposit at Petitcodiac, ten days were consumed in visiting other quarries and outcrops in New Brunswick, and the remainder of the time was devoted to a comparison of the gypsum of Nova Scotia with that of New Brunswick. The quarries visited in Nova Scotia were those near Windsor, at McKinnon Harbour, at St. Ann, and Eastern Harbour. During the greater part of the time the writer was efficiently assisted by Mr. A. K. Willis, of St. John.

Hillsborough.

The Hillsborough deposits are mentioned in a number of the earlier publications of the Geological Survey, the most complete description being given by Bailey[1] in 1898. He has also described the general geological relations which were verified by the writer.

The deposits are associated with the rocks of the lower Carboniferous series and occupy a position in the upper portion of this group.

Red conglomerates composed of slightly waterworn angular fragments of metamorphosed rock, fairly well consolidated, carrying interbedded thin strata of a red sandstone, outcrop along the western bank of the Petitcodiac. South of Edgett Landing a slight dip towards the south can be observed in the interbedded sandstone. Near Hopewell cape the action of the tides in the Petitcodiac has undermined the banks of conglomerate, isolating portions of it and causing them to stand out in grotesque and fantastic shapes, that are locally known as "the rocks.'

The conglomerate is overlain by a limestone which reaches a thickness of about 40 feet. It is of a greyish colour, due to impurities, is well crystallized, and has almost slaty cleavage. A slight dip about 5° to the south can be observed at a place near Edgett Landing where the limestone has been quarried. No indication of fauna or flora was observed by the writer in this limestone, and if such originally were present, they have been obliterated during the crystallization of the limestone. At the point of exposure noted above, the limestone is seen to dip under the bed of gypsum and anhydrite, but the direct contact is masked by the mass of overburden. Anhydrite and gypsum overlie the limestone. The total thickness of the bed is perhaps 250 feet. Gypsum usually forms a capping of varying degrees of thickness on the anhydrite.

While all of the above beds are apparently in conformity with each other, the gypsum and anhydrite bed is unconformably covered by quartz conglomerate and interbedded, coarse-grained, grey freestone of the Millstone Grit. In places red conglomerate, sandstones, etc., intervene between the gypsum beds and those of the Millstone Grit.

[1] The Mineral Resources of the Province of New Brunswick, No. 661, 1898, pp. 84-100.

The surface in general is covered by an overburden of residual soil, and this, together with the unconformity and considerable faulting, make geological relations somewhat obscure.

The area of gypsum and anhydrite which actually outcrops covers approximately 1½ square miles. Considerable quantities of gypsum are, however, covered up by Millstone Grit or carry an overburden of soil and rock debris, the presence of the gypsum being indicated by numerous sink holes. A fault line which runs approximately north and south appears to limit the deposit towards the west, while other fault lines probably limit it towards the south.

The gypsum is usually of the massive crystalline variety, although it is possible to find other varieties in the deposit. It ranges in colour from colourless to pink and grey. The colour is the result of impurities of which calcium carbonate, oxide of iron, and organic matter are the most prominent. The bedded nature of the deposit is shown by seams of impurities, which can be found in the anhydrite as well as in the gypsum and which were laid down along parallel planes.

Considering the gypsum deposit in a general way, four zones may be recognized.

The first zone is on and near the surface and is in evidence only where gypsum outcrops, being thus exposed to the action of the atmosphere. The gypsum is brittle, more or less broken up, and crumbles easily into small fragments. The action of surface waters has caused a concentration of impurities by carrying off the pure gypsum, which is comparatively soluble, and by carrying in matter mechanically. This zone is not pronounced where the gypsum is covered by clay or soil.

In the second zone the gypsum is more massive and tough. Within the solid mass can be found numerous crystals of selenite which are of a secondary nature. It is found most abundantly along joint fissures, and because it cleaves into plastic plates which resist fine grinding it is considered as "not desirable" by the quarryman. The quantity of these crystals gradually diminishes with depth.

The third zone consists of the crystalline massive variety of gypsum. The lower part of it contains lenticular bodies of anhydrite, in some cases entirely surrounded by gypsum, in others leading into the solid mass of anhydrite which underlies the gypsum and constitutes the fourth zone.

Gypsum is exposed to the south of Hillsborough in a number of places. The following places were visited and samples of the gypsum obtained.

Curryville.

To the north of Curryville the limestone which underlies the gypsum comes to the surface and has been calcined and is utilized.

A gypsum quarry is being operated at the present time in close proximity to the Salisbury and Harvey Railway track. The rock is massive in character, rests upon anhydrite, and is covered by an overburden of considerable thickness carrying the characteristic pebbles of Millstone Grit.

Outcrops of anhydrite and gypsum are also found a fourth of a mile to the southwest of the above quarry. They cover a considerable area and reach a maximum height of about 100 feet. Here the surface waters have leached out a cavity in the anhydrite, which is partly filled with water and is said to have an extent of 6 acres.

Woodworth Settlement.

Two quarries were being operated on a small scale several years ago on the gypsum outcrops of this locality. All that remains to be seen at the present day are the cavities from which the gypsum was taken, and in one of them some boulders of anhydrite are exposed. Aside from these there are no indications of the presence of calcium sulphate, the whole being effectually covered up by Millstone Grit.

Hopewell Cape.

Gypsum occurs at Hopewell Cape, but is not exposed through the overburden of soil and Millstone Grit. Prospecting work, to determine its quality, has been done, and about 200 tons of the rock have been quarried and are on the dump. The gypsum is massive and of excellent quality.

To the southeast of Hopewell Hill, on the Salisbury and Harvey railway, about one-half mile from the shore of Shepody bay, gypsum was mined on a small scale, but no work is done at the present time and no gypsum is exposed.

New Horton.

Gypsum is also known to occur at New Horton. It is covered by Millstone Grit, and at the time of the writer's visit about 20 tons had been taken from two short cuts which exposed a white massive variety.

Petitcodiac.

A succession of beds similar to those at Hillsborough was found at Petitcodiac in connexion with the gypsum outcrops. A bed of crystalline limestone stands out very prominently and can be followed for a distance of about 3 miles. Its trend is approximately northeast-southwest with a dip of 60° to the southeast.

To the southeast of the limestone, and adjoining it, gypsum is exposed. The area covered up by it is approximately 700 feet wide and can be traced for 2½ miles, having the same trend and always adjoining the limestone. Still farther to the southeast Millstone Grit conglomerate and freestone are encountered, the latter overlying the former with a slight dip to the southeast.

To the northwest of the limestone is found a red calcareous shale, dipping with an angle of 80° to the northwest. The line of contact between limestone and shale is a fault line.

The surface-gypsum has been utilized in past years for land plaster. Very little development work has been done to show its quality in depth, but in several places where exposures have been made a good quality of white massive gypsum was found.

Upham.

The gypsum area near Upham, which lies on the railway connecting Hampton with St. Martin, can be traced for several miles by sink-holes and small ponds. The gypsum is covered by Millstone Grit and only at a few places does it outcrop.

The geological conditions are similar to those at Petitcodiac. A fault with approximately the same trend as that at Petitcodiac has brought the crystalline limestone underlying the gypsum to the surface. The limestone is of a greyish-black colour, is exposed in a few places only, and has a dip of 19° to the southeast.

Mining of the gypsum was begun in 1907 and several carloads were shipped to St. John. Owing to heavy freight charges the venture did not prove a success and was given up.

At Upham as well as at Petitcodiac no anhydrite was observed.

Plaster Rock.

While all the gypsum deposits noted in the preceding showed a great similarity in character as well as in their stratigraphic relations to other rocks, the gypsum found at Plaster Rock on the Tobique river differs from them. It has a decided bedded appearance and breaks easily along horizontal planes. It is impure and its colour varies from a hematite brown to a light green with now and then layers which carry an abundance of red shale, to which crystals of selenite give a mottled appearance. The different colours do not, as a rule, blend into each other, but are sharply defined. Thus a greyish white variety may be found overlying and sharply separated from a red variety, the plane of separation being one of easy cleavage. The thickness of these layers varies from an inch to a foot or more and their character suggests constantly changing conditions of deposition. Secondary deposition has given rise to numerous veins of satin-spar which are approximately parallel to the bedding planes and the fibres are arranged perpendicular to them. No anhydrite is found nor is there any evidence of change from anhydrite to gypsum.

The gypsum beds are horizontal or have a slight dip, the direction of which is variable. They are exposed for a distance of about 1 mile along the eastern bank of the Tobique, which exposes a maximum thickness of about 125 feet. An overburden of residual soil covers the gypsum which overlies and is interbedded with a red calcareous shale, carrying seams of a greenish-white siliceous limestone, which on account of its colour stands out prominently.

The gypsum is too impure to be utilized for wall plaster, but is ground into a fine powder and used as a fertilizer. Its principal use, however, is in the manufacture of cement.

Nova Scotia.

Gypsum is being mined in Nova Scotia on an extensive scale, and consequently the facilities for a study of the conditions under which it occurs are excellent. On the whole, the gypsum of the localities visited resembles that of New Brunswick (with the exception of the Tobique River gypsum) to such an extent that it would be difficult to tell one from the other in hand specimens.

Anhydrite is very prominent and has been found, wherever it does not outcrop directly, to underlie the gypsum. While some of the quarries which work near the surface are entirely in gypsum, in others, lenses of anhydrite which are capped by gypsum are encountered, while still others have reached and are working upon the floor of solid anhydrite. A few examples will illustrate.

At the Eagle Swamp quarry, about 4½ miles to the east of Windsor, anhydrite is encountered in lenses of variable size surrounded by gypsum or capped by it.

The Frazer quarry is three-fourths of a mile to the southwest of the Eagle Swamp quarry, and is not being worked at the present time. According to information received from the manager, Mr. N. Dimock, a diamond-drill hole in this quarry from its drainage level, about 100 feet below the gypsum outcrops, passed through 110 feet of gypsum, 140 feet of anhydrite, and at this depth was still in anhydrite.

At the Mosher quarry, about 6 miles to the southeast of Windsor, a capping of gypsum is being removed from the anhydrite, which constitutes the floor of the quarry.

Conditions similar to the above were found to exist in quarries visited in Cape Breton.

It is a comparatively simple matter to ascertain the conditions of gypsum occurrence where a deposit has been opened up, but some large areas may show little or no development work, and the investigation of the commercial possibilities of such properties becomes a difficult if not an impossible problem. The nature of the deposit as to colour and amount of impurities is likely to change suddenly even within the limited area of a quarry. The general conditions prevailing within a given district in which such properties are located can, however, usually be applied and are of great help.

As an example we may cite the Wilken's, Redden, and Thompson properties, which adjoin each other, and are located about 3 miles to the southeast of Windsor, in Hants county, Nova Scotia. They have been opened up to a limited extent only, but enough to permit a comparison with quarries in the same neighbourhood.

The general conditions which obtain in these quarries are in the main those pointed out in connexion with the deposits at Hillsborough, N.B. Thus four zones as described in the preceding may be recognized, with the solid mass of anhydrite constituting the fourth one. The anhydrite may crop out at the surface or may have a gypsum covering up to 200 feet in thickness. Calcite grains in varying amounts are distributed throughout the gypsum and anhydrite masses, and the quantity at a given level may increase to such an extent that a seam of limestone is formed. The amount and occurrence of calcite and limestone cannot be predicted, but more than a certain small percentage must not be present if the gypsum is to be used in the manufacture of wall plaster. Other impurities besides calcite are oxide of iron and organic matter. Varying proportions of these will tint the gypsum differently. The quarryman thus recognizes a blue, a grey, a green, a white, etc., gypsum. All of these varieties have been utilized in the manufacture of wall plaster, but the white variety is preferred because it yields the whitest plaster.

These conditions apply in a general way to the Wilken's, Redden, and Thompson properties. While all of the areas covered by these adjoining properties appear to be underlain by gypsum, there is some variation in the kind of gypsum.

The northern portion is occupied by a blue variety cropping out in many places, whereas in the southern portion there is found a white variety.

The blue gypsum compares favourably with that mined in neighbouring quarries, and an analysis of what may be considered an average sample shows it to be of good quality chemically. In appearance it does not differ, except perhaps in colour, from the ordinary gypsum mined at Hillsborough. It has been quarried to some extent in past years, there being three quarries, each having a working face of from 20 feet to 25 feet in height.

White gypsum probably occupies all of the southern portion of the property, but outcrops are few in number and the gypsum is of high quality and obvious purity.

What the thickness of the gypsum on these properties is, cannot even be surmised, because in the case of practically all undeveloped properties this is entirely a matter of test work. Since no anhydrite outcrops anywhere, it may well be assumed that the gypsum reaches below the level of the present drainage system, that is, the level to which it can be economically worked. The difference in elevation, as determined by aneroid, between the level of the road leading into the quarries and the highest point in the northern part of the properties is 90 feet, while the highest point in the southern part is about 160 feet above the same road. If it is assumed that the gypsum extends to the level of the drainage system, and if the unknown thickness of the overburden and the drainage slope necessary in operation of quarries be disregarded, the maximum thickness possible of the gypsum deposit is 160 feet.

The conditions affecting the above-named properties have been described somewhat at length since, in general, they represent the conditions prevailing throughout the Windsor district; moreover the same conditions affect all undeveloped gypsum properties both in New Brunswick and Nova Scotia.

Origin of Gypsum.

The evidence obtained in the field relative to the origin of the gypsum points towards a derivation from anhydrite. Such evidence is summarized in the following:—

(1) The solid mass of the gypsum is always found overlying the anhydrite. It is true, that lenses of gypsum which may be several feet in thickness are encountered

within the anhydrite mass, but they are not bedded, and follow the irregular system of joint fissures.

(2) The experience at Hillsborough has been that the thickness of the gypsum varies in a general way with the topography. "The bottom rises as we drive into a hill" is a common saying.

(3) Specimens of gypsum which still contain a core of anhydrite are common. The outer layer of gypsum has a tendency to split and break off in scales which seems to be caused by the expansion which gypsum undergoes when changing from anhydrite.

(4) Specimens of pure anhydrite are comparatively rare. The freshly-broken pure specimen is of a bluish-green colour and has an intense vitreous lustre. Exposed to the sun and atmosphere for a few days the lustre is destroyed and a white film of gypsum forms on the surface of the anhydrite.

While thus the field evidence shows that at the present time the gypsum is being formed by hydration of anhydrite, no one could say that it was originally laid down in the form of anhydrite. There is no doubt that the calcium sulphate deposits originated by being deposited from sea-water. Their distinctly bedded character and enormous quantities are proof of it. It is well known, however, that under ordinary conditions of temperature and pressure calcium sulphate is deposited in the form of gypsum. If Van't Hoff's results are accepted, at 36° C., in a saturated sodium chloride solution, calcium sulphate is laid down in the form of anhydrite, but such high degrees of temperature of sea-water extending over great areas are not observed at the present time even in our most tropical countries. Since gypsum, according to Van't Hoff, when subjected to a temperature of 63½° C. turns, within a few weeks, into anhydrite, a much simpler solution seems to be that calcium sulphate was laid down as gypsum, and that it later was dehydrated. We know that enormous layers of sediments were deposited on the calcium sulphate beds, and the resulting pressure could easily have produced a temperature of 63½° C. or more. With the removal of the sediments a rehydration began, which is going on at the present time.

As to the Tobique River deposit, its dissimilarity mineralogically and in character of deposition from other deposits of New Brunswick, suggests a different period of deposition.

JOGGINS CARBONIFEROUS SECTION OF NOVA SCOTIA.

(*W. A. Bell.*)

Introduction.

During the field season of 1911, the writer spent three months in the field, making a palæontological study of the Carboniferous rocks exposed along the shores of Chignecto bay, Nova Scotia. The main object of the work was to secure a collection of the flora and fauna from the various fossiliferous horizons, for the purpose of working out the chronogenetic history, and the physical conditions of deposition of the Carboniferous of the Cumberland and adjacent basins, and further of correlating these deposits with the Carboniferous elsewhere.

The greater part of the time was spent in gathering collections from the numerous beds composing the coal measures of the widely-known Joggins section, and considerable material was collected, all of which awaits final study. Some time was also spent along the opposite shore of the bay in Albert county, New Brunswick, as well as in the vicinities of Springfield and Windsor, Nova Scotia, for the purpose of establishing the geological age of the rocks in these places.

The present report presents some of the results attained in the field and in the geological laboratory of Yale University, after a rapid preliminary survey of the fossils.

Previous Work.

The Joggins section early attracted the attention of geologists by the reported occurrences of many fossilized trees still standing erect in the sandstones. Lyell visited the locality in 1842, at which time he wrote his first impressions:[1] "Whither I went to see a forest of fossil coal-trees, the most wonderful phenomenon, perhaps, that I have seen, so upright do the trees stand, or so perpendicular to the strata . . . . trees 25 feet high, and some have been seen of 40 feet, piercing the beds of sandstone and terminating downwards in the same beds, usually coal. This subterranean forest exceeds in extent and quantity of timber all that have been discovered in Europe put together." In 1852-53 he restudied the section in the company of Dawson. Since then his drawings of these logs and those of Dawson have appeared in many text books on geology. In 1885 Dawson, in his Acadian Geology, published an excellent account of the general geology of the district, with detailed description of the stratigraphic succession, but particularly of the Productive Coal Measures. Later editions of the same work contain additional supplementary matter. The fauna and flora have been described at various times by Lyell,[2] but more especially by Dawson.[3]

The section was first measured in detail by Logan[4] in 1843, while Fletcher[5] later, in 1896, completed the measurements from Shulie to Spicer cove. Both Fletcher

[1] Life of Sir Charles Lyell, Vol. II, 1881, p. 65.

[2] Lyell—Am. Jour. Sci. 1843, pp. 353-356; ibid., 1853, pp. 33-41; Travels in North America, 1845, pp. 148-187.

[3] Dawson—Acadian Geology, 1st ed., 1855, 4th ed., 1891, pp. 150-212. Quart. Jour. Geol. Soc. Lond., 1853, p. 58; ibid., 1894, pp. 435-437; Am. Jour. Sci. (3), V, 1873, pp. 16-24; Can. Rec. Sci., 1894, pp. 1-7, 117-134; ibid., 1897, pp. 316-323; ibid. 1898, p. 396; Can. Roy. Soc., Proc. and Trans., 1895, pp. 71-88; ibid., 1898, pp. 58-78.

[4] Logan,—Geol. Surv., Can. Ann. Rept., 1845, 92-156.

[5] Fletcher,—N. S. Inst. Sci., Proc. and Trans., XI, 1902-1906, pp. 417-550.

and Ells have done valuable work in mapping and in working out the geological structure in this and adjacent regions. Their results may be found in the Canadian Survey reports cited below.[1]

TABLE OF FORMATIONS.

Recent.—Marsh alluvium, drift sands, stream gravels.

Pleistocene.—Fluvio-glacial gravel, sand, clay, glacial till.

Great depositional break.

Pennsylvanian (Upper Carboniferous):—

Upper Coal Measures (Permo-Carboniferous of Fletcher)—

Greenish grey, buff-weathering sandstones and conglomerates with drift logs or plants aggregating 947′, alternating with beds of dark red argillaceous and arenaceous shales (670′). Total thickness, 1,617′.

Erect Calamites were found in two beds.

Upper Grindstone division—

Grey or drab coloured massive sandstone (300′) with reddish-yellow sandstones (28′) and alternating beds of chocolate (204′) or grey (118′) argillaceous and arenaceous shales. Total thickness, 650′.

Erect Sigillarian tree here in one bed, erect Calamites in another bed.

Middle Grindstone division—

Includes twenty-two small seams of coal, a total of 5′, with associated carbonaceous shale (4′). Underclays (174′) having generally the appearance of fireclays underlie all the coal seams. Interbedded sandstones, many of grindstone quality, grey (739′), reddish (204′); and shales, grey (137′), variegated (669′); concealed (202′).

Total thickness, 2,134′.

Five erect Sigillarian trees and fourteen beds with upright Calamites.

Middle Coal Measures—

Upper division predominantly grey. Coal in thirty-two small seams, total of 35′, associated with carbonaceous shale (27′) and bituminous limestone (17′). Associated underclays, with ironstone nodules (67′), without ironstone (246′); sandstones, greenish-grey (428′), brick-red (12′); shale, grey with ironstone (166′), without ironstone (338′), variegated (95′), reddish (16′), brick-red (87′), brick-red with ironstone (48′).

Total thickness, 1,582′.

Twenty erect trees were observed and fourteen beds holding erect Calamites.

Lower division predominantly reddish or red. Coal in thirteen small seams, totalling 3′ with carbonaceous shale (9′) and bituminous limestone (6′); underclays, with ironstone (127′), without ironstone (64′); sandstone, greenish grey (68′), reddish (124′), brick-red (14′); shale, grey with ironstone (63′), without ironstone (73′), variegated with ironstone (122′), without ironstone (106′), brick-red with ironstone (34′), without ironstone (144′). Total thickness, 957′.

Four erect trees were observed in this division.

[1] Geol. Surv., Can. Ann. Rept., I, 1885, Part E; ibid., V, 1890-91, Part P. Summary Reports, 1891, pp. 52-55 AA; 1892, pp. 59-64 A; 1899, pp. 162-168 A; 1902, pp. 390-401 A.

Millstone Grit or Lower Coal Measures—

Upper red measures consisting of shales, brick-red (937′), greenish-grey (4′); sandstone, brick-red (121′), reddish (151′), reddish associated with concretionary limestone (53′), greenish-grey (28′), greenish-grey associated with concretionary limestone (20′); concealed, probably red shale (768′). Total thickness, 2,082′.

Lower Grindstone division: Shales, brick-red (200′), variegated (63′), greenish-grey (45′), greenish-grey with ironstone (11′); coal and carbonaceous shale (2′), underclays (58′); sandstone, greenish-grey (200′), greenish-grey with patches of concretionary limestone (5′), variegated (8′), brick-red (57′); concealed (101′). Total thickness, 750′. Underlaid with shale, greenish-grey (97′), greenish-grey with ironstone (38′), brick-red (114), concealed red (108′), associated with coal and carbonaceous shale (9′), bituminous limestone (1′), underclays (42′); sandstone, greenish-grey (1,647′), light buff (25′), brick-red (31′), greenish-grey with lenticular beds of concretionary limestone (102′). Total thickness, 2,214′.

Lower Conglomerate division: Brick-red pea and egg-sized conglomerates (164′) with siliceous pebbles; sandstone, greenish-grey (9′), variegated partly calcareous (20′), brick-red (113′); shale, brick-red (228′), associated with bituminous limestone (2′); concealed (357′). Total thickness, 893′.

Probable great depositional break.

Mississippian:—

Windsor series: Shale, brick-red micaceous (1,204′); sandstone, brick-red (209′), reddish (36′), greenish-grey with comminuted plant remains (156′), greenish-grey with lenses of concretionary limestone (88′). Total thickness, 1,693′.

The plant fragments are frequently coated with green carbonate of copper or grey sulphuret of copper. These measures are underlaid by at least 100 feet of drab dolomitic and bluish-black fossiliferous limestones, interbedded with light yellow calcareous sandstone and brick-red marls. The limestone beds carry a marine fauna identical with that found at Windsor in beds of similar lithologic character. Gypsum does not outcrop in this section, but occurs in abundant quantity a few miles to the north on Cape Maringouin, associated with similar beds of limestone.

General Geology.

The rocks of the Joggins expose an oblique transverse section through the broad Cumberland synclinal trough, which extends in a general east-westerly direction, parallel with and to the north of the Cobequid range of hills. The simplicity of the structure is interrupted by a few minor longitudinal transverse folds, and by local faulting.

The base of the section begins with the Windsor series (lower Carboniferous) which forms an anticline across the country from the Bay of Fundy, opposite Shepody mountain, to the neighbourhood of Minudie, Nova Scotia, and to Pugwash on the Straits of Northumberland. The highest beds lie in the axis of the syncline, which strikes the shore of Chignecto bay near Shulie. Between Shulie and Spicer cove there is a partial repetition of the measures downwards to a thick formation of conglomerate which flanks the Cobequid igneous rocks. This conglomerate was correlated by Fletcher with the New Glasgow conglomerate and assigned to the Permian, but from the palæobotanical evidence derived from the overlying beds, and gathered by the writer, appears to be of a much earlier Carboniferous age.

STRUCTURAL RELATIONS.

Minor folding and faulting is frequent in the Cumberland basin, but the displacements are in most cases of a few feet only. In the Joggins section faulting is common in the upper portions with a resulting partial repetition of outcrops. At Spicer cove a displacement of considerable amount has taken place, and there is also a distinct brecciated fault zone, bringing the Coal Measures unconformably against the red New Glasgow conglomerate. The downthrow of the northern side has been estimated by Fletcher at 500 feet. At the base of the Joggins section a fault of unknown displacement occurs near Minudie, apparently in the line of the anticline which defines the northern limit of the basin. This anticline is well exposed on the shores of Shepody bay or Cape Maringouin, where the strata are tilted to a vertical position. Near Hard ledge, on the same shore, occurs a small syncline dipping about 15° towards Shepody mountain.

NATURE OF THE DEPOSIT.

The fauna of the marine dolomitic limestones of the Windsor series at the base of the Joggins section indicates broad, clear-water, shallow, and warm seas. The succeeding and widely distributed deposits of gypsum were undoubtedly accumulated in shallow pans of the sea under a sub-arid and probably warm climate. The interbedded and overlying red shales and marls, barren of life, with an abundance of mud cracks and ripple marks, together with the general unleached condition expressed by the calcareous concretions and high alkali content, denote similar climatic conditions and a general retreat of the sea, followed by estuaries or wholly fresh-water deposition. The environmental conditions at this time appear to have been especially favourable for the formation of fresh-water subaqueous delta deposits, adjacent to very shallow seas, having had, it is thought, the forms of narrow but long basins, situated between mountain masses that had their origin in Devonian times.

A complete withdrawal of the sea with consequent relative uplift of the land prevented further deposition in this area, but possibly an extensive period of erosion again brought about conditions favourable for fluvial deposition early in Pennsylvanian time—conditions which seemingly persisted to the beginning of Permian time, as no truly marine or even estuarine fauna occurs in the Coal Measures of the Joggins area.

The sediments of the Millstone Grit were laid down under more fluvial conditions, an environment attested by the presence of occasional coal seams, the increasing importance of dark to black shales, and the lighter coloured, though still imperfectly leached, sandstones. The interbedded red shales, barren of fossils, may represent the muds of fluvial flood flats, that subsequently were oxidized sub-aerially, while the irregular lenticular beds of concretionary limestone associated with the grey sandstones apparently add their evidence in favour of fluvial conditions and a warm climate.

During the early Coal Measures the strata were laid down under more fluvial and swamp conditions, as expressed by the many thin coal seams, the predominant dark shales, and the more perfectly leached sandstones.

In later Coal Measures time there is no evidence for a continued abundance of water, as the red shale beds indicate seasons of aridity when all of the carbonaceous elements were removed through oxidation under sub-aerial conditions. There was at this time probably a return to more arid conditions, very similar to those of the Millstone Grit.

ERECT TREES.

The great number and erect condition of fossil trees in the Joggins section is good evidence that they are preserved in the position of their growth, *i.e.*, growth in situ. Thirty-five Sigillarian upright trees were observed in the Coal Measures of the Joggins section. Of those examined, three contained the remains of land reptiles or of land snails, while three others were observed with Stigmarian roots still attached. The general absence of roots may be explained by the fact that most of the trees have their bases directly over a thin underlying coaly or carbonaceous seam, indicating a probable decay of the roots and reduction into coaly matter. All of the erect Sigillaria had their basal terminations in shales which have little or no drift material other than fragments of leaves and Stigmarian rootlets.

Forty-one different beds in the Joggins section were noticed having upright Calamites, which in every case were confined to the sandstones or arenaceous shales.

CORRELATIONS.

The Coal Measures of the Joggins section are relatively poor in the abundance and variety of their flora and fauna when compared with the Carboniferous elsewhere. Another striking character is the lack of normal marine faunas, and divisional classification by means of organisms is here impossible. The classification and correlation of these deposits is, therefore, dependent largely on the stratigraphic sequence and lithologic characters, fortified by the more or less sparingly preserved flora and the land animals. On account of the continued vertical recurrences of similar lithologic characters, of abrupt local changes in sedimentation, and of the difficulties attendant on minor faulted and folded structure associated with discontinuous outcrops, such a classification is open to errors. A more restricted zonal classification than that given in the generalized section is also desirable, and such appears to be possible after further collecting and study of the fossil flora.

Windsor Series.

The correlation of the limestone beds at the base of the Joggins section with the dolomite gypsum series at Windsor is based on the occurrence of an identical fauna in both localities. The same fauna has recently been discovered by Clarke on the Magdalen islands and is described by Beede,[1] who agrees with Schuchert[2] that the age of the Windsor fauna is that of the lower Mississippian, or more specifically, about that of the Kinderhookian.

The overlying red beds may then represent either an estuarine or fresh-water phase of later Mississippian time.

Disconformity.

Undoubtedly there is a great depositional break between the beds of the Windsor series and the overlying Millstone Grit. Schuchert[3] has pointed out the fact that there is no reliable evidence for the presence of the lower Tennesseean deposits and none at all for the upper Tennesseean in the Maritime Provinces. The writer believes that this depositional break occurs at the base of the red conglomerate series, but further field work will be necessary to fix the horizon of disconformity (non-apparent unconformity).

[1] Beede. N. Y. State Mus., Bull. 149, 1911, pp. 156-186.
[2] Schuchert. Bull. Geol. Soc., America, 20, 1910, p. 551.
[3] Ibid., p. 554.

Millstone Grit.

The name Millstone Grit is retained with its customary broad application in the Maritime Provinces to those deposits underlying the Productive Coal Measures of the Pennsylvanian (upper Carboniferous) and overlying the Mississippian (lower Carboniferous). It is here divided into three members, each representing a distinct kind of sedimentary deposit: a lower red member of conglomerates, sandstones, and shales; a middle grey sandstone member with subordinate shales and thin coal seams; and an upper red member consisting mainly of shales with some sandstones. Scarcely any plants are found in the red beds, but the massive grey sandstones frequently contain abundant drift logs and floral fragments in poor condition. It is probable that the Millstone Grit may be in whole or in part equivalent to the Pottsville of the Appalachian region.

Coal Measures.

Further study of the floral evidence will probably furnish data for a more detailed correlation with the established subdivisions of the American Pennsylvanian.

A rapid review of the flora, as given by Dawson, from the highest members in the Joggins section, failed to reveal any plant not found in the undoubted Pennsylvanian (Carboniferous) below, a condition demonstrating the probability that there are no deposits of Permian age in this thick section.

The conglomerate at Spicer cove, correlated by Fletcher with the New Glasgow conglomerate and assigned to the Permian, underlies beds which apparently have the Pennsylvanian Coal Measures flora. Should this observation prove correct, then this conglomerate represents a portion of the Millstone Grit.

ECONOMIC GEOLOGY.

COAL.

Coal occurs in marketable quantities in two areas in the Cumberland basin—in the Joggins, or Northern area, and in the Springhill or Southern area. Mining operations are carried on in the Joggins area by the Maritime Coal, Railway, and Power Company, Limited, in the Springhill areas by the Dominion Coal Company.

GRINDSTONE.

At present no stone is being worked, but in all probability there still remains much good material which could be worked at a profit were the demand increased. The material has largely been exhausted from the reefs where production was cheapest.

GYPSUM.

Extensive deposits of gypsum of good quality occur in Maringouin peninsula and in the neighbourhood of Nappan, Nova Scotia. Quarrying is now carried on at the latter place, and intermittently at Cape Maringouin.

GOLDBEARING SERIES OF THE BASIN OF MEDWAY RIVER, NOVA SCOTIA.

(*E. R. Faribault.*)

Introduction.

The district topographically and geologically surveyed by the writer during the field season of 1911, lies in the southwestern part of Nova Scotia, immediately west of that surveyed in the two preceding years. It comprises the lower portion of the basin of the Medway river, extending from Medway to Ponhook lake, and includes a part of the Atlantic coast from Vogler Cove, in Lunenburg county, to the town of Liverpool, in Queens county. The area of this district is about 276 square miles, 12 miles east and west by 23 miles north and south. This completes the Vogler Cove sheet No. 90, Greenfield sheet No. 94, and the eastern part of Liverpool sheet No. 93. More field work is still required, however, to work out the geological structure and the altitudes of the western part of sheets Nos. 90 and 94.

An additional area, further inland, of about 50 square miles, was also surveyed, of a portion of the basin of Pleasant river—a tributary of the Medway river—comprised between the Annapolis County line on the north and the Caledonia branch of the Halifax and Southwestern railway on the south.

The examination of the geology and mineral occurrences was carried out by the writer; while the work in connexion with the topographical surveying was for the most part accomplished by the two assistants, J. McG. Cruikshank and M. H. McLeod, who were engaged from the beginning of June until the end of October, and performed their duties in a painstaking and satisfactory manner.

The main control lines to tie in the surveys of that region consist of the transit-chain survey made in 1905 by L. N. Richard of the highway road between Annapolis Royal and Liverpool, and of the Caledonia Branch railway with connexion at Lows landing on Lake Rossignol; the location plan of the Halifax and Southwestern railway between Bridgewater and Liverpool; the transit-stadia traverses made in 1907 by F. O'Farrell of the main road between Bridgewater, Pleasant River, and Middlefield; and the charts of the Atlantic coast made by the British Admiralty. In the settled regions, all the wagon roads were surveyed with a self-registering one-wheel odometer and the compass; while in the unsettled parts chain and compass traverses were run mostly along wood roads and county lines as tie-lines. Between points thus established the main rivers and lakes were surveyed with the Rochon telescope-micrometer and compass; while the smaller streams, lakes, etc., were filled in by compass and pace traverses.

The elevations were taken with a 3 inch surveying aneroid barometer checked by half-hour readings of a similar instrument stationed at central points, using for base the mean sea-level, the profiles of the three branches of the Halifax and Southwestern railway, and O'Farrell's transit-stadia levelling of the roads above referred to.

Special detailed examination and surveys were also made of the gold-mining districts of Blockhouse, Mill Village, Vogler Cove, and Fifteenmile Brook; of the important tungsten deposits exploited by the Scheelite Mines Limited Company at Scheelite, near Moose River Gold Mines, Halifax county; of the recent discoveries of scheelite at Waverley, Baker Settlement, and Fifteenmile Brook; and of the prospects of tin and tungsten ore at Mill Road near New Ross.

Physical Features.

The district under examination is drained by the lower part of Medway river, which flows in a southeasterly direction for 15 miles along almost a straight course from the outlook of Ponhook lake to Medway on the Atlantic coast. The greater part of the waterway has a gentle descent with occasional rapids, and it runs along a narrow valley between undulating hills of glacial drift, the elevations of which do not exceed 300 or 450 feet above mean sea-level. Transverse rocky ridges, however, cross the river at a few places along its course, forming important waterfalls and cascades that would afford good water-powers. The river has a total descent of 302 feet in the 15 miles between Ponhook lake and the head of tide at Mill Village.

The following data on the principal water-powers of the Medway river were collected in 1910 by A. V. White, hydrographer, and tabulated for the Commission of Conservation.[1]

Site.	A. Sq. miles.	B. Feet.	C, Horse-power	Remarks.
Mill Village	602	9·7	730	Old saw-mill: Davison Lumber Co.
Salter fall	545	16·0	1,100	Nova Scotia Pulp and Paper Co., 1,800 H.P. developed.
Big Salmon fall	532	4·9	330	Fall in about 300 feet.
Poultice fall	508	9·0	570	Fall in about 750 feet.
Glodes fall	486	8·3	500	Fall in about 300 feet
Big Rocky fall	486	12·0	730	Fall in about 800 feet.
Bear fall	453	5·8	330	Fall in about 300 feet.
Bangs fall	453	7·0	400	Shingle mill; possible to obtain 16 feet.
Ponhook fall	437	17·6	960	Saw and shingle mill.
Harmony pulp mill	125	30·0	470	Pulp mill; 1,000 H.P. developed.

A.—Approximate area of watershed in square miles.
B.—Approximate head in feet.
C.—Estimated low water 24 hour H.P., 8 months, theoretical.

The measurements of flow of Medway river, metered on October 10, 1910, at Mill Village bridge, gave:—

Width of river, where metered	100 feet.
Area of river section	175·8 sq. ft.
Discharge per second	109 cubic ft.
Effective drainage area above section	602 sq. miles.
Discharge per sec. per sq. mile	0·18 cubic ft.

Several streams empty into the river from both sides and drain a succession of lakes, lagoons, and stillwaters which have a general southerly and southeasterly trend through a generally flat country with occasional low undulating hills of glacial drift largely made up of granite debris carried from the north. In the southern part of the basin and as far west as Liverpool the surface covering is very heavy and rock exposures are scarce; but the bed-rock is well exposed along the sea-shore between Medway and Liverpool harbour.

Much of the surface is strewn with numerous angular blocks of rock detached from the thick beds of quartzose-sandstone of the region. These blocks often attain very large dimensions and stand out conspicuously above the surface, which on this account is rendered very rough and much different to that of Lahave basin adjoining to the east, where the slates predominate.

The district is covered over in part with woods, young growths, burnt woods, or barrens; and in part with numerous swamps and hay-marshes along the streams, and some peat-bogs. It is unfit for agricultural purposes. With the exception of Greenfield at the foot of Ponhook lake and a few scattered habitations along the river, the interior is altogether uninhabited. Along the shore, between Vogler cove and Liverpool, are scattered several small villages of fishermen, the most important of which

[1] Water-powers of Canada, Report Commission of Conservation, 1911, pp. 217 and 227.

are Mill Village, Medway, Eagle Head, Beach Meadows, and Brooklyn. Medway has an excellent harbour, free of ice in winter, and from which much lumber was shipped at one time by the Davison Lumber Company, but it is now used exclusively as a fishing station. The Nova Scotia Pulp and Paper Company has a pulp-mill in operation at Charleston, 2 miles north of Mill Village, situated at the head of tide on the river. A few small saw and shingle mills are also located on the river.

The river is considered one of the best in the Province for the fishing of salmon and trout, which are caught with the fly in the months of April, May, and June as far up the river as Harmony, 30 miles above tide-water. At many points along the river between Mill Village and Greenfield fishing rights have been leased by sportsmen who have erected summer cotttages and club-houses on the river bank.

The region is reached from Halifax and Yarmouth by the Halifax and Southwestern railway to Medway station, which is also a stopping place for moose hunters in the autumn on their way to the interior hunting grounds, more especially to Indian Gardens on the Mersey river.

The small area surveyed on Pleasant river is rocky, swampy, and unsettled, and it is unsuitable for agriculture. It is largely covered with forest, burnt woods, or barrens. Spruce and pine are lumbered on a small scale on the upper part of the river. Beaver dams and houses were observed at the outlet of Beaver lake, a western tributary of the river, showing the presence of a colony of beavers. Beaver cuttings were also observed in 1902, near the outlet of Lower Shingle lake, 2½ miles south of the railway. This is probably the farthest east locality where beavers are known to exist on the southern watershed of the Atlantic coast. The information is worth recording as the beaver is fast becoming extinct in the Province and should be more vigorously protected.

General Geology.

The portion of the Medway basin surveyed last summer is entirely underlain by the quartzite and slates of the Goldbearing series which cover the seaward half of the peninsula of Nova Scotia between Canso and Yarmouth. In the absence of fossils and other conclusive evidence as to their age, it has been customary to provisionally refer these rocks to the lower Cambrian, though on account of their similarity to the quartzites and slates of the Avalon peninsula of Newfoundland, which have been assigned on fossil evidence to the Pre-Cambrian, as well as for other reasons, it is possible that they may be Pre-Cambrian.

On the Atlantic slope of Nova Scotia, between Medway and Canso, these sedimentary deposits have been found everywhere to form one conformable sequence of strata, the total known thickness of which has been estimated at 27,700 feet. This great series of rocks has been divided into two distinct lithological divisions: a lower one, called the Goldenville quartzites, and an upper one called the Halifax slates. The Goldenville formation as exposed at Moose river, has a thickness of over 16,000 feet of strata largely made up of thick beds of metamorphic quartzose-sandstone or quartzite interstratified with numerous layers of slates. The Halifax formation has a thickness of 11,700 feet and is entirely composed of argillaceous and siliceous slates with occasional flinty layers. In this sequence of strata is not included, however, the upper slate series of the Gaspereau valley which conformably overlies the two prominent bands of Whiterock quartzite, which in turn apparently overlie conformably the Halifax slates, as described in the Summary Report for 1908. The upper slate series of the Gaspereau valley has a thickness of 2,800 feet which, added to the 27,700 feet of the Goldbearing series proper of the Atlantic coast, would give a total known thickness of 30,500 feet of probably conformable strata.

After deposition, the Goldbearing series was uplifted and sharply folded into a succession of huge anticlinal ridges and intervening synclinal troughs which have a general east and west direction roughly parallel with the Atlantic coast. During and after the folding, extensive erosion truncated the crest of the folds and gradually planed down the surface to its present level, exposing the uptilted, once deep seated, strata. The anticlinal folds seldom lie horizontally, but generally pitch to the east or west, and where they pitch in opposite directions anticlinal domes are formed. Much economic importance is attached to the location and structure of the anticlinal folds and domes, because practically all the gold and tungsten deposits in Nova Scotia are situated on anticlinal domes, where they occupy zones of interbedded fractures caused by the folding.

In the eastern part of the Province, the folds are sharper, and pitch to the east or west at lower angles then to the westward of Halifax; as a result, in the east the domes are very narrow and much elongated, while in the west they are broader and more circular in shape. This latter form of domes is especially well developed in the Medway and Lahave districts, where the folds have a pronounced pitch to the eastward as far as the transverse north-south syncline along Lahave river, while towards the west they form broad elliptical domes which indicate the existence of a general transverse upheaval or anticline. As a result of this geological structure the Halifax slates cover the greater part of the Lahave basin and extend westward in narrow infolds along the synclines; while the Goldenville quartzites are brought up to the surface over the greater part of the Medway and Mersey basins and extend eastward into the Lahave basin in narrow belts along the crests of the anticlines. The great extent of the slate formation in Lahave basin is the principal cause for the predominance of the fine soil and smooth surface of that district contrasting with the characteristic stony and rough nature of the lower Medway and Mersey basins.

In many cases the structure is rendered still more complex by the occurrence of several small subordinate folds along the apex of the major anticlines, as well as along the bottom of the major synclines. This complex structure is well exposed along the sea-shore between Medway and Liverpool bay, but inland the rock exposures are scarce and widely scattered, and, on this account, more detailed field work is still required to make out in detail the geological structure of that section.

The only igneous rock observed in the district is an important dyke of diabase, 200 to 500 feet wide, extending along the sea-shore in a westward direction for at least 25 miles, from West Ironbound island at the mouth of Lahave river to Liverpool, beyond which it was not traced. It outcrops on West Ironbound island immediately north of E. DeWolf's house, crosses Cape Lahave island along Halibut and Bantam bays, where it shows prominently above the surface, then it strikes the mainland at Cherry cove where it is deflected southerly along Back and Apple coves, then resumes its westerly course along the north side of Conrad beach and crosses Medway between Selig and Great islands, beyond which it is concealed by soil for a few miles but outcrops again on Great hill and on a small knoll one-fourth of a mile north of the railway station at Liverpool.

The area surveyed last season on Pleasant river is covered on its southern portion by the Goldbearing rocks which extend south to the sea, while its northern portion is occupied by the granite which forms part of the main batholith constituting the South mountain. The granite boundary has been traced westward from where it crosses Lahave river, 1 mile below Meisner bridge and 3 miles north of New Germany, to the old Liverpool road, 2 miles north of the Halfway brook, crossing Rocky and Pleasant River lakes and passing a short distance to the north of Beaver and Cranberry lakes.

The greater part of the area covered by the Goldbearing rocks is occupied by the Halifax slate formation spreading westward along a deep and broad syncline, the axis of which passes half a mile north of New Germany and Hemford Railway station. A good section of these slates and the syncline is well exposed on the West Lahave river. The Halifax slates are underlain on the north by the Goldenville quartzites which are cut a little farther north by the granite and form a narrow belt, from half a mile to 1 mile in width, extending westward.

The granite is for the most part light grey, coarse, and porphyritic with large feldspar crystals. A fine-grained biotite granite, generally dark grey or reddish grey, also occurs in small irregular lenticular masses throughout the coarser variety. This latter phase of granite intrusion sometimes sends dykes into the older granite in the form of aplite dykes and quartz veins which are often mineralized and similar to those already described at New Ross.

Economic Geology.

At the present time it is thought advisable to offer only a few general remarks on some of the mineral deposits examined last summer, since a large part of the surveys are not yet compiled and, in some cases, more field work is still required.

Gold and tungsten-bearing veins are the only deposits of economic value so far discovered in the lower part of the Medway basin. Gold quartz has been mined quite extensively for many years at Molega and to a limited extent at Vogler Cove, Mill Village, and Fifteenmile Brook; but no actual mining was in progress at these mines last summer, except some exploratory work at Molega and Fifteenmile Brook.

The valuable tungsten-bearing mineral scheelite was discovered in quartz veins at Molega in 1894 and also at Fifteenmile Brook and Baker Settlement in the last two years.

As a general rule, the character of the country is unfavourable to the prospector, since the bed-rock is, in most places, deeply covered with drift. This is especially the case at Mill Village and Fifteenmile Brook where some rich float of gold quartz found in the drift could not be traced to its source. Hence, to guide the prospector, it is important to map out as accurately as possible the position and structure of the anticlinal domes on which the gold and tungsten deposits generally occur.

Attention may be drawn here to the excellent road material afforded by the diabase dyke, already described, crossing the district from east to west along the shore and passing at Great hill, a short distance north of the town of Liverpool, where it might be advantageously utilized to macadamize the streets. From experiments made in the States of Massachusetts, Maryland, and Wisconsin[1] on the comparative wearing and cementing values of different materials generally used for road macadams, diabase was found to be one of the best for strength and durability.

MOLEGA.[2]

A detailed survey was made in 1904 of the gold mining district of Molega, and a plan was published on the scale of 250 feet to 1 inch. The plan shows the extent of the mining and development work done on numerous interbedded quartz veins occurring in the Goldenville quartzites, over a large area, on the northeastern side of an anticlinal dome. Since then, some exploratory work was done on the South Rabbit lode and on the anticline where superimposed saddle-veins were uncovered pitching east 15°. These saddle-veins determine the exact position of the anticlinal axis which is 58 feet farther south than that indicated on the published plan.

FIFTEENMILE BROOK.

This gold district is situated on the road to Brookfield, 15 miles north of Liverpool and 2 miles north of Middlefield post-office. The Goldenville quartzites are

[1] Highway Construction in Wisconsin, by E. R. Buckley, Bull. No. X, 1903, Wisconsin Geological Survey.

[2] Molega is the name of the post-office, but Malaga Barrens is sometimes used by the Department of Mines of Nova Scotia to designate the mining district.

exposed here at the surface for a width of over 1 mile on the eastern part of an anticlinal dome, on which they dip to the north at high angles and to the east and south at lower angles, and are conformably overlain by the Halifax slate. At a distance of 2,100 feet north of the major anticline, rich float of gold quartz has been found along the north side of Fifteenmile brook for a distance of 1,000 feet east and 1,600 feet west of the road. The exploratory work done so far has failed to discover the veins from which the float was derived, on account of the heavy soil covering the bed-rock. Several interbedded veins have been cut on both sides of the road, but so far none of these have been found to carry payable ore. On the western side of the road a small ore-shoot pitching west at a low angle, was worked for a while on a "fissure" vein cutting the strata at a slight angle. Apparently on this same vein and 690 feet east of the road, several pieces of scheelite associated with arsenopyrite were discovered last October while examining the quartz taken from a trial pit dug by Ells. This new discovery of tungsten may prove of economic importance, for at a short distance to the southwest several loose pieces of the same mineral were discovered last year in drift by W. H. Prest, of Bedford, N.S., indicating a widespread distribution. It may be observed that, on this vein, the scheelite will probably occur in ore-shoots formed at the intersection of the fissure vein with the interbedded veins and will pitch to the west at a low angle; while in the interbedded veins the ore-shoots will more probably pitch westward like the rolls and anticline.

BAKER SETTLEMENT.

The new discovery of scheelite made last spring at Baker Settlement, Lunenburg county, is situated 12 miles northwest of Bridgewater and half a mile north of Huey lake. Eight interbedded quartz veins, from 2 to 18 inches thick, occur here within a space of 300 feet in bluish-grey siliceous slate of the Halifax formation. The veins dip south 35°, and occupy a zone of fissures on the southern side of an anticline which is followed a short distance farther north by a syncline, forming a double crumpling of the strata pitching to the east at a low angle. Scheelite was found on two of these veins, in pockets and in thin veinlets along the walls. One of the veins is 4 to 8 inches and the other 2 to 3 inches thick. Both veins are crinkled in rolls and contain much massive mispickel and some crystals of quartz, mispickel, and pyrites mostly along the centre and in the rolls. The slate forming the walls is also spotted with small crystals of mispickel. Scarcely any prospecting has yet been done; the two scheelite-bearing veins having been stripped only a few yards where the surface is shallow. Prospecting should be extended farther north across the anticline and syncline, and also east and west along these two folds. The ore-shoots will probably be found to pitch eastward at low angles, following the lines of intersection of the bedding with the cleavage, or the plunge of the rolls or folds, as at Moose river.

No minerals of economic value have been found yet in the Goldbearing rocks or granite covering the Pleasant River district. A few small dykes of aplite and quartz slightly mineralized with iron pyrites have been observed in the granite, however, which may also contain useful minerals like those discovered at New Ross.

Outside of the area surveyed last summer, special examinations were made, in Lunenburg county, of the gold mines of Blockhouse, the tin prospect of New Ross, and the gypsum and limestone deposits of Chester Basin; and, in Halifax county, of the tungsten deposits being developed at Scheelite, near Moose River Gold Mines, and those prospected by A. L. McCallum 1 mile north of Waverley.

NEW ROSS.

At Mill Road, 4 miles north of New Ross, two shafts, 100 feet apart, have been sunk on the tin-bearing vein of quartz discovered by E. Turner, in the granite. The south shaft is 55 feet and the north one 25 feet deep. At the surface, where first discovered, the vein was 2 feet wide and showing good tin ore, but the development work has proved the vein to be irregular and to pinch out horizontally and in depth, and the prospect has been abandoned. The associated minerals observed in the vein besides cassiterite were chalcopyrite, stannite, wolframite, scheelite, tungstite, zinc blende, molybdenite, mispickel, purple fluorspar, pale green serpentine, white mica, and reticulated veinlets of opalescent and smoky quartz and of red feldspar. Crossing the river below the bridge, a short distance west of the tin-bearing vein, is a large dyke of pink feldspar which may be of economic value.

CHESTER BASIN.

Lower Carboniferous deposits of shell-limestone, gypsum, sandstone, and shales were observed on several islands in Chester basin, where their presence was hitherto unknown; notably on the mysterious Oak island, renowned for the extensive excavations that have been made from time to time during the last 60 years searching for Captain Kidd's fabulous hidden treasures which are supposed to have been buried somewhere along the Atlantic coast. It is said that several hundred thousand dollars have been spent already in sinking shafts and driving tunnels, and further work is still contemplated. There is strong evidence to prove that the supposed artificial openings which originally led to such undertakings were really but natural sink-holes and cavities formed by the gradual dissolution of gypsum deposits underlying thin layers of soft sandstone and shales which gave way under the pressure of the superincumbent covering of glacial drift. Similar sink-holes may still be observed on the shore of the main land nearby.

It is interesting to record the information received by the writer from Mr. H. S. Poole, Spreyton, Guildford, England, who was for several years in Nova Scotia as superintendent of the Acadia Colliery at Stellarton, that in 1862, he found float of tungsten in Guysborough county, about 3 miles south of Sherbrooke, behind the cottage of—Lynch, on the east bank and within half a mile of the river.

Float of scheelite is reported to have been found in Halifax county, some distance south of Pockwock lake, to the west of Sackville, by W. H. Prest; also some distance back of Oldham, by Charles Donaldson, of Enfield.

LAHAVE VALLEY AND STARRS POINT, NOVA SCOTIA.

(*W. J. Wright.*)

Two weeks were spent in the Lahave valley, Lunenburg county, Nova Scotia, studying the rocks in the field, collecting specimens for thin sections, and examining in more detail several minor problems that arose during the work in 1910.

The topography of the area is due largely to the work of the continental ice-sheet on the surface of an uplifted and dissected peneplain. Immediately before the glacial period, the country had a low relief and a gentle regional slope of less than 15 feet per mile towards the Atlantic, with a marked river valley where the Lahave is now located. Glaciation removed the loose material from some parts, and accumulated it in others. Consequently, large areas are denuded of soil, while other areas are covered with great amounts of drift in the form of irregular groups of hills elongated in the direction of ice-movement. The rearrangement of material has had a marked effect on the country. For not only has it interfered with the drainage, even going so far as to pond up the waters of the Lahave to form two large lakes, but also, since the drift forms most of the farming land in the country, its distribution determines the location of most of the country villages.

While the location of much of the present drainage has been influenced by glaciation, Lahave valley existed in preglacial times. A probable explanation of its location grows out of the study of the fault system of the area. There are no faults large enough to be shown on the map; but there are numerous small fractures, striking parallel to the valley, in which the western side always seems to be downthrown, and shifted to the south. This movement has been concentrated along the Lahave. Consequently, we have here a zone of weakness, which has yielded more readily to erosion, and along which the valley has been excavated.

In this connexion, it is interesting to note that the greater part of the drainage lines of the Atlantic slope of Nova Scotia, fall into a parallel system, which lies across the folded structure of the rocks, and is independent of the initial slope of the peneplain. The completed structural maps show a system of major northwest and southeast faults; there has been displacement of the western side towards the south. It seems probable also that the strain producing these faults must have produced other lines of weakness like that in Lahave valley, where the movement was too small to be shown on the maps. The drainage system is parallel to the fault system and some of the rivers are located on major fault zones throughout the whole, or greater part, of their courses.

The suggestion at once arises that there is a close relation between the two systems; and that the direction and location of drainage have been influenced by the fault zones. Furthermore, the system of parallel valleys probably influenced the direction of movement of the ice-sheet, and the consequent shape of the drift hills. These, in turn, have influenced the directions of minor drainage and roads. And the remarkable parallelism between the roads, streams, and faults, shows how structural lines laid out in a remote geologic period, may influence later geologic agencies, and be reflected, even to-day, in the topography and human activities of the country.

The general geology of this area has been discussed by Mr. Faribault in his summary report for 1910; but a few words more may be said about the granite. The main mass of the granite is coarse-grained, porphyritic rock, made up chiefly of plagioclase, quartz, and biotite. The feldspar crystals, often an inch or more in length, give the rock its porphyritic texture. This rock is cut by numerous dykes, which appear to grade from typical pegmatites, through a light-coloured aplite, made up chiefly of plagioclase, quartz, and muscovite, to a darker rock in which biotite is abundant.

Besides the coarse-grained granite, there is at least one area of a younger granite, which lies just east of Woodworth brook, with its southern boundary about half a mile north of the sedimentary rocks. Near the contact, the younger granite is a light-coloured rock, with a fine, even, texture, made up chiefly of plagioclase, quartz, and muscovite. Away from the contact, the rock is coarser grained, and biotite becomes the predominant mica. The main body of the younger granite has about the same mineral composition as the older granite; but the two rocks differ in texture and general appearance. There is a marked similarity between the younger granite and the dykes which cut the older granite. It seems probable that they are closely related, and that both are differentiated parts of the magma which formed the older granite. If this be true, it is probable that in places one granite grades into the other, and that the two cannot be completely separated.

The Triassic sandstones at Starrs point, Kings county, were visited in order to obtain some information regarding the manner of their deposition. The Triassic sandstones of the Connecticut valley are fluvial deposits in a region having a semi-arid climate. In Nova Scotia, the predominant red colour, presence of gypsum, mud cracks, sub-angular pebbles, crossbedding, and the unsorted nature of the material, all indicate a similar mode of deposition. But further study is necessary to decide the question.

The sea-wall at Starrs point rises perpendicularly above the level of high tides, and shows erosional forms which are not commonly associated with moist climates. The sandstone is poorly cemented and decomposes readily to a fine sand. The wind carries much of this sand against the cliffs and has carved them into forms characteristic of dry climates where wind erosion predominates.

BORE-HOLE RECORDS. (WATER, OIL, ETC.).

(*E. D. Ingall.*)

Since the period occupied by the last annual report a large proportion of the time of the officer in charge of the branch has been occupied in the clerical and routine work involved in the collection of boring records, sets of drillings, and the geological data necessary to the elucidation of the material collected.

The packing up and removal of the drillings, etc., from the old to the new museum necessarily resulted in the consumption of considerable time in the unpacking and rearrangement of the specimens so as to have them accessible for further study, reference, and comparison. Very effective assistance in unpacking was rendered by Mr. F. J. Barlow for a few weeks previous to his departure for the field, and later, for a similar period, by Mr. F. Hallam.

A number of sets of drillings from wells drilled throughout the peninsula of Ontario are still packed away in boxes. These represent material collected by Mr. Brumell many years ago, the logs of many of which are to be found in his report on gas and oil (Part Q, Vol. V). There are also some collected by Mr. Chalmers, whose death prevented the information therein contained from becoming available.

When time and space permit of the unpacking of these drillings and they can be placed in series with the other sets illustrative of various sections of Canada, they should be very useful for purposes of corroboration and comparison as well as for study by drillers and operators contemplating similar operations in the future.

Whilst the additions to our collection of records have not, during the year, been as numerous as might be wished, it is believed that, judging from the statements of various drillers, a considerable improvement in this regard can be expected when it is found possible to have a fund out of which some slight recognition can be made of their goodwill and efforts on behalf of the work.

As in previous years, the branch has been able to render service to those interested in boring operations in different parts of the country in the way of information embodied in memorandum, or given verbally, relating to the general geological conditions where boring operations were contemplated or proceeding.

The sets of drillings and logs of numerous wells bored by the Maritime Oil Fields Company of Canada, near Moncton, N.B., are being studied by Dr. G. A. Young and utilized in connexion with the working out of the geological map he is making of that district.

As a result of the epidemic of typhoid which developed in Ottawa last autumn public attention was directed toward the possibility of obtaining pure water from deep borings. In response to inquiries by the Senate, as well as by the management of the Chateau Laurier, a preliminary study was made and a memorandum prepared of the conditions of occurrence of the crustal waters as far as shown by the available records of deep bores already made in the district. The evidence was not very extensive or final either as to quantity or quality of the water thus to be obtained. At most of the producing wells the water is used mainly for cooling purposes in connexion with dairy, cold storage, brewing, and sulphite plants. The chemical composition of the water being unimportant for the above purposes no effort has been made to case off the water of the different depths at which it has been encountered, so that the borings so far made give no definite data as to the quality of the supply in the different strata pierced.

The information regarding the occurrence of water in the sedimentary strata underlying the Ottawa district then is as yet quite incomplete and inconclusive, but our knowledge of the general conditions would lead to the surmise that there will be found to be no essentially water-bearing stratum except, possibly, that of the sandy shales below the limestones of the Trenton and Black River age which may prove to have somewhat greater porosity than the other members of the series. In the limestones mentioned there are doubtless many water-worn channels and enlarged joint systems, but it could only happen that such would be encountered by chance. Furthermore, the water in the limestones would perhaps be more likely to carry a higher content of mineral salts than that in the sandy shales. The fact that the water from many of the borings so far made has carried considerable mineral salts casts no light upon these questions, as it always represents a mixture from several different horizons.

The rocks of the district being considerably faulted, a condition favourable to the existence of water supplies may exist in certain sections where these faults are plentiful. Investigations were commenced during the summer to trace out these features of the geology, especially in view of the considerable amount of rock excavation now in progress in connexion with the extension of the city drainage system throughout the newly annexed districts.

Other interesting problems which have been under consideration during the year are those connected with the operations of the Canadian Standard Oil Company which has put down a number of holes in search of oil and gas, both in the vicinity of Ottawa and in the county of Kent. Through the courtesy of the officials of this Company valuable and complete sets of drillings were obtained from three wells in the Ottawa district and from two in Kent county. Thanks are due to Mr. F. H. Simmons of the staff of this corporation for his assistance in helping the branch to keep in touch with operations, as well as to Messrs. E. W. Mooney and J. Bowlby of the drilling staff for their courteous co-operation.

In their operations in Kent county the Company could use the information contained in various published reports of the district as well as the experience of numerous operators in the vicinity. In the Ottawa district, however, although a certain amount of spasmodic boring has been done over a wide area, the search for gas and oil is yet in the pioneer stage. In initiating operations, therefore, the choice of localities for boring became one of a summing up of the general conditions of the region as elucidated by the geological studies of the officers of the Geological Survey and of the results of previous borings as far as known.

As in the case of the boring previously made at Plantagenet, the evidence in the case was thoroughly reviewed with the interested parties in order to give all possible assistance in the selection of the most likely places to bore.

Amongst the various factors to be taken into account are the presence of anticlines and synclines; the porosity or storage capacity of the different strata; the presence or absence of adequate cover for holding in the gas or oil; the presence of faults, etc. The geological maps of the eastern Ontario area contain a large amount of information of a general nature on most of these points, but a very detailed re-survey would be necessary to define the minor structural features which have so important an influence in determining the limits of the pools, although a short memoir might be written summarizing the data at present available and in discussion of their bearing on the problems under consideration.

The operations of the Standard Oil Company in the eastern Ontario field consist of three holes covering a triangular area some 5 miles in extent in the township of Cumberland, about 14 miles easterly from Ottawa along the line of the Grand Trunk railway to Montreal.

The importance to the Capital of success in finding an adequate supply of natural gas within piping distance of the city gives added interest to these explorations. In the first hole the whole sedimentary series was penetrated down to the Potsdam, when drilling was discontinued on account of the very slow progress made, due to the great hardness of the sandstone encountered. In the other two no attempt was made to penetrate below the upper beds of the Trenton. In all of the bores gas was obtained in varying quantities, the last made giving the most encouraging result; no measurements of the quality were made, however, by the owners.

As aresult of the operations of the Company in western Ontario, large yields of oil are reported.

The search for gas and oil throughout the northwest provinces of Canada is known to have been active, but unfortunately under present conditions few returns can be obtained.

With the sanction of the Director, field work was prosecuted during the latter part of the summer in Ottawa, Hull, and environs in tracing out the fault systems in extension of the work done by Dr. R. W. Ells in previous years. Advantage was taken, as before-mentioned, of the considerable amount of excavation being prosecuted by the city. An area of some 5 square miles, covering the western parts of the above-mentioned cities, was gone over very closely in search for evidence both positive and negative of the existence of lines of faulting and their extension, and of other structural features, having in mind especially the possible connexion of water-bearing borings with zones of disturbance. The section of the strata in the cliffs along the water-front of the Ottawa river, from above the Chaudière falls to Rockcliffe, was carefully gone over, and fossils were collected and referred to the palæontological branch for determination of horizons. Especial care was taken to study many places left bare by the exceptionally low water, which would perhaps not again be accessible for a long time.

Pursuant to the understanding arrived at in conversation with the Director just previous to his departure for the west, field work was extended outside of the Ottawa and Hull district proper.

PALÆONTOLOGICAL DIVISION.

I

Vertebrates.

(Lawrence M. Lambe.)

The removal of the fossil collections from the Sussex Street building of the Geological Survey to the Victoria Memorial Museum was effected between December 29, 1910, and January 4, 1911, the old cases being temporarily utilized for the display of the fossils on the ground floor of the new building. The office assigned to me in the Victoria Memorial Museum was occupied on January 5.

The greater portion of my time, during the past year, has been devoted to the study of recent accessions to the Museum, and to preparations for the arrangement, and proper public display, of the collections of fossil vertebrates.

In this connexion work on the catalogue of the fossil vertebrata, begun in 1908, was continued. By the addition of the species in our possession belonging to the Agnatha, the Amphibia, those sections of the fishes not already recorded, and the numerous accessions, principally of mammals, made to the collections during the past two years, the catalogue has been almost completed and could be put in shape for publication within a short time.

Descriptive labels have been prepared for the principal specimens which illustrate different vertebrate orders, and the life of definite geological periods. These are written in a popular style and are intended specially to interest and instruct the public. Labels of a similar character have also been written descriptive of the evolutionary changes illustrated by series of fossil forms (Horses, Proboscidea, etc.) lately acquired by the Department.

These labels are to be supplemented by a list, which has been prepared, in tabulated form, of the "Orders of Vertebrate Animals" both fossil and recent. It was also thought desirable to have for exhibition with the fossil vertebrates a table of geological formations as developed in Canada, giving the animals characteristic of the various horizons and successive vertebrate life zones, and illustrating the gradual change from low to higher forms. Such a table is now in course of preparation.

During the past year a descriptive and illustrated popular guide to the fossil vertebrate collections was begun, and will be continued as time permits.

A valuable addition to the vertebrate palæontological collections consists of the lately acquired Pleistocene mammal remains from Yukon, mentioned in the list of accessions to the Museum for the year. These remains include, besides those of mammoth, horse, deer, etc., the greater portion of the bones of one individual of *Bison crassicornis* which could be mounted with little restoration to make a complete skeleton.

Other important specimens received during 1911 are enumerated below, and serve to illustrate, in the general scheme of evolution, forms not hitherto represented in the collections of the Geological Survey.

The series of casts of skulls, feet, and type specimens of fossil Equidæ, illustrating the evolution of the horse, which the American Museum of Natural History, New York, has lately presented to the Geological Survey, is a most welcome addition to our palæontological collections and forms in itself an exhibit of great interest and value. Dr. W. D. Matthew, Acting Curator, in formally presenting the series, on behalf of the American Museum, writes that the donation is made in appreciation of the many courtesies received from members of the Survey staff, and of the "splendid scientific work which the Canadian Geological Survey has accomplished and is now continuing."

Miss A. E. Wilson has continued, in a most satisfactory manner, the work of cataloguing the type and figured specimens of fossils in our possession. This included the recording of information relative to type material subsequent to a full examination of all literature bearing on the subject. She has also attended to the cataloguing of lately acquired fossil vertebrate material.

As recorded below a number of mounted skeletons of recent vertebrates have been added, during the past year, to the "Osteological collection" which is primarily intended for use in connexion with palæontological studies.

The following papers were written during the year:—

"On Arctotherium from the Pleistocene of Yukon;" descriptive of the new species *A. yukonense* and published in the May number, vol. XXV, of the Ottawa Naturalist.

"The Past Vertebrate Life of Canada," being the Presidential Address of Section IV, Royal Society of Canada, at its annual meeting in Ottawa in May.

"Bibliography of Canadian Zoology for 1910 (exclusive of Entomology); presented at the annual meeting of the Royal Society in May.

"On the occurrence of Helodont teeth at Roche Miette and vicinity, Alberta," describing the new species *Helodus subtuberatus* from upper Devonian rocks. (In press.)

A small, detached fish tooth of the genus Helodus, collected by Mr. D. B. Dowling during the past season, from the limestones of the summit of Roche Miette, Alberta, is described and figured in the last-mentioned paper. The genus Helodus has not hitherto been recorded from Canada, and the species represented is apparently new. For the species the name *subtuberatus* is proposed, with reference to the inconspicuous swelling observed on either side of the central prominence of the crown. The limestone beds at the summit of Roche Miette are apparently of uppermost Devonian age. A portion of a second tooth, referred to this species, was also obtained last summer by Mr. Dowling, 6 miles north of Roche Miette, from limestones presumably of the same geological age as those forming the summit of this mountain.

ADDITIONS TO THE VERTEBRATE PALÆONTOLOGICAL COLLECTIONS DURING 1911.

Collected by Officers of the Geological Survey.

Dowling, D. B.—

Two teeth of Helodus, Agassiz, from the upper Devonian of Roche Miette and vicinity, Alberta. Acc. No. 35.

MacKay, B. R.—

Portions of humerus, radii and tibia of *Bison americanus,* from Pleistocene terrace gravels, Crowsnest river, Alberta, one mile west of Coleman. Acc. No. 36.

Received by Purchase.

Portheus molossus, Cope. Mounted composite specimen from the chalk beds of the Niobrara Cretaceous, Gove county, Kansas. Acc. No. 26.

Stylemys sp., carapace. Miocene. Acc. No. 10.

Naosaurus claviger, Cope. Permian, Texas. Restoration model in plaster, one-fifth natural size. Acc. No. 20.

Ichthyosaurus quadriscissus. Quenstedt. Lias, Würtemberg, Germany. Fossil on slab. Acc. No. 33.

Phytosaurus (Belodon) cylindricodon, Jäger. Trias, Würtemberg, Germany. Plaster cast of skull with lower jaw. Acc. No. 11.

Steneosaurus bollensis (Jäger). Lias, Würtemberg, Germany. Head and front portion of body on slab. Acc. No. 12.

Steneosaurus bollensis (Jäger). Lais, Würtemburg, Germany. Specimen complete on slab. Acc. No. 32.

Pterodactylus antiquus (Sömmering). Lithographic stone (Kimmeridgian), Bavaria. Plaster cast, natural size. Acc. No. 30.

Archæopteryx macrura, Owen. Lithographic stone (Kimmeridgian), Bavaria. Plaster cast, natural size. Acc. No. 29.

Dinornis maximus, Owen. Quaternary: alluvial deposits, New Zealand. Complete skeleton. Acc. No. 13.

Prozeuglodon atrox, Andrews. Middle Eocene, Fayum, Egypt. Restored model of the skull and mandible, natural size. Acc. No. 28.

Arsinoitherium zitteli, Andrews. Lower Oligocene, Fayum, Egypt. Plaster cast of skull with lower jaw. Natural size. Acc. No. 23.

Dinotherium giganteum, Kaup. Lower Pliocene, Eppelsheim, Germany. Skull with lower jaw: coloured plaster cast, natural size. Acc. No. 14.

Mastodon (Tetrabelodon) longirostris, Kaup. Miocene, Eppelsheim, Germany. Cast of mandible with incisors; natural size. Acc. No. 24.

Mastodon (Dibelodon) giganteus, Cuvier. Pliocene. Scotchtown, New York. Cast of cranium with mandible; natural size. Acc. No. 25.

Elephas (Stegodon) ganesa, Falconer and Cautley. Pliocene. Siwalik hills, India. Skull without mandible; coloured plaster cast; natural size. Acc. No. 15.

Elephas imperator, Leidy. Lower Pleistocene, western United States. Restoration model. Acc. No. 21.

Elasmotherium sibiricum, Fischer. Pleistocene, Nouvonsenck, Russia. Plaster cast, natural size, of cranium. Acc. No. 31.

Titanotherium sp. Skull without lower jaw. Miocene, Chadron, Nebraska. Acc. No. 9.

Titanotheres, series of heads of; illustrating the evolution and polyphyletic development of the lower Oligocene forms, as under:—

a. *Brontotherium platyceras* (Scott and Osborn).
b. *Megacerops robustus*, Marsh.
c. *Titanotherium ingens* (Marsh).
d. *Symborodon acer*, Cope.
e. *Diplacodon emarginatus*, Hatcher.

Restoration models, one-sixth natural size. Acc. No. 22.

Merycoidodon culbertsoni, Leidy. Miocene, Chadron, Nebraska. Two skulls with lower jaws. Acc. No. 16.

Ungulate remains: purchased through Mr. D. D. Cairnes. Pleistocene, Last Chance creek, Yukon, viz:—

Mammoth *(Elephas primigenius)*. Portion of mandible with teeth, occiput, limb bones, vertebræ, etc.

Horse *(Equus caballus)*. Part of lower jaw with teeth; separate teeth.

Deer *(Rangifer)*. Parts of antlers, and leg bones, of *R. caribou* and probably of *R. grœnlandicus*.

Sheep *(Ovis montana)*. Back of skull with bases of horn-cores.

Bison *(B. crassicornis)*. Horn-cores with back portion of skull; most of the vertebral column of one individual; separate vertebræ, foot bones, etc.

The above specimens were from about 35 feet beneath the surface, and within a distance, up and down the creek, of 50 feet. Acc. No. 34.

Ungulates, a series of fifty-five coloured casts of the crowns of upper molar teeth of: illustrating the lines of differentiation from the simple tri-tubercular to the more complex forms. Acc. No. 27.

Ursus spelœus, Rosenmüller. Pleistocene. Europe. Skull with lower jaw. Acc. No. 17.

Homo neandertalensis, King. (Palæolithic man.) Pleistocene, near Hochdal, Germany. Plaster casts, natural size, of—the roof of the skull, right and left femora, parts of the hip-bone, collar-bone, and shoulder-blade, arm bones, etc. Acc. No. 18.

Recent skeletons, mounted, of—

Amia calva, L. Bowfin; in alcohol. Acc. No. 2.
Perca fluviatilis, L. European perch. Acc. No. 3.
Didelphis virginiana, Kerr. Opossum. Acc. No. 4.
Felis catus, L. Domestic cat. Acc. No. 5.
Canis familiaris, L. Dog. Acc. No. 6.
Erinaceus europœus, L. Hedgehog. Acc. No. 7.
Sphenodon punctatum, Gray. The "Tuatara" of New Zealand. Acc. No. 8.
For comparison with fossil forms.

By Presentation.

American Museum of Natural History, New York, through Dr. W. D. Matthew, Acting Curator, Department of Vertebrate Palæontology.

Casts of skulls, jaws, fore and hind-feet, and type specimens of fossil Equidæ, forming a series illustrating the evolution of the horse. The series includes twenty-one species, representing eleven genera, from Eocene, Oligocene, Miocene, and Pliocene deposits in the United States. Acc. No. 19.

Grant, Sir J. A., K.C.M.G., Ottawa, Ont.—

Three specimens of *Mallotus villosus*, Cuvier, in one clay nodule, from Green creek, below Ottawa. Pleistocene. Acc. No. 37.

ADDITIONS TO THE INVERTEBRATE PALÆONTOLOGICAL COLLECTIONS DURING 1911.

Dr. Raymond reports the following additions to the collections of invertebrate fossils:—

Collected by Officers of the Geological Survey.

Dresser, J. A.—
A large collection of graptolites from the lower Trenton at Castle brook, Quebec. Acc. No. 63.

Harvie, R.—
Large collection middle Silurian fossils, mostly trilobites, from Knowlton Landing, Lake Memphremagog, Quebec. Acc. No. 74.

Johnston, W. A.—
Large collection from the Lowville, Black River, and Trenton, from various localities east of Lake Simcoe. Acc. No. 73.

Lawson, A. C.—
Richmond fossils from a point 6 miles west of Fort Frances, Ontario. Acc. No. 62.

Leach, W.—
Small collection from the Benton and Mississippian near Blairmore, Alberta. Acc. No. 75.

Raymond, P. E.—
Several collections from Ordovician formations in southern and eastern Ontario and western Quebec. Acc. Nos. 55, 56, 60, 61, 66, 67.

Raymond, P. E., and Johnston, W. A.—
Collections from the Lowville and Trenton east of Mud lake and north of Kirkfield, Ontario. Acc. Nos. 57, 58, 59.

Raymond, P. E., and Whittaker, E. J.—
Collections from the Ordovician formations in eastern Ontario, western Quebec, and near Clayton and Watertown, New York. Acc. Nos. 64, 65, 68, 69, 72.

Whittaker, E. J.—
Several lots of fossils from localities in eastern and southern Ontario. Acc. Nos. 70, 71.

Wilson, W. J.—
Marine fossils from the Mississippian near Norton station, Kings county, New Brunswick. Acc. No. 49.

By Presentation.

Grant, Col. C. C.—
Three small collections from the Silurian at Hamilton, Ontario. Acc. Nos. 52. 53, 54.

Grant, Sir James—
Collection fossils, largely from the Trenton in vicinity of Ottawa. Acc. No. 51.

Narraway, J. E.—
Box invertebrate fossils from the Richmond at Stony Mountain, Manitoba. Acc. No. 48.

Wilson, Miss A. E.—
Twenty-five specimens from the Trenton at Cobourg, Ontario, and a collection of Pleistocene shells from Lampton Mills, near Toronto. Acc. Nos. 45, 47.

Wilson, W. J.—
Large collection fossils from the lower part of the Utica, between Rochester and Preston streets, Ottawa, Ontario. Acc. No. 77.

By Purchase.

Bassler, Dr. Ray S.—
A collection of 400 species of bryozoa. Acc. No. 50.

Comer, Capt. George—
Fifteen specimens from the Silurian at Southampton island, Hudson bay. Acc. No. 46.

ADDITIONS TO THE PALÆOBOTANICAL COLLECTIONS DURING 1911.

Mr. W. J. Wilson reports that collections of fossil plants were received, during the past year, as follows:—

By Presentation.

Mr. James Crawford, Ottawa, per W. J. Wilson—
Four large segments of a fossil tree and twelve small fragments of same, from Wallace quarry, Cumberland county, Nova Scotia (Coal Measures).

Collected by Officers of the Geological Survey.

Keele, Joseph—
Twenty small specimens of Tertiary fossil plants from the Dirt hills, Saskatchewan.

Leach, W. W.—
Four small specimens of Cretaceous fossil plants from Blairmore creek and Ma butte, Alberta.

Malloch, Geo. S.—
Thirty-four specimens of fossil plants (Kootenay) from the Groundhog coal basin and Upper Skeena river, British Columbia.

Dowling, D. B.—
Twelve specimens of fossil plants (Kootenay) from Jasper Park collieries and near Folding mountain, Jasper Park, Alberta.

Reinecke, L.—
Twelve specimens of fossil plants (Miocene) from Beaverdell district, British Columbia.

II

Invertebrate.

(*Percy E. Raymond.*)

FIELD WORK.

OTTAWA VALLEY.

The months of June. July, and a part of August were spent in an investigation into the stratigraphy of the Ordovician formations of the Ottawa valley. The principal rock exposures about Ottawa, Hawkesbury, Montreal, Cornwall, Brockville, and Kingston were studied, and a short trip into New York state at Clayton and Watertown was made under the guidance of Professor H. P. Cushing of Western Reserve University. A week was also spent with Mr. W. A. Jonhston, in going over some of the better sections at localities on the Brechin and Kirkfield sheets, Simcoe district. These sections are described in Mr. Johnston's reports. Mr. E. J. Whittaker acted as assistant throughout the season, and did very excellent work.

The Ordovician formations of the Ottawa valley usually rest upon the Potsdam sandstone, which is supposed to be of upper Cambrian age, and formations of the following ages occur, beginning with the oldest: Beekmantown, Chazy, Pamelia, Lowville, Black River, Trenton, Utica, Lorraine. The result of the season's work on each of these may be summarized briefly.

Beekmantown.

In the vicinity of Brockville and Smiths Falls the Beekmantown is divisible into two formations. The older formation has two members. The lower part is a rather soft calcareous sandstone, usually thin-bedded. In places, however, the cement is siliceous and the beds very hard. These beds are especially well exhibited about the railway station at Smiths Falls, and in the cuttings south of the station on the line to Brockville. Fossils are there fairly common, and the presence of *Ophileta complanata,* and a gastropod very like *Pleurotomaria canadensis* indicate the Beekmantown age of the formation. The upper member of this formation is a thin-bedded bluish dolomite which weathers to a rusty yellow colour. These beds contain obscure gastropods and crinoidal remains. At Smiths Falls the thickness of the whole formation is above 70 feet, but it seems to thin northward, for it appears to be only about 20 feet thick at Rockland, where it also contains gastropods, and only the lower, sandy member is present. At Ste. Anne de Bellevue this formation seems to be absent, and the layers which are above it at Smiths Falls rest directly upon the Potsdam sandstone.

This formation appears also in New York state, in the vicinity of Clayton, and has been given the name Theresa by Prof. Cushing. This name may be adopted in Canada also.

Above the thin-bedded dolomite of the Theresa there are heavier-bedded limestones and dolomites with a rather large fauna. The greater part of the species are found also in the lower part of the Beekmantown section in the Champlain valley, thus fixing the age rather definitely as lower Beekmantown. It will, however, be necessary to give a new formational name to these beds, and Beauharnois may be suggested, from the classic exposures along the Beauharnois canal between Valleyfield and Beauharnois. In the upper beds at Grenville and at the mouth of the Little Rideau, there is a rather peculiar fauna, dominated by *Bathyurus angelini,* which has heretofore been incorrectly referred to the Chazy.

Chazy.

The investigation of the stratigraphy of the Chazy formation, started last year, was continued, and it was found that the so-called Chazy of the Ottawa valley was composed of two formations, separated by an unconformity which represents a time interval during which the eastern sea withdrew to the east and the interior sea advanced from the southwest.

The beds in the Ottawa valley which are really of Chazy age are those referred to as the Chazy sandstone in the various reports on the district. In the vicinity of Ottawa, this formation has a thickness of 125 to 150 feet, the upper 20 feet being an impure limestone, and the lower part sandstone and shale. The limestone at the top contains fossils characteristic of the upper Chazy. Although this limestone is thin, it can be traced eastward along the south side of the Ottawa river, through Rockland, L'Orignal, and Hawkesbury, becoming thicker, purer, and more fossiliferous as one proceeds eastward. At the Ross quarry on the Little Rideau, 6 miles east of Hawkesbury, it is a massive coarse-grained limestone, with a very abundant and characteristic upper Chazy fauna.

The name Aylmer formation has been applied to this development of the upper Chazy in the Ottawa valley.

Pamelia.

At Ottawa, the thin limestone of the upper Chazy is followed by a formation which is shaly and sandy in its lower portion, but consists for the greater part of limestone. There are two easily recognizable divisions, the lower composed of dark blue and grey limestone full of ostracods, with sandy shales at the base. The second consists of light buff, fine-grained, pure limestone alternating with beds of bluish magnesian limestone, which weathers yellow. At the base of the upper division is a bed of coarse sandstone. Neither division contains any greater variety of fossils, but such species as are found are more nearly akin to the Lowville and Black River faunas than to the Chazy. As this formation is traced eastward it becomes thinner. The last actual outcrop seen in that direction is at L'Orignal, and at Montreal the Lowville rests directly upon the limestone of the Aylmer formation.

In northern New York there is a formation beneath the Lowville which is lithologically similar to this. It, too, consists of two members, the lower of rather pure dark limestone, and the upper of alternations of pure buff limestones and "cement beds." Through the kindness of Prof. Cushing the writer was able to see some of the best exposures of this formation, and found the upper beds identical in lithology and fauna with the beds in a similar stratigraphic position at Ottawa. The dark limestone of the lower division in New York has, however, a very different fauna from the beds in a similar position at Ottawa. The characteristic fossil of these beds in New York is a species of *Tetradium*, still undescribed. This coral has not yet been found in the Ottawa valley, but the writer found it to be abundant in the lower Pamelia of southern Ontario, at Kingston Mills (near Rideau station) and at Rush bay on Wolfe island. At the latter locality, the limestone holding the *Tetradium* is underlain by a brown and black shale with an abundance of ostracods, among them *Isochilina? clavigera*. This ostracod is abundant in a similar black shale beneath the dark limestone at Ottawa, and it is believed that the shales at the two localities represent the same horizon. If this be so, then the name Pamelia can be adopted for the formation in the Ottawa valley.

Lowville.

As at present restricted, this name is applied only to the buff, fine-grained limestone characterized by *Tetradium cellulosum* and *Bathyurus extans*. During the season very good collections of the fossils of this formation were made at Pointe Claire, Rockland, and Ottawa. The formation is from 15 to 30 feet thick in the Ottawa valley, but thins northward and eastward, being entirely absent at Joliette, where the Black River rests upon the upper Chazy.

Black River.[1]

In the Ottawa valley the Black River formation proves to be from 30 to 40 feet in thickness, and consists of two portions. The lower 15 feet consists of fine-grained,

[1] The name Black River is here used in the sense in which it has been accepted in New York until recently, i.e., as including those beds between the 'Birdseye' and Trenton which contain Columnaria, Gonioceras, Hormotoma, etc. It may be well to use the term as was done by Vanuxem in 1842, in which case a new name must be given to the formation, and it, with the Lowville and Pamelia, would constitute the Black River group.

black, earthy limestone with a large fauna, while the upper part is usually coarser-grained, blue limestone with very few fossils. The lower member is unlike the Leray formation of the typical Black River at Watertown, New York, in that it lacks the chert which is so abundant there, and the upper part differs from the Watertown limestone in its fauna. The question of the nomenclature of this formation is too complicated to be entered upon here.

Trenton.

The various exposures of the Trenton around Ottawa were studied with great care, in an attempt to correlate the various beds and make out a complete section of the formation. In spite of the numerous and good exposures, the faulting has so obscured the relationships of the various beds that it is difficult to ascertain the exact thickness of the formation. The following zones have been recognized, beginning with the lowest:—

(1) Thin-bedded pure blue-black limestone characterized by *Orthis tricenaria, Phragmotites compressus,* etc. These beds are very poorly exposed at Ottawa, and have an estimated thickness of about 40 feet. They are well shown above the Black River in the Stewart quarry at Rockland, and were also seen at Fenelon Falls, and at Kirkfield lift-lock, in the region surveyed by Mr. Johnston.

(2) Thick and thin-bedded blue limestone with a large amount of chert, developed as flat plates parallel to the bedding. These beds are particularly well shown in Hull, and furnish a large part of the building stone and crushed stone used in Ottawa. Just at the top of these beds are the layers from which a large part of the crinoids found in Hull have been obtained. Strata with the same fauna as these beds occur in central Ontario at Fenelon Falls and the Kirkfield lift-lock, where they occupy the same stratigraphic position as at Ottawa. The thickness of these beds is about 65 feet.

(3) Massive, coarse-grained, blue-grey limestone with few fossils. This is the horizon in which are located the large quarries on Montreal road, 3 miles east of Ottawa. The same beds are exposed in Hull, but are not quarried at the present time. They seem to be absent from the section in Simcoe district, central Ontario. The most common fossil is a species of *Tetradium,* very like *T. cellulosum.* The thickness is about 35 feet.

(4) Very thin-bedded limestone with thick shale partings. Characterized by abundant large bryozoans of the genus *Prasopora.* This bed seems to have a very wide distribution, and the fossils are beautifully preserved. Specimens were collected from it this season at Brechin, Kirkfield lift-lock, and Fenelon Falls in central Ontario, at Ottawa and Finch in eastern Ontario, and at Montreal, Charlesbourg. Beauport, and Chateau Richer in Quebec. In spite of their thin-bedded and shaly character, the strata of this zone are extensively quarried. The thickness of the zone is small, usually not more than 25 feet. and frequently less.

(5) Rather thin-bedded light-grey limestone with thin shale partings. This is the zone with *Pleurocystites, Agelacrinites,* and a crinoid fauna similar to that found in No. 2. Thickness, about 75 feet.

(6) Heavy-bedded, fine-grained limestone with clay irregularly distributed through it. These layers weather into an irregular rubbly mass. Characterized by *Hormotorma trentonensis, Rafinesquina deltoidea,* sponges, and, at the very top, by a great abundance of *Cyclospira bisulcata.* Thickness, about 75 feet.

Utica.

Lower Utica (Collingwood formation).—The rubbly-weathering limestone at the top of the Trenton is succeeded by a thin formation consisting of layers of fine-grained, rather pure blue limestone alternating with thick beds of soft brown shale. The total thickness of the formation is not definitely known, but it appears to be less than 50 feet. The fauna of this formation differs from that of the typical Utica in many respects. Graptolites are practically absent, and the characteristic species are *Ogygites canadensis* (Chapman), *Dalmanella emacerata,* Hall, *Triarthus becki,* Green, and *Oxoplecia calhouni,* Wilson. This Atlantic fauna is well developed at the same stratigraphic horizon at Collingwood, Ont., and that name is suggested for the formation.

Typical Utica.—The shales above the Collingwood formation are much darker than those in the lower formation, and contain the graptolite fauna of the typical Utica.

QUEBEC AND VICINITY.

The time from August 15 to October 8 was spent in the study of the Ordovician formations in the vicinity of Quebec. Mr. Whittaker devoted his time with marked success to the study of the upper formations north of the St. Lawrence and east of the St. Charles river, making especially fine collections from the Trenton. In spite of the large amount of work which has been done on these particular strata, and the abundance of fossils, there still seems to be some uncertainty as to the age of these relatively undisturbed beds, and a brief account of the results obtained by Mr. Whittaker and the writer this season will serve to set forth the data.

The oldest beds now exposed in this area are those in the gorge at Lorette, where the basal layer contains Parastrophia hemiplicata, Phragmolites compressus, and other fossils. This layer is followed by 10 feet of limestone with numerous straight cephalopods and Receptaculites, and then comes the bed with the coiled cephalopods, Trocholites canadensis and Plectoceras halli, in abundance, and Tetradium fibratum. This section is very similar to the basal portion of the Trenton on Lake Champlain, the Parastrophia hemiplicata fauna being the oldest in the Trenton there.

The oldest beds exposed in the bed of the Montmorency river are a half mile above the falls. At this locality *Plectoceras halli* and *Trocholites canadensis* are abundant, as is *Tetradium fibratum,* and thus correlate this bed with the third zone at Lorette. In passing southward to the brink of the falls, beds higher than these are seen resting on the granite with a basal arkose which has frequently been described. Groups of sponges in situ, attached to the granite, show that this was a granite ridge in the Trenton sea, as was pointed out long ago by Bigsby.

Above the *Trocholites* zone there is a considerable thickness of limestone, probably about 250 feet, of Trenton age. The lower half is characterized by an abundance of *Triplesia nuclea* and *Trinucleus concentricus,* well shown at Montmorency, Chateau Richer, and Beauport. In the middle is the zone with *Prasopora,* and at the very top, at Point Trembles, is a zone with *Cyclospira bisulcata,* as at Ottawa. The presence of this zone is important, as it indicates that the base of the black shale (Utica) can not be much older here than at Ottawa.

Above the *Cyclospira* bed are about 100 feet of thin-bedded, clayey limestone containing a few Trenton survivors, and the first Utica invaders, *Triarthus becki* and graptolites. These beds are best shown in the eastern ravine below the falls at Montmorency, and at Point Trembles. Above these beds are black and brown shales with graptolites which Dr. Ruedemann very kindly examined and which he finds to be typical expressions of the Utica species.

These black shales are about 200 feet thick, and they are followed at Montmorency and along the north shore of the St. Lawrence, west of Cap Rouge, by several hundred feet of soft brown micaceous shales with graptolites, brachopods, and trilobites. From their positions above the Utica and the presence of *Climatograptus bicornis, Triarthus becki, Trinucleus concentricus,* and *Catyzyga erratica,* these beds are thought to be of Frankfort age, possibly shading upward into the Lorraine. In the upper part are thin layers of sandstone and limestone conglomerate.

QUEBEC CITY.

A considerable time was spent in a search for fossils in the limestone and shale of the Quebec City formation, but although a number of new localities for graptolites were found, no fossils other than graptolites and inarticulate brachiopods were obtained, except in the pebbles of the conglomerates.

A band of conglomerate with very fossiliferous limestone pebbles is well exposed in the axis of an anticline at the foot of Mountain hill, and a similar conglomerate, with the same fossils, can be traced from the foot of the hill at Dambourges street along the northern bluff to Côte de la Negresse. The pebbles of this conglomerate, and the higher one back of the Montcalm market, have afforded numerous fossils to Mr. T. C. Weston, Dr. H. M. Ami, and the writer. The more important species are:—

Nidulites, sp. ind.,
Christiania trentonensis, Ruedemann,
Plectambonites pisum, Ruedemann,
Hebertella bellarugosa, (Conrad),
Rafinesquina champlainensis, Raymond,
Parastrophia hemiplicata, Hall,
Ampyx hastatus, Ruedemann,
Ampyx cf. *A. halli*, Billings,
Tretaspis reticulata, Ruedemann,
Isoteloides cf. *I. augusticaudus*, Raymond,
Sphærocoryphe major, Ruedemann.

This is the fauna described by Ruedemann from the conglomerate at Rysedorph hill, near Albany, and the fossils have more recently been found in place in the Chambersburg limestone of eastern Pennsylvania by Ulrich and Stose. There seems to be no doubt that this fauna is of the age of the lower Trenton, but no such fauna has been found in the more "normal" Trenton rocks north of the St. Charles.

LÉVIS.

A detailed study of the stratigraphy of the closely folded shales and limestones of the Lévis formation was made, in an attempt to locate the various graptolite zones in a section. The results of the surveys and measurements have not yet been compiled. About ten days were also spent in studying localities in the vicinity of the Champlain-St. Lawrence fault in northern Vermont, at Philipsburg, Bedford, Mystic, and St. Dominique. It was found that there were no strata of Chazy age in the section at Philipsburg, and that the so-called Chazy shales which overlie the Beekmantown at Bedford are probably the equivalent of the Lévis shales at Lévis.

OFFICE WORK.

The work on the catalogue of the types in the collection of invertebrate fossils has been actively prosecuted by Miss A. E. Wilson, and the identifications checked by the writer. The portion of the collection containing the Cambrian, Beekmantown, and Chazy fossils has been practically completed. This portion presented more difficulties than can be expected from any other part of the collection, as the specimens were poorly figured, frequently not figured at all, or the types were not marked, and the collection has suffered by passing through many hands. In this part of the collection many of the types appear to be lost.

Besides the routine work of the office, the writer undertook the study and revision of the species of the trilobite genus *Bathyurus*, a genus whose real stratigraphic value has been destroyed by the incongruous assemblage of forms which have been referred to it. This work can not be carried further until the illustrations are made for it.

In speaking of the accessions to the collection during the year, especial mention should be made of the liberality of Sir James Grant in presenting his collection to the Museum. This collection contained the type of *Harpes ottawaënsis*, Billings, and several especially fine cystids from the vicinity of Ottawa.

Collections have been examined and reported upon for the following members of the staff:—

Mr. D. D. Cairnes—
Large collection from the upper Ordovician, Silurian, and Carboniferous from the Yukon-Alaska boundary, south of the Porcupine river.

Mr. C. Camsell—
Specimens of *Aucella piochii* from Lightning creek, Yale district, British Columbia.

Mr. D. B. Dowling—
A large collection of middle Cambrian, upper Devonian, and Mississippian fossils from Jasper park, Alberta.

Mr. R. W. Ells—
A large collection of middle Silurian fossils from Charlotte county, New Brunswick.

Mr. E. R. Faribault—
A small collection from the Mississippian on Birch island, Chester basin, Lunenburg county, Nova Scotia.

Mr. R. Harvie—
Large collection of middle Silurian fossils from Knowlton Landing, Lake Memphremagog, Quebec.

Mr. W. A. Johnston—
Large collection of lower Ordovician fossils from central Ontario.

Mr. A. C. Lawson—
Collection of Richmond fossils from 6 miles west of Fort Frances, Ontario.

Mr. W. Leach—
Small collection from the Benton shale and a single specimen from the Mississippian, near Blairmore, Alberta.

Mr. George S. Malloch—
Small collection of Mesozoic fossils from the Skeena district, British Columbia.

Mr. S. J. Schofield—
Small collection of Mississippian fossils from Wardner, East Kootenay district, British Columbia.

Mr. G. A. Young—
Collection of lower Devonian fossils from western New Brunswick.

III.

PALÆOBOTANY.

(*W. J. Wilson.*)

The first part of the year was occupied in packing fossils preparatory to moving them to the Victoria Memorial Museum, and in unpacking them and placing them temporarily in cases in the new Museum. Continuing work begun last year, considerable time was spent in the preparation of a catalogue of the type specimens in the Museum. A large collection of Carboniferous plants from New Brunswick was labelled, and labels were prepared in manuscript for all the fossil plants in the Museum so far catalogued. These labels were prepared for the printer so as to be ready when the specimens are placed on exhibition in the new cases. This list required considerable research as the synonomy of each species had to be carefully examined.

There were several collections of Tertiary plants from British Columbia stored in drawers under the exhibition cases, that had been identified by Sir J. W. Dawson. These were numbered and catalogued, also some small recent collections identified by Dr. F. H. Knowlton. A collection of Oligocene plants from British Columbia, containing several hundred specimens collected by Mr. L. M. Lambe and identified by Dr. D. P. Penhallow was also numbered and catalogued. Miss A. E. Wilson assisted with this lot.

Among the Carboniferous plants from Minto, New Brunswick, were the section of a cone and several separate bracts belonging to the same species. These I have described under the name *Lepidostrobus mintoensis*, sp. nov., and the description will be published in the bulletin soon to be issued by this Department.

During the present year different members of the staff brought in small collections of Cretaceous and Tertiary plants from British Columbia, Alberta, and Saskatchewan. These specimens were studied and named in part and were afterwards forwarded to Dr. F. H. Knowlton, of Washington, who revised my list and extended it by adding several species. The following species are from the list as revised.

The largest collection was obtained by Mr. G. S. Malloch from the Groundhog coal basin and vicinity, Skeena river, B. C. In this collection the following genera and species were identified:—

Cladophlebis virginiensis, Fontaine.
" *fisheri*, Knowlton,
" *?* sp.,
Nilsonia parvula, (Heer) Fontaine,
" sp. ?,
Oleandra graminæfolia ?, Knowlton,
Zamites montana, Dawson,
Equisetum phillipsii ?, (Dunker) Brongn,
Baiera multinervis, Nathorst,
Podozamites lanceolatus ?, (L. and H.) Br.
Gleichenia, sp. ?.

Of these *Cladophlebis virginiensis*, *C. fisheri*, *Equisetum phillipsii*, and *Baiera multinervis* are reported from Canada for the first time.

The plants of this collection are of Kootenay age except *Baiera multinervis* and *Podozamites lanceolatus* which indicate the Jurassic.

In Mr. Leopold Reinecke's collection of about a dozen specimens from the Beaverdell district, B.C., there are only two specimens sufficiently well preserved to admit of specific identification, and these apparently belong to a new genus which will be described later. The general appearance of these plants indicates the Tertiary.

In Mr. D. B. Dowling's small collection of plants from Jasper park, Alberta, there are only two species, viz.:—

Sequoia reichenbachi, (Gein) Heer,
Sphenolepidium kurrianum, Heer.

The latter is new to Canada and both species are of Kootenay age.

In Mr. J. Keele's fragmentary collection from the Dirt hills, Sask., the following species were identified:—

Equisetum, sp. nearest *E. oregonense,* Newb., but smaller, and probably new,
Glyptostrobus europæus, Brongn,
Leguminosites arachioides, Lesq.,
Onoclea sensibilis fossilis, Newb.,
Fragments of dicotyledonous leaves but not determinable.

These plants belong to the Fort Union group.

A few specimens brought in by Mr. W. W. Leach from Blairmore, Alberta, contain the impression of rootlets and are indeterminable.

MINERALOGICAL DIVISION.

(*Robt. A. A. Johnston.*)

The work performed in this section has not differed materially in character from that of previous years. About four hundred and fifty specimens have been examined and reported upon. The removal of the Geological Survey from the old building on Sussex street to the Victoria Memorial Museum has entailed a serious handicap in the matter of laboratory facilities, and it has not been possible to give the attention to details in many cases in which it has been desirable. It is hoped though that with the installation of a small laboratory equipment in the Museum building this difficulty will be in large measure removed.

Mineralogical Notes.

DIAMOND.

The finding of microscopic diamonds in association with the chromite of Olivine mountain (Summary Report of the Geological Survey, 1910, p. 262) suggested the possibility of finding this mineral under similar circumstances elsewhere, and at the suggestion of Mr. J. A. Dresser, examinations were made of a number of specimens from the vicinity of Black Lake, Megantic county, Quebec. Specimen No. 1 consisted of massive chromite from the Montreal pit, and was found to contain 0·06 per cent of microscopic diamonds similar in all respects to those which have been described from Olivine mountain; specimen No. 2 consisted of serpentine, but the presence of diamond in it was not detected; a third piece consisting of peridotite also gave negative results.

A very interesting occurrence of diamond was noted in connexion with the chrome picotite of Scotty creek, Bonaparte river, Cariboo district, British Columbia. From a specimen of this material a mass was obtained which measured $\frac{3}{16}$ of an inch in diameter. This mass rapidly broke up into a number of pieces which, under the microscope, could be seen to be made up of minute octohedral crystals arranged in parallel position; in the course of few days the mass had completely disintegrated.

During the summer season Mr. Charles Camsell made a collection of eleven samples of concentrates from the gravels of Tulameen river and tributaries, Yale district, British Columbia. Time, however, did not permit of the examination of more than three of these, all of which came from the vicinity of Eagle creek. One sample consisting of 5 grammes of fine concentrates, about a third of which was magnetite, did not yield any diamonds; another labelled "Concentrates from loose sand" weighed 7 grammes, and yielded two minute diamonds along with a number of minute rubies; the third sample, which was labelled "Conglomerate river-gravels," weighed 391 grammes and yielded a number of minute diamonds along with a few rubies.

TOPAZ.

This mineral was first noted in some specimens sent to Mr. E. R. Faribault by Mr. Samuel Freeze, Doaktown, N.B. The locality of occurrence was given as "One-half mile up from mouth on Burnthill brook (S. W. Miramichi), N.B." These specimens had evidently been taken close to the surface, as they were all rather heavily coated with rust and otherwise showed the effects of exposure to the weather. Subsequent to the receipt of these specimens the locality was visited by the Director of the Geological Survey, Mr. R. W. Brock, who observed the same mineral occurring at other places in the neighbourhood, particularly on a hill on the south side of the Southwest Miramichi river, opposite to and about a fourth of a mile distant from the mouth of Burnthill brook (The Canadian Mining Journal, vol. 32, 1911, p. 549). Here, as elsewhere in the district, the mineral is generally very much weathered and it is only rarely that material of gem quality has been observed. The topaz occurs either as crystalline masses or as individual crystals ranging from those of minute dimensions to others having a diameter of ¾ of an inch. The colour, where it can be observed on a fresh surface, is generally milk white; in the case of a few of the smaller translucent crystals the colour is smoke grey. The associations are quartz, wolframite, molybdenite, and cassiterite. The wolframite and molybdenite are reported to occur in considerable abundance; the cassiterite has so far not been noted in any appreciable amount.

Work Performed by Members of Division.

MR. R. L. BROADBENT.

Excepting short periods in which he was engaged in securing specimens for the Festival of Empire Exhibition in London, Mr. Broadbent was employed continuously during the first half of the year in preparing mineralogical specimens for the Museum, and the excellent order in which the collections now are bears testimony to the diligence and patience with which he carried on this work.

Mr. Broadbent died on the 16th day of July after a brief illness. He had been continuously in the employ of the Geological Survey since 1881, and had superintended the arrangement of the mineral exhibits in the Canadian sections at a number of the World's Fairs. In the interval between 1903 and 1908, his time was devoted almost entirely to this work under the direction of the Canadian Exhibition Commissioner, Mr. Wm. Hutchison. His experiences at these exhibitions rendered him particularly well fitted for the duties which would have devolved upon him in arranging the collections in the Victoria Memorial Museum, and his death at this juncture entails a serious loss in the Mineral Section of the Museum.

MR. STANLEY P. GRAHAM.

The vacancy created by the death of Mr. Broadbent was filled in October by the appointment of Mr. Stanley P. Graham.

Since his appointment Mr. Graham has for the most part been engaged in the extension of the Index of Canadian Minerals, and has made very satisfactory progress in this connexion.

MR. A. T. MCKINNON.

As in previous years, Mr. McKinnon has continued to render most faithful service in connexion with the duties that have been entrusted to him. In addition to the materials which he has collected for the educational series, he has also made important additions to the Museum collections. During the season just closed over 10 tons of material have been assembled for use in the educational collections. Collections have been distributed by provinces as follows:—

	Grade 1.	Grade 2.
Alberta	1	2
British Columbia	1	
Manitoba	3	2
New Brunswick	3	3
Nova Scotia	11	21
Ontario	16	11
Quebec	11	15
Saskatchewan	2	2

The thanks of the Department are due to the following gentlemen for much kindly assistance in assembling materials for these collections:—

Captain Lawson, Copper Cliff, Ont.; Messrs. J. G. Sipprell, and B. R. Gordon, and Captain Church, Cobalt, Ont.; Mr. W. A. McMurray, Gilmour, Ont.; Mr. Thos. Momson, Bancroft, Ont.; Mr. Wilson Bailey, Madoc, Ont.; Mr. Bush Winning, Ottawa, Ont.; Mr. James McCabe, Notre Dame du Laus, Que.; Captain Johnston, St. George, N.B.; Messrs. C. M. Hoyt and A. M. Reid, Middleton, N.S.; Mr. John Wasson, Two Islands, N.S.

Additions to Mineral Collection.

The following additions have been made to the Canadian section of the mineral collections:—

DONATIONS.

Mr. Samuel Freeze, Doaktown, N.B.—Topaz, molybdenite, and wolframite from Burnthill brook, York county, New Brunswick.

Mr. S. R. Lanigan, St. Réné de Amherst, Que.—Group of quartz crystals from Amherst, Labelle county, Quebec.

Mr. J. A. Leamy, Ottawa, Ont.—Native silver from near Wallace mountain, Osoyoos division, Yale district, British Columbia.

Mr. M. Lodge, Moncton, N.B.—Wolframite from the parish of Stanley, York county, New Brunswick.

Mr. James McEvoy, Toronto, Ont.—Coke made from a 12 inch seam, north end of Folding mountain, Jasper park, Alberta. Coal from lot 133—above Groundhog mountain, head-quarters of the Skeena river, British Columbia—6 foot seam.

Mr. Thomas Gough, Nelson, B.C., per O. E. LeRoy.—Auriferous pyritous quartz from the Poorman mine, Eagle creek, Nelson, British Columbia.

Mr. H. G. Stillwell, Nelson, B.C., per O. E. LeRoy.—Pyrargyrite from the Hewitt mine, Silverton, West Kootenay, British Columbia.

Mr. James Matheson, Stornoway, Quebec.—Fetid quartz from Winslow, Compton, Quebec.

Mr. Robert Musgrave, Victoria, B.C.—Diatomaceous earth from a point about 2 miles from Quesnel, Cariboo district, British Columbia.

Mr. H. G. Tucker, Owen Sound, Ont.—Sphalerite from the township of Keppel, Grey county, Ontario.

COLLECTED BY OFFICERS AND EMPLOYES OF THE DEPARTMENT OF MINES.

Mr. R. W. Brock.—Topaz, molybdenite, cassiterite, and wolframite from Burnthill ridge, parish of Stanley, York county, New Brunswick.

Mr. D. D. Cairnes.—Native gold in quartz from Bear creek, Dawson district, Yukon. Ankerite from near the intersection of the Alaska-Yukon boundary with the Arctic circle. Magnesite from near the intersection of the Alaska-Yukon boundary with the Arctic circle. Knot from lignite deposit, Sloko lake, Atlin Mining division, Cassiar district, British Columbia.

Mr. D. B. Dowling.—Rock showing casts of salt crystals from the yellow band at the foot of Roche Miette, Jasper park, Alberta. Three samples of coal from the Castor Coal Company's property, sec. 3, tp. 38, range 14, west of 4th meridian, Alberta.

Dr. Eugene Haanel.—Collection of sixty-five specimens to illustrate Dr. W. A. Parks Report on the Building and Ornamental Stones of Ontario.

Mr. A. T. McKinnon.—Wire silver from the Cobalt Lake mine, Cobalt, Ont. Chromite, Coleraine, Que. Staurolite, Publico, N.S. Chrysotile in serpentine, Thetford, Que. Garnet crystals, Tudor, Ont. Anhydrite, Hillsborough, N.B. Alabaster with crystals of selenite, Hillsborough, N.B. Alabaster (pink), Hillsborough, N.B. Gypsum showing bedding, Hillsborough, N.B. Fluorite coated with barite, Madoc, Ont. Olivine sps., Bigelow, Que. Spinels in olivine, Bigelow, Que. Crystals of pyroxene, Hull township, Quebec. Zeolites, including heulandites, chabazites, analcites, stibnites, and geodes containing each of these minerals, Two Islands and Minas basin, N.S. Agates, Two Islands and Partridge island, N.S. Native copper, Horseshoe cove, N.S. Apatite crystals, Hull township, Quebec. Pyroxene crystals, Hull township, Quebec.

Mr. Hugh S. de Schmid.—Przibramite from North Burgess, Lanark county, Ontario.

Mr. Stewart J. Schofield.—Pyromorphite and cerussite from the Society Girl Claim, Fort Steele Mining division, East Kootenay, British Columbia.

Mr. Joseph Keele.—Kaolinite from St. Remi de Amherst, Labelle county, Quebec.

Mr. O. E. LeRoy.—Series of eight specimens of the ore from the Sunlight mine, Anderson creek, Nelson Mining division, West Kootenay, B.C. Specimen of slickensided ore from the Queen Victoria mine, Beasley, Nelson Mining division, West Kootenay, B.C. Two specimens of quartz crystals with dependent pyrite crystals from the Sunlight mine, Anderson creek, Nelson Mining division, West Kootenay, B.C. Calamine from the Hudson Bay mine, Sheep creek, West Kootenay, B.C.

PURCHASES.

Sebastopol, Renfrew county, Ont.—Two large crystals of titanite and series of large crystals of red apatite.

Per Mr. A. A. Cole, Cobalt, Ont.—Large sheet (7½ lbs.) of leaf silver from the Nova Scotia mine and three specimens of native silver from the Cobalt Lake mine, Cobalt, Nipissing, Ontario.

Evans collection.—This collection, which was made by Mr. J. W. Evans, Belleville, Ont., has now been acquired for the Museum. It contains a large series of Canadian minerals as well as many from foreign localities.

The following additions have been made to the foreign division of the mineral section of the Museum:—

Mr. Henry T. Buie, Murfreesboro, Arkansas, U.S.A.—Four specimens of diamondiferous peridotite from Pike county, Ark.; greenockite on quartz from Marion county, Ark.

Mr. J. H. Haslam, Hebron, N.D., U.S.A., per D. B. Dowling.—Coke made from lignite found near Hebron, N.D.

METEORITES.

Purchase.—Model of the Willamette meteorite.

Purchase.—The "Blithfield" meteorite. This is a small siderolite which was found August 13, 1910, by Joseph Legree, Renfrew, Ont., on lot 20, con. II, Blithfield tp., Renfrew county, Ontario.

TOPOGRAPHICAL DIVISION.

(*W. H. Boyd.*)

PART I.

FIELD WORK.

The field work during the past season was allotted as follows: Messrs. R. H. Chapman (in charge) and K. G. Chipman, the Alberni and Cowichan Lake sheets, Vancouver island, B.C. The work was divided along the 49th parallel of latitude: Mr. Chapman mapping the Alberni sheet and Mr. K. G. Chipman the Cowichan Lake sheet; Mr. W. E. Lawson, the Moncton, N.B., map-area; Mr. A. C. T. Sheppard, the completing of the Slocan, B.C., map-area; Mr. S. C. McLean, the triangulation of the Moncton map-area and Windermere, B.C., area. The reports relating to the above work are submitted separately.

The writer took charge of the Blairmore-Frank, Alta., map-area and of the detail map of Turtle mountain and Frank landslide. Field work on these areas was started on June 10 and closed on October 17.

BLAIRMORE MAP-AREA.

The Blairmore-Frank map-area lies between latitudes 49° 30′ and 49° 45′, covers an area of about 195 square miles, and includes the towns of Coleman, Blairmore, Frank, Hillcrest, Bellevue, Passburg, and Burmis. The publication scale is $\frac{1}{62500}$, or nearly 1 mile to 1 inch, contours are shown at intervals of 100 feet. The methods employed were triangulation control from a measured base at Blairmore, plane-table intersection, camera, plane-table and stadia and telemeter. The work on this map-area was discontinued on August 1, the detail mapping of Turtle mountain being started in order to have it completed before the Commission appointed to investigate the condition of Turtle mountain arrived at Frank.

The detail map of Turtle mountain and Frank landslide was made on the scale of 800 feet to 1 inch with contours at 20 foot intervals. The map-area is 3½ square miles. The methods employed were triangulation control from measured base at Frank, plane-table intersection, transit, and stadia, the greater part of the detail being put in by plane-table and stadia. The camera was also used for part of the broken rock detail on the lower slope of the mountain and was found to give very satisfactory results for this particular subject on the scale used. The following figures will give some idea of the quality of work done on this map: 13,870 points were fixed and used for the control of the detail over the map-area, this gives an average of 89 points per square inch of map surface. This map was completed about the end of September; blue-print copies, profiles along certain sections as well as a cardboard model of the mountain, were supplied to the Commission. During the remainder of the field season the work on the Blairmore-Frank map-area was continued.

Messrs. B. R. McKay, D. A. Nichols, and A. G. Haultain were attached to the party as topographical assistants and rendered efficient services. The field assistants were Messrs. J. R. Cox, D. B. Cole, L. Sewell, H. D. Rogers, F. E. Elliott, and W. C. Murdie. Mr. A. C. T. Sheppard and his party, after completing the Slocan work, joined the party at Blairmore on July 25 and remained until the close of the field season, greatly assisting with the work of the general and detail mapping.

The weather conditions during the whole summer were very unfavourable for field work; the large amount of rainfall and the very high winds greatly retarded the progress of the work. A quantity of snow fell about the middle of September, causing considerable delay.

During the early part of May, the writer spent a week in the vicinity of Moncton, N.B., in connexion with the topographical mapping of that area.

The writer's thanks are due to Mr. R. W. Coulthard, general manager of the West Canadian Collieries Company at Blairmore, Alta., and to his staff, for information and kindly assistance.

(*a*)

ALBERNI SHEET, VANCOUVER ISLAND.

(*R. H. Chapman.*)

The field season of 1911 was spent in mapping the Alberni sheet, the map-area extending from longitude 124° W. to longitude 125° W., and from latitude 49° N. to about latitude 49° 45′ N., and lying north of the territory mapped by K. G. Chipman.

Field work was not begun until the first week in July and continued until October 25. This region has many peaks rising between 4,000 and 6,000 feet, having bare rocky tops, separated by low grade, densely-timbered valleys. The party was constantly handicapped by smoke, seldom working at more than 60 per cent or 70 per cent efficiency.

The whole area has been greatly eroded by major ice-streams and locally modified by smaller isolated glaciers. The drainage is complicated and largely hidden by timber growth.

The method employed was essentially plane-table survey. Many stations were located from carefully plotted points which had been determined by triangulation in 1909 and 1910. Many miles of traverse were run, in the timber and rough mountain country paced distances were used, while the wagon roads were run by "wheel" traverse methods. These traverses were checked by the plane-table control. Micrometers were used on lake and sea-shore lines, which were also controlled by plane-table location.

The total area mapped is 1,435 square miles. The field scale adopted is 1:192000 —almost precisely 3 miles to 1 inch—for publishing at 1:250000, or approximately 4 miles to 1 inch, and contours with an interval of 200 feet were drawn.

Satisfactory assistance was given by W. H. Davies and W. C. Griesbach.

(*b*)

COWICHAN SHEET, VANCOUVER ISLAND.

(*K. G. Chipman.*)

The field season of 1911 was spent in mapping the Cowichan Lake sheet. Field work was started the last of May and continued to the end of October. During this time 1,370 square miles were mapped for publication at 4 miles to an inch with a contour interval of 200 feet. J. J. Phillips rendered efficient assistance.

The map area extends in longitude from 124°-125° W., and in latitude from 49° —about 48°·25 N.—and is south of that mapped by R. H. Chapman. It includes Cowichan and Nitinat lakes and the drainage of San Juan, Gordon, Carmanah, Sevenmile, and Clanewah rivers, with part of the Jordan. North of Cowichan lake the greater part of the country is almost alpine in character, while that to the south is lower in relief and everywhere heavily timbered.

The method employed was plane-table intersection. The micrometer eye-piece was used in connexion with the alidade for traversing shore-lines. The area is without roads; trails were put in from pace aneroid traverses or route sketches, the latter also furnishing considerable detail in the country where there were no trails.

The work along the coast was much delayed by fog and the rest of the work to a lesser extent by rain. Because of the heavy timber, stations were very few, while the undergrowth and scarcity of trails made travelling difficult.

The meetings in Trail of the Western Branch of the Canadian Mining Institute were attended on May 18 and 19.

(*c*)

TRIANGULATION WORK.

(*S. C. McLean.*)

The early part of the field season of 1911 was spent near Moncton executing a local triangulation for the primary control of the Moncton map-area. This work was begun on May 5 and finished June 10. The remainder of the season was spent in the Columbia-Kootenay valley executing a secondary triangulation of this valley from a point near Golden towards the International Boundary.

Moncton Triangulation.

This was of a purely local character, meant solely to furnish the primary control of the Moncton map-area. Accompanied by W. H. Boyd, chief topographer, and W. E. Lawson, the area included in the sheet was visited and the scheme of triangulation, afterwards executed, was planned. This comprised the measurement of a base-line about 1½ miles in length, just below Moncton, on the south side of the Petitcodiac river, an expansion therefrom to the necessary control points and the tieing in of the whole to our initial position, an astronomic pier established in Moncton in 1908 by the Astronomic Branch of the Department of the Interior. Twelve stations, including two towers, one 40 and the other 15 feet high, were found necessary and these were signalled and observed. When observing, any prominent points such as church steeples, factory chimneys, etc., which promised to help the control, were cut in. An observation was made on polaris for azimuth, and the geodetic positions of all the points were computed and handed to W. E. Lawson (in charge of the topography) before leaving the field.

A 4½ inch Berger transit reading to 1 minute was used for this work, the angles being read by repetition, three direct and three reverse. The weather throughout was very favourable.

Columbia-Kootenay Triangulation.

This is a secondary triangulation to serve the double purpose of connecting the trigonometric survey of the railway belt, executed by the Topographic Branch of the Department of the Interior with the triangulation of the International Boundary

Survey, and of furnishing the primary control for the proposed Windermere and East Kootenay Topographic sheets.

Stations XXI (Spillimacheen) and C of the railway belt triangulation were chosen as base and, using the mountain ranges of each side of the valley, eleven other stations were selected and signalled, thus carrying the triangulation south as far as Sheep creek. This work took until about September 1, when it was decided to begin revisiting and observing the stations signalled. The weather for the remainder of the season was very unfavourable and only seven of these stations were reoccupied.

The instruments used were—for obtaining the approximate position of the stations when planning the triangulation, a 15 × 15 inch plane-table—for reading the angles, a 6½ inch Berger theodolite with horizontal circle graduated to 10 seconds, vertical circle to 30 seconds. The horizontal angles were read by repetition, 6 direct and 6 reverse. For the vertical control, double zenith distances were taken. The centre of all stations was marked by a C.G.S. Standard brass plate B.M. fixed in a drill-hole in the rock. The signals are cairns of rock and were covered with white or black cloth as seemed best.

The season was wetter than is usual in this district. The first week or ten days of both July and August were passed in enforced idleness due to continuous rain and fog. The remainder of each month was fine. September, being a month of low-lying clouds with considerable snow on the mountains, was almost wholly lost for triangulation, one station only being occupied. October, after the first few days, proved fine and it was then that most of the observing was done. The new snow at this time on the mountains made the climbing of the more difficult points dangerous, so the easier points having been observed the season closed on October 24.

J. Lanning, technical assistant, proved specially well adapted for the work.

(*d*)

SLOCAN MAP-AREA, BRITISH COLUMBIA.

(*A. C. T. Sheppard.*)

The writer's instructions for the field season of 1911 were to finish the topographical mapping of the Slocan district, and on the completion of this work, to join Mr. Boyd at Blairmore, Alta., on the mapping of that area. Owing to the dense smoke caused by the fire which swept a portion of the Slocan in 1910, it was found impossible to finish in that year, and to complete the work it was necessary to occupy some seventeen camera stations and traverse about 40 miles of trails and railways this season.

Work was commenced on June 10. The spring was late, heavy snow remaining on the higher peaks until the end of June, so it was considered advisable to leave the stations on these peaks to the last. During the latter half of June and the first week in July, rain fell almost continually. All traverses were run by plane-table and stadia. Mr. F. S. Falconer proved a valuable topographical assistant, and Mr. W. H. Losee, as field assistant, did his work in a satisfactory manner.

Field operations in this area were completed on July 24, and the party joined Mr. Boyd at Blairmore on July 25. The balance of the season was spent on the Blairmore sheet and on the detail map of the Frank landslide.

(e)

MONCTON MAP-AREA, NEW BRUNSWICK.

(*W. E. Lawson.*)

Field work during the season of 1911 in connexion with the topographic map of the Moncton map-area commenced about the middle of May and continued without interruption up to the end of October. The area mapped is somewhat larger than the standard fifteen-minute sheet, being 12·3 miles in an east and west, and 18·7 miles in a north and south direction, covering a total area of approximately 230 square miles. The astronomic boundaries are roughly as follows: latitude, 45° 51′ N. to 46° 07′ 30″ N.; longitude, 64° 37′ W. to 64° 52′ W. This includes portions of the counties of Albert and Westmorland; the city of Moncton and suburbs; a portion of the oil-field worked by the New Brunswick Petroleum Company; the producing oil and gas fields of the Maritime Oilfields Ltd.; the large gypsum quarries at Hillsborough; the gypsum deposits on Wilson creek (not being worked at present); Albert Mines; and the oil-shale belt south and west as far as Rosevale.

The field scale used was 4,000 feet to an inch; the scale of publication to be $\frac{1}{62500}$ or approximately 1 mile to an inch. A 20 foot contour interval was adopted, as being best suited to the topographic features of the district.

Primary control of the area was obtained by triangulation worked up by S. C. McLean, of the topographical division, and tied to the astronomic pier at Moncton, which latter was observed in 1908 by the Astronomic Branch of the Department of the Interior. The scheme of triangulation including base expansion gave eighteen fixed points, all of which were used as tie-points for road traverses. It was also found necessary to run about 45 miles of transit and stadia control traverse to govern a section in which it was impossible to get a triangulation station.

Thirty-nine miles of primary levels run during the early part of the summer gave good vertical control. The elevations used were obtained from bench marks left by the Astronomic Branch when levelling over the Intercolonial railway from St. John to Moncton, and which in turn are based on mean sea-level. Permanent iron posts, brass-capped (Standard bench mark posts), were sunk at intervals of every 3 miles along the line of levels, the elevation to the nearest foot being stamped on the cap. The exact location and adjusted elevation correct to tenths of a foot are on record in this office and are available should they be required in local engineering work.

The plane-table traverse method was used almost entirely in filling in detail; only a few sections being favourable for plane-table intersection work. Stadia traverses were run along all roads, all shore-lines, and wherever possible across open country, being tied in to the triangulation points mentioned above, or to some previously located traverse station. Between stations on these main traverses, minor traverses with plane-table, tape and aneroid were run along all creeks, all bush roads, or straight across country at an average distance apart of 1,200 feet. On all traverses, the contouring and delineation of topographic features was done by the traverseman when in the field. The past season was especially favourable for aneroid work, the 2¾″ aneroids reading direct to 20 feet, giving negligible errors on a majority of the shorter traverses. The following figures, approximately correct, may prove of interest as giving some idea of the amount of traversing necesary:—

Transit and stadia	50	miles.
Plane-table and stadia	406	"
Plane-table, 300 foot steel tape and aneroid	893	"
Total	1,349	"

My thanks are due to officials on the engineering staff of the Intercolonial railway, and to the City Engineer of Moncton for blue prints and data supplied, assisting materially in mapping Moncton and the immediate vicinity. The corps of field assistants was composed of the following men: A. G. Haultain, F. H. McCullough, W. G. Hughson, S. D. Robinson, N. A. Thompson, L. H. Badgley, M. B. Heebner, A. M. James, J. Messervey, and M. O'Brien. The manner in which these men performed their work was highly satisfactory.

Weather conditions during the season were exceptionally favourable, May, June, July, and August being uniformly warm and dry, though considerable time was lost through heavy rains during September and the early part of October.

PART II.

SPIRIT LEVELLING NEAR MONCTON, N. B., 1911.

The route followed was from Moncton, south along the shore road on the east side of the Petitcodiac river to its crossing with the Salisbury and Harvey railway at Weldon, thence along this railway to Boundary Creek station on the St. John branch of the Intercolonial railway. A short line connecting Grey Island wharf with the Salisbury and Harvey railway was also run. The instrumental work was done by Mr. A. G. Haultain.

Instruments and Methods.

A 15 inch Y level and New York target rod were used. The line was run only once. Sights were limited to 300 feet. Backsights and foresights were of equal length, or were equalized daily. Both levelman and rodman read the rod independently and kept separate records. While running the line temporary bench marks were established about every mile, later a permanent standard pipe bench mark was put in at intervals of about 3 miles. The standard pipe B.M. is a heavy 3 inch iron pipe about 5 feet long, the lower end of which is split for about 9 inches and spread out to form a T-bearing surface; on the upper end is rivetted a brass cap bearing the inscription, "Geological Survey of Canada. Elevation above sea." This pipe is buried to within 8 or 10 inches of the surface of the ground, the elevation being stamped thereon to the nearest foot. The brass nail and washer used for temporary B.M.'s consist of a round-headed brass nail, 1 inch × ½ inch, with a brass washer 1 inch in diameter stamped C. G. S. B. M.

Datum.

The elevations are based upon mean sea-level as determined by a tide-gauge of the United States Coast and Geodetic Survey at Calais, Me., and carried to Moncton by the precise levels of the Geodetic Survey of Canada. The Geological Survey line starts from B.M. 132 B and connects with B.M. 128 B of these precise levels of the Geodetic Survey.

The precise levels of the Geodetic Survey are connected at Moncton with B.M. CCCXXXVI of the precise levels of the Public Works Department. The relations between the different lines with the closing errors are given below.

	Elevation.
B. M. No. CCCXXXVI—Moncton—Public Works Department	51·42 feet.
B.M. " " Geodetic Survey of Canada	51·38 "
B.M. 132 B, Moncton—Geodetic Survey (reference for Geological Survey line)	51·41 "
B.M. 128 B, Boundary Creek, Geodetic Survey	92·84 "
B.M. 128 B, " " as per Geological Survey line	92·95 "
B.M. 129 B, " " Geodetic Survey	67·54 "
as per Geological Survey line	67·65 "
Closing error of Geological Survey line	0·11 "

The above figures and those in the following list of bench marks are actual readings without adjustment.

From I. R. C. Station, Moncton, to Weldon platform on the Salisbury and Harvey railway; via road east side of Petitcodiac river.

Moncton—I.C.R. station—brass plug in the stone water table course at S. end of E. wall; Geodetic Survey of Canada, B.M. No. 132 B, reference	51·41
Moncton—on turn of road by the round house—4″ wire nail driven in supporting brace of first braced telephone pole north of bridge	27·98
Moncton—2·4 miles from—200 ft. east of Bridgedale school house; in root of willow tree, fourth tree from east end of row of trees on north side of road; small brass nail and washer	79·96
Moncton—3·3 miles from—1 mile south of Bridgedale school house; 1,250 ft. N. of N. end of earth fill over Mill Creek flats, on west side of road, about 1½ ft. wide; 10 ft. S. of spruce tree blazed at base of trunk facing B.M. Standard pipe B.M.	70·94
Moncton—3·7 miles from—Centre of bridge over Mill creek	26
Moncton—4·1 miles from—2,200 ft. N. of Mud creek; 1,560 ft. N. of Mud Creek church; on east side of road, in root of a double trunked spruce tree opposite red house, third tree from N. end of row of trees, small brass nail and washer.	64·87
Moncton—5·2 miles from—0·6 miles S. of Mud creek; 0·5 miles N. of Lower Coverdale school house; 500 ft. S. of Bobs creek; a knob of quartz (distinguished by chisel marks) on granite boulder on east side of road, opposite grey and white house	103·03
Moncton—6 miles from—on southern lot line of Lower Coverdale church, about 2 ft. inside of road allowance, 90 ft. S. of centre of road to Niagara, 36 ft. W. of centre of road to Hillsborough, 63·6 ft. S. of corner of church; Standard pipe B.M.	182·22
Moncton—7.3 miles from—1·3 miles S. of Lower Coverdale church; 340 ft. N. of spring and watering trough on west side of road; head of large nail in telephone pole on west side of road	142·17
Moncton—8 miles from—2 miles S. of Lower Coverdale church; top of Stoney Creek hill, white house on west and deserted house on east side of road; cross chiselled on sandstone slab under fence on west side of road, first slab N. of road-gate of white house	195·27
Moncton—9 miles from—185 ft. north of a point on Stoney Creek bridge directly over centre of creek, 24 ft. east of centre of road, 39·6 ft. west of maple tree with crooked trunk, tree blazed and notch cut in root on side facing B.M. Standard pipe B.M.	44·61
Moncton—10 miles from—1 mile S. of Stoney Creek bridge; 600 ft. S. of white house with red barn and flag pole, on west side of road on top of stump of small tree at foot of larger one; small brass nail and washer	171·21
Moncton—11·1 miles from—2 miles south of Stoney Creek bridge; 1·4 miles N. of Weldon school house; 860 ft. N. of white house on east side of road; small brass nail and washer on stump on west side of road	225·14
Moncton—12·1 miles from—3 miles south of Stoney Creek bridge; 0·4 miles N. of Weldon school house; almost directly opposite residence of F. W. Miller, 28 ft. west of centre of road and 1½ to 2 ft. inside road allowance. Standard pipe B.M.	133·88

From Weldon platform to Boundary Creek, via Salisbury and Harvey railway.

Weldon—1 mile from—22·8 miles from Boundary Creek; nail in guard stringer on N. side of trestle over branch of Weldon creek, 4 ft. from west end	67·47
Weldon—1·9 miles from—21·9 miles from Boundary Creek; top of rail opposite Salem platform	112·0

Weldon—2·9 miles from—20·9 miles from Boundary Creek; 80 ft. N. of the third crossing of the Salisbury wagon road from Weldon, 28 ft. S.W. of the centre of the railway track, 49 ft. W. of the centre of the wagon road, 11 ft. westerly from blazed and pointed 4 inch pine stump; Standard pipe B.M.	187·89
Weldon—3·4 miles from—20·4 miles from Boundary Creek; switch at branch to Manganese mines; top of rail	215·2
Weldon—4 miles from—19·8 miles from Boundary Creek; 0·5 miles west of switch to Manganese mines; 1 mile east of Stoney Creek platform; top of east end of centre ground stringer of water tank; small brass nail and washer	257·23
Weldon—4·9 miles from—18·9 miles from Boundary Creek; 38 ft. S. of centre of track at a point 115 ft. west of centre of road crossing and 150 ft. west of centre of Stoney Creek platform, 16 ft. west and north of a birch tree blazed and with good notch in the root on side facing B.M. Standard pipe B.M.	340·56
Weldon—5·9 miles from—17·9 miles from Boundary Creek; 1 mile west of Stoney Creek platform; 0·2 miles west of section shanty at old crossing; cross on boulder 3 ft. outside fence on south side of track	373·82
Weldon—8 miles from—15·8 miles from Boundary Creek; 31 ft. south of centre of track at a point 354 ft. west of centre of Baltimore platform and 343 ft. west of centre of road crossing, 3·3 ft. south of squared witness post (2½ ft. × 4 inches) marked "W"; Standard pipe B.M.	423·19
Weldon—9 miles from—14·8 miles from Boundary Creek; 1·1 miles west of Baltimore platform; 1,700 ft. east of a section shanty, 110 ft. west of east and of burnt area; cross on sandstone boulder on S. side of track	377·47
Weldon—11·1 miles from—12·7 miles from Boundary Creek; 97 ft. south of the centre of track at a point 776 ft. east of east end of trestle over Turtle creek; Standard pipe B.M.	258·49
Weldon—11·8 miles from—12·0 miles from Boundary Creek; at Turtle Creek platform, small nail and washer on centre log west end of platform	244·24
Weldon—13·6 miles from—10·2 miles from Boundary Creek; 1·8 miles west of Turtle Creek platform; top of rail at road crossing	284·7
Weldon—17·4 miles from—6·3 miles from Boundary Creek; at Coverdale platform, head of nail driven in S.E. corner post of platform with small brass nail and washer above	101·67
Weldon—19·6 miles from—4·2 miles from Boundary Creek; 2·2 miles west of Coverdale platform; at Trunk road crossing; top of rail	68·2
Weldon—20·1 miles from—3·7 miles from Boundary Creek; west end of railway bridge over Petitcodiac river; top of rail	48·6
Weldon—20·6 miles from—3·2 miles from Boundary Creek; at Moncton and North Shore road crossing; top of rail	68·9
Weldon—21·7 miles from—2·1 miles from Boundary Creek; on I.R.C. opposite mile post 77 from St. John; top of rail	102·8
Weldon—22·7 miles from—1·1 miles from Boundary Creek; on I.R.C. opposite mile post 78 from St. John; top of rail	106·6
Boundary Creek—23·8 miles from Weldon; in top course of stone work of south wall of Baptist church, 2·2 ft. from southwest corner of building, brass bolt B.M. No. 128 B of Geodetic Survey of Canada	92·95
Elevation according to Geodetic Survey precise levels	92·84
I. R. C., St. John Branch—2,070 ft. east of mile post 82 from St. John—in second course of stone work below top in west end of north face of north retaining wall of iron pipe culvert under track; brass bolt B.M. No. 129 B of Geodetic Survey of Canada	67·65
Elevation according to Geodetic Survey precise levels	67·54

From Weldon platform to Hillsborough, via Salisbury and Harvey railway.

Weldon—top of rail in front of railway platform	24·7
Weldon—Railway bridge over Weldon creek; top of rail	25·6
Weldon—0·5 miles east of; in front of section shanty; small brass nail and washer in railway tie	24·6
Hillsborough—Grey Island wharf—North side, 100 ft. from shore end; small brass nail and washer in log	24·41

NATURAL HISTORY DIVISION.

I.

(*John Macoun.*)

Since the date of my last summary report my time has been chiefly devoted to writing in winter and collecting in summer, the routine work being, of course, attended to as usual.

We moved from the old Museum late in January, 1911, and when we were in the new Museum I resumed my work on the flora of the Maritime Provinces; this I finished before spring. After this the manuscript was sent for revision and additions to Dr. G. U. Hay, at St. John, N.B., then to Dr. A. H. MacKay, Superintendent of Education, Halifax, N.S., and then to Mr. Lawrence Watson, Charlottetown, P.E.I., who returned it to me. I then made the necessary additions and corrections and turned the whole completed manuscript over to you for transmission to the printers. In addition to our collections made during several seasons work in the Maritime Provinces, we have a fine series of eastern species in our herbarium; reference is made in the catalogue to all these specimens.

As soon as the flora of the Maritime Provinces was complete, I commenced work on the flora of Ottawa and the district surrounding it. I worked on this until the middle of May and then collected within 30 miles of Ottawa for four months—until the middle of September, when nearly forty species of flowering plants were added to the list as a result of the season's work.

In anticipation of a part of the Museum being set aside for a special collection of the flora and fauna of the Ottawa region, I took out all the specimens that had been collected in the 30 mile radius. These have been placed in new wrappers and in a separate case, so that we have now in a readily accessible form all the species of plants known to occur in this region.

During the winter and spring my assistant, Mr. J. M. Macoun, in addition to his routine duties, worked up the very large collection of plants made by him on the west coast of Hudson bay in 1910, and continued his work on the collections made by him and myself in previous years. This work has also occupied most of his time since last September, and we hope that by the end of 1912 all the old collections will have been worked over. Early in May he went to Washington with Sir Joseph Pope as one of Canada's representatives at the Fur-Seal Conference. He remained in Washington ten weeks, and after his return to Ottawa spent six weeks in collecting and studying the flora of the Gatineau valley, a region that had not been properly studied botanically before. The number of sheets of plants mounted and placed in the herbarium during the year was 3,269, and the number distributed to other herbariums 3,985. The number of letters written up to December 31 in connexion with our work was 790.

Upon the appointment of Mr. P. A. Taverner last May, he was given charge of all the vertebrates. A report of his work appears below. Mr. C. H. Young, with the exception of ten weeks spent collecting in New Brunswick, has been employed during the whole year in cataloguing, rearranging, and relabelling the invertebrates, a work which it will take some time to complete, but the more attractive groups, such as star-fish, crabs, etc., are now ready for exhibition. Miss Stewart has performed her duties in her usual efficient manner.

II.

ZOOLOGICAL SECTION.

(P. A. Taverner.)

I assumed the duties of Assistant Curator in the Museum, May 1 of the current year. A few weeks were spent in going over the collections and Museum for the purpose of obtaining an idea of the specimens, their number, scope, and general condition; then, June 6, I left Ottawa on an inspection tour of some of the larger museums to the south, visiting in the following order, the Museum of the Boston Society of Natural History; the Agassiz Museum at Cambridge, Mass.; Col. Thayer's private museum at Lancaster, Mass.; the American Museum of Natural History, New York; the Philadelphia Academy of Sciences, Philadelphia, Pa.; the United States National Museum, Washington, D.C.; the Museum of the University of Michigan, Ann Arbor, Mich.; and the Field Museum, Chicago, Ill. During this tour, special attention was paid to the following subjects: organization of staff; general arrangement of exhibitions; detail preparation of habitat and other groups, and displays; and registration, arrangement, and storage of study specimens. While engaged in this work, I received every aid from the various officials of the institutions visited, aud wish to thank them all and severally for their courtesies.

Upon my return, the middle of July, plans were studied and matured, and drawings made of same, showing an exhibitional scheme for the Museum halls, embodying a comprehensive series of habitat groups illustrating the distinctive features of the distribution of life in the Dominion, and an arrangement of the systematic collections on public exhibition. Details were also developed for the arrangement of the study and storage laboratories and systems of classification, registration, and storage of the study collections within them.

As soon as these preliminaries were decided upon and approved by the Director, work was commenced on the arrangement and cataloguing of the collection, beginning with the class *aves*, the birds, which, from their relative numbers, required first attention. At this time I was aided by Mr. Frank C. Hennessey for about three months, who was of the greatest assistance in the relabelling of specimens, verifying data, and doing other work on both the old and the incoming collections. He also made a number of water-colour drawings of bills and feet of the birds that Mr. Young sent in from time to time, all of which will be of the greatest assistance to us when we come to finish the Atlantic Coast group now under way.

The relabelling and tracing out of the history of the accessions already in the bird collections was a long and tedious piece of work, involving the most careful deciphering of obliterated labels, searching of maps for little-known localities, and research among the various summary reports and old records scattered through many registers and manuscript lists for years back. At the end of the year this preliminary work is practically finished, and a start has been made on actual cataloguing.

From the latter end of August to late in October, Mr. C. H. Young was on the New Brunswick coast, collecting the material, listed among the accessions, for an Atlantic Coast group. This was sent in, from time to time, in the form of fresh specimens, and their need of prompt attention drew both Mr. Hennessey and myself away from the above work intermittently throughout that time. However, we now have ready mounted, some 84 birds, and a supply of crabs, fish, seaweed, and other accessories, together with photographs of the same in situ, to make a most interesting group. A model of the same has been built to scale, but no further work can be done upon it until a properly trained preparator, experienced in modern museum methods, can be obtained. In fact, no constructive exhibition work of any kind can be prosecuted until such a man is available.

Throughout the summer and autumn a number of short trips were made within the vicinity of Ottawa, more for the purpose of observing the character and resources of the country for future collecting than for actual gathering of specimens at present; but some material was incidentally taken and specimens brought in for experimental and other work in the casting and preservation of the lower forms of vertebrates and accessories for groups. In this way come valuable processes have been either developed or originated for future case work.

Certain members of the Geological Survey staff have also shown their interest in the work of the Museum, notably Mr. D. D. Cairnes, by bringing in collections of specimens made during their work in the field in out of the way and little-known sections of the country. The value of these incidental collections can hardly be overestimated, and it is the hope of the writer that this interest will increase and afford an important source of supply to the growth of the Museum collections. The various members of the staff, covering as they annually do, a great section ot the Dominion in their summer work, have unexcelled opportunities for collecting rare or little-known material, both specimens and notes, that could not otherwise be obtained without elaborate and costly expeditions. A set of printed instructions have been planned, and, at present writing are well under way, for the collection and preservation of zoological material for the benefit of the field staff and others who desire to aid us in the accumulation of knowledge of the Canadian fauna.

During the summer we received from Ward's Natural History establishment, the group of Stone's mountain sheep that was sent them for mounting before my arrival. The work has been done in a very satisfactory manner and it is planned to make it the central feature in our proposed Rocky Mountain habitat group.

The following additions have been made to the zoological collections during the past year (1911):—

By Purchase.

Accession Nos.

11–2 —From H. E. Porter, Whitehorse, Y.T.—
One Bull Moose, with skull, collected December, 1910, near Lake Kusawa, Y.T.

11–3 —Through D. D. Cairnes, Geological Survey—
One Canada Porcupine skin, collected about May 1, 1911, near Whitehorse, Y.T.

11–5 —From J. Poole Field, Ross River, Y.T.—
Three Mountain Goat, head and neck, scalps and skulls, collected near heads of South Nahanni, Pelly, and Highland rivers, Y.T., during the winter of 1910-11.

11–32—From W. Simpson, Ottawa, Ont.—
About 3,000 specimens of coleoptera, taken near Ottawa, Ont.

By Museum Staff.

11– 7—By Wm. Spreadborough—
One Black Bear, skin and skeleton, collected on Vancouver island, B.C., June 19, 1911.

Accession Nos.

11-18—By C. H. Young—

Bird skins, mostly gulls and waders.. 227

Marine shells, about.. 450

Fish, crabs, sea-weed, and other accessories for an Atlantic Coast group. All collected near Youghall and Inkerman, N.B., during late summer and autumn of 1911. Eighty-four of the birds have been mounted for the above purpose and the remainder placed in the study series.

11-22—By P. A. Taverner—

Two Myrtle Warbler and a Cliff Swallow, skins, collected August 19, 1911, near Ottawa.

11-23—By P. A. Taverner and C. H. Young—

One King bird, one partial albino Song Sparrow, and stump containing nest and eggs of House Wren, collected June 6, 1911, near Ottawa, Ont.

11-24—By P. A. Taverner—

One American Titlark and one Savanna Sparrow, collected September 13, 1911, at Casselman, Ont.

11-25—By P. A. Taverner and C. H. Young—

One Swamp Sparrow and one Garter Snake, collected May 6, 1911, near Ottawa, Ont.

11-26—By J. M. Macoun and P. A. Taverner—

Nests of Phoebe and Chimney Swift, and one Ruffed Grouse skin, collected October 8, 1911, near Meach Lake, Quebec.

11-27—By P. A. Taverner and C. H. Young—

One pair White-breasted Nuthatches, nest and eggs, collected May 19, 1911, near Ottawa, Ont.

11-29—By Wm. Spreadborough—

Bird skins.. 5

Small mammal skins.. 13

All taken during summer of 1911 near Cowichan lake, Vancouver island, B.C.

11-31—By C. H. Young—

Toads.. 5

Bullfrog.. 1

Leopard Frogs.. 4

Garter Snake.. 1

All taken during May and June, 1911, near Ottawa, for the purpose of making casts.

11-33—By C. H. Young—

Insects as follows:—

Hymenoptera..	21	specimens.
Lepidoptera..	145	"
Diptera..	14	"
Coleoptera..	60	"
Hemiptera..	12	"
Orthoptera..	4	"
Neuroptera..	15	"
Total..	271	"

Accession Nos.

Mostly taken in vicinity of Ottawa during summer of 1911.

11–37—By J. M. Macoun—
One pair of Canada Grouse feet, taken September, 1910, in vicinity of Fort Churchill, Hudson bay.

By Geological Survey Staff.

11–8 —By J. A. Allen—
Two Woodchucks, with skulls, from near Field, B.C., collected September 1, 1911.

11–11—By Percy Selwyn—
One Blue Jay, in flesh, collected near Kirk Ferry, Gatineau river, Que., September 24, 1911.

11–12—By D. D. Cairnes—
14 bird skins and one small mammal, from Alaska-Yukon Boundary, lat. 67-30, during the summer of 1911.

11–14—By Percy Selwyn—
One Pileated Woodpecker, in flesh, collected October 21, 1911, in Lynedoch township, Renfrew county, Ontario.

11–20—By R. Harvie—
Nest of Chimney Swift, collected in Bolton township, Brome county, Quebec, during the summer of 1911.

11–21—By A. T. McKinnon—
Two sponges (*Clatheria sp?* and *Tentorium sp?*), collected on Two Islands, N.S., July, 1911.

11–36—Transferred from Ethnological Department—
Three fragmentary skins and one mounted head of Dall's Sheep. No data.

By Presentation.

11–1 —By Andrew M. Talyor—
Four Dall's Mountain Sheep. skins, skulls, from British Columbia.

11–4 —By Frank C. Hennessey, Ottawa, Ont.—
One Herring Gull skin, collected August 24, 1909, south of Cornwallis island, Arctic ocean.

11–6—By J. A. Gillies, Gillies Depot, Ont.—
Twenty-nine Hummingbirds' skins, of several species collected near Guayaquil, Equador, South America, about 1906.

11–9 —Thomas Kinsella—
Red-tailed Hawk, in flesh, collected September 14, 1911, at Franktown, Lanark county, Ontario.

11–10—W. Creighton—
Nineteen Eider Duck skins from northern Canada.

11–13—Oliver Trafford, St. Eugene, Ont.—
One Jumping Mouse, in flesh, collected near St. Eugene, October 4, 1911.

Accession Nos.

11-16—Geo. Mulharvey, Simmons, Quebec—
One Snowy Owl, in flesh, taken October 31, 1911.

11-17—J. M. Macoun, Ottawa, Ont.—
Polar Bear skull, collected in autumn of 1910, near Fort Churchill, Hudson bay, by Dr. Borden.

11-19—By Frank C. Hennessey, Ottawa, Ont.—
Two Woodpeckers, in flesh, from near Ottawa, November 1, 1911.

11-28—By Frank C. Hennessey, Ottawa, Ont.—
Two Bird skins, Ottawa, Ont., collected September 20, 1911.

11-30—By Dr. Malte and J. M. Macoun, Ottawa, Ont.—
Fresh Water Sponge, likely *Meyenia fluviatilis,* collected in Gatineau river, Que., October 20, 1911.

ANTHROPOLOGICAL DIVISION.

PART I.

ETHNOLOGY.

(*E. Sapir.*)

Museum.

All the ethnological material of the Victoria Memorial Museum has been unpacked and carefully sorted out according to culture areas and tribes. Owing to the fact that a large percentage of this material had remained unnumbered, and owing further to the fact that the enumeration of the part already numbered had proceeded on no definite principle of classification, it was decided to renumber the whole collection according to a definitely established scheme. The ethnological material has been divided into five main groups corresponding to as many culture areas of Canada. These are: Eastern Woodlands ethnology labelled III; Arctic or Eskimo ethnology (labelled IV); Plains ethnology (labelled V); Plateau and Mackenzie Valley ethnology (labelled VI); and West Coast ethnology (labelled VII). I and II have been reserved for materials coming under the head of physical anthropology, while VIII-XII have been reserved for archæological material. Capital letters are used as means of sub-classification by tribes; thus V.B. refers to material obtained from the Blackfeet, one of the Plains tribes. By following out this method it is possible to assign any numbered specimen to its proper culture area and tribe without the irksome necessity of looking up a catalogue. The labelling and cataloguing of ethnological specimens is now practically completed, and, after a certain amount of sorting for purposes of exhibition is done, they will be ready to go into cases when these arrive. A set of lantern slides illustrating Canadian ethnology is being prepared as the beginning of a stock for lecture purposes.

An inventory of ethnological material now owned by the Victoria Memorial Museum would show that it is relatively rich in West Coast (particularly Haida, Tsimshian, and Kwakiutl) material, to a less extent also in Eskimo (particularly Alaskan Eskimo) material, but not at all well represented as yet in other ethnological regions of Canada. During the last year, however, systematic efforts have been made to fill this lack for eastern Canada. Iroquois, Huron-Wyandot, Micmac, Malecite, and Montagnais material has been purchased, partly by members of the staff and partly by others conducting ethnological research in eastern Canada under the auspices of the Geological Survey. A standing order has been left with Chief John Gibson of the Senecas for Iroquois material from Grand River reserve; much Iroquois material of value has thus come into the Museum in addition to that already secured by Dr. Goldenweiser and myself, as well as by purchase from Mr. M. R. Harrington. Dr. D. D. Cairnes of the geological staff of the Survey has been helpful in securing museum material from the somewhat inaccessible Athabaskan tribes of the region of Tagish lake, Yukon. Valuable Tsimshian material was purchased from C. C. Perry, of Metlakalitla, B.C.

Field Work.

Systematic research among various tribes of Canada was undertaken during the year. Dr. A. A. Goldenweiser, lecturer in anthropology of Columbia University, New York, spent part of the summer in studying the social organization of the Iroquois of Grand River reserve; Mr. C. M. Barbeau of the permanent staff made three research trips (Lorette, Province of Quebec; neighbourhood of Amherstburg, Ont.; and Quapaw agency, Oklahoma) for the purpose of studying the Huron-Wyandots; Mr. William H. Mechling, of Philadelphia, spent the summer in ethnologic and linguistic research among the Micmac and Malecite Indians of New Brunswick; Dr. Cyrus MacMillan, of the Department of English, McGill University, spent five months in research, particularly in order to obtain folk-lore material, among the Micmacs of Nova Scotia and Prince Edward Island; the month of August was spent by myself in a reconnaissance of various Iroquois and Algonkin reserves in Ontario and Quebec. Reports of these field trips are appended.

WORK IN IROQUOIS AND ALGONKIN RESERVATIONS OF ONTARIO AND QUEBEC, 1911.

I spent the month of August, 1911, in a reconnaissance of several of the more readily accessible Iroquois and Algonkin reserves of Ontario and Quebec. The first of these reserves to be visited was Grand River reservation near Brantford. The main purpose of this visit was to secure an Iroquois museum collection, as the resources of the Victoria Memorial Museum were extremely limited for the Iroquois tribes. I was fortunate enough to secure a fairly large and representative group of objects, including such comparatively uncommon specimens as gourd rattles, blowguns, and feather head-dresses. Moreover, arrangements were made with Chief John Gibson, as noted above, for the forwarding of further Iroquois material to the Museum. The balance of the six days spent at this reserve was taken up in Seneca and Mohawk linguistic work. The chief object of this and other linguistic researches made during the trip was not so much to investigate the structures of the languages concerned, as this would evidently be quite impossible in the time consumed, as to get a clear phonetic insight into them. Great care was taken in the matter of phonetic accuracy, and it soon became apparent that most, if not all, attempts at recording Iroquois had been notably lacking in this regard.

An afternoon was also spent at Smoothtown in the southern part of the reserve in order to obtain linguistic data on Delaware. The material obtained shows Delaware to be a phonetically quite specialized Algonkin language. In pronunciation it is peculiarly lifeless, and it abounds not merely in voiceless final vowels, like several other Algonkin languages, but in voiceless final syllables or groups of syllables. Peculiar to Delaware is also the presence of voiceless vowels in other than final positions, a phonetic trait that I had not met with before except in certain Shoshonean languages of Utah and Arizona.

The next reserve visited was Caughnawaga, opposite Montreal, which is occupied by thoroughly Catholicized Iroquois of Mohawk speech. There is comparatively little of value to be obtained here in the way of museum specimens, most of the native industries catering primarily to the white trade. Linguistic material obtained here, supplementary to the Mohawk material obtained at Grand river, shows conclusively that the Mohawk of these two places is dialectically distinct.

At the Abenaki reserve of Saint Thomas Pierreville conditions similar to those prevailing at Caughnawaga were found, except that while the Caughnawaga Indians rely chiefly on the making of beaded moccasins, the Abenaki do more basketry for purposes of sale. Linguistic material obtained at Pierreville shows Abenaki to be a somewhat specialized Algonkin language. Phonetically it impresses one as being rather lazy in utterance and it makes much use of weakly nasalized vowels. At Rivière du Loup, which was next visited, material obtained on Malecite showed this to be phonetically rather a difficult Algonkin language; there are several phonetic peculiarities to be noted, such as musical cadence (which, however, is perhaps of no etymological significance) and the presence of consonants that are so weakly articulated as to be practically inaudible. A side trip taken to Cacouna resulted in the securing of some Malecite museum material and linguistic material on Micmac. Micmac was found to be far less difficult phonetically than either Malecite or Abenaki.

The last part of the trip was spent at Pointe Bleue, on the west shore of Lac St. Jean. Some valuable Montagnais material was here obtained including several pieces that were said to have come from the region of Lake Mistassini. It is highly desirable that ethnological work be done among these Montagnais, as well as those of Bermis and Escoumains, but this work should be undertaken by one thoroughly familiar with spoken French. Linguistic material was obtained on both Montagnais and Cree, the latter from a woman belonging originally to Rupert House, James bay. It is quite clear that Montagnais and Cree are dialects of one language; this means that what is a single language, all the dialects of which are mutually intelligible, is spoken from the Gulf of St. Lawrence west of the Yellowhead pass of the Rockies. Montagnais seems to be somewhat more specialized phonetically than Cree, yet not enough material was obtained of either to make this statement certain. Cree and Montagnais are evidently more archaic Algonkin dialects than any of the others from which material was obtained; at the same time they offer less phonetic difficulties than Delaware, Abenaki, or Malecite .

(*a*)

ON HURON WORK, 1911.

(C. M. Barbeau.)

The ethnographic research on the Hurons or Wyandots of Lorette (Quebec), Amherstburg (Ontario), and Wyandotte (Oklahoma), taken up at intervals from April to December, 1911, has given excellent opportunity for collecting abundant data on their general ethnography, that is, their social statics, social dynamics, and technology. Notwithstanding the widely accredited barrenness of this field of research, owing to the advanced state of civilization prevailing among the few hundred dispersed descendants of the once numerous Huron tribes of Ontario, the results secured have so greatly surpassed, in quantity and quality, our expectations, that it has proved impossible to exhaust the sources of information at disposal.

Among the foremost informants may be mentioned: Messrs. Maurice and Antoine Bastien; Mrs. Etienne Groslouis, and her daughters, of Lorette, Quebec; Rev. Prospère Vincent, of Lévis, Quebec; Miss Mary McKee, of Anderdon, Ontario; Messrs. Smith Nicols, B. N. O. Walker, Hiram (Star) Young, Mrs. Catherine Armstrong, and Catherine Johnson, of Wyandotte. Okla.; and Mr. Eldredge H. Brown and Mrs. Mary Kelly, of the same place, as interpreters and informants on linguistics. Other informants of lesser importance have also contributed valuable information. No mention is here made of information available from other sources, in print or manuscript.

(1)

The data that relate to the social statics or morphology of the Hurons may conveniently fall under the following headings: the phratries, the clans, and a fraternity; the heirarchy of the clans in the phratries, and of the individuals in the clans; and, finally, the ancient villages.

On account of their having long ago been broken up, the phratries have left almost no trace of their existence and would not have been revealed, had it not been for a text recorded in Wyandot and translated into English, and for some survivals in connexion with the seed game. This text gives an explicit account of the origin, at a great council of prehistoric times, of the federation of all the clans but one into two mutually dependent phratries, respectively under the leadership of the Big Turtle and Deer clans. A careful study of the clans and an extensive survey of the clan individual names has led to the conclusion that the notions now generally prevailing on this point will have to be partly revised. The eleven Huron clans, in order of precedence, may be put down as follows: the Moss Turtle (Big Turtle), the Speckled Turtle (or Small Turtle), the Prairie Turtle (or Terrapin), and the Beaver clans constituted the Big Turtle phratry; while the Deer phratry consisted of the Deer, the Bear, the Porcupine, and the Hawk clans. These two phratries in the old tribal councils occupied the opposite sides of the council fire. The Wolf clan was a third unit, all by itself, standing at one end of the fire. Extensive accounts of the subsequent origin of the Snake and Snipe clans have brought an interesting contribution to the much disputed question as to how clans originate. The origin of the Snake clan —vividly described in a text, and in a series of songs recorded phonetically with translation as well as on the phonograph—is still clearly remembered by most of the old Oklahoma Wyandots. Briefly, it runs as follows: At the end of her puberty seclusion a maiden was devoted to a mythical Monster-Snake by her relatives, of the Deer clan, with a view to securing "powers" and a new crest. Thereafter the relatives of the maiden, in collateral line, became the constituent members of the Snake clan, that has held annual feasts until about half a century ago to commemorate this event. The mode of origin of the Snipe clan among the Wyandots, the existence of which has probably not yet been recorded, is radically different, as, about two centuries ago, it was brought from outside into the Wyandot social system. A Seneca woman of the Snipe clan, having married a Wyandot, came to reside among the Wyandots. Owing to her not having been adopted into a Wyandot clan, as was the custom, she retained her own clan and transmitted it to her descendants. The Snipe clan, thereafter assimilated to the other Wyandot clans, has subsequently counted many members, the individual names of whom, framed according to the traditional rules of the Hurons, have been recorded. Three out of these eleven clans—the Prairie Turtle, the Hawk, and the Beaver clans—have been extinct for some length of time; and only a few representatives of the Snake and Snipe clans are still to be found. The number of traditional individual clan names collected in the course of the present study may exceed seven hundred; approximately a sixth of these could not be translated, as their meaning has now been forgotten. A small proportion of the names that could be translated have been found to refer to the mythology of the clans, while the greater number alludes either to various attributes of the clan totems or to a characteristic trait of some deceased ancestor.

With regard to societies devoted to shamanistic and doctoring practices, the former existence of the White Lion fraternity has been demonstrated, while the copious recollections bearing upon the agents of magical, secret, or doctoring arts show these to have stood by themselves as individuals, without the concerted co-operation of human confederates. The origin of the White Lion fraternity seems to have taken place two or three centuries ago, at the time when a number of Huron bands were dwelling in the vicinity of Lake Michigan. A text and a series of ritual songs, duly recorded, and other collateral information describe circumstantially how, in the course of fantastic events, many individuals belonging to three different clans evoked from an awful stream a Monster-Lion, to whom they surrendered a maiden with the definite purpose of getting his blood for magical operations. At the special command of the monster annual or occasional feasts have been held until recent years, in the course of which songs and rituals were performed in conformity with the initial instructions.

In regard to the ancient social hierarchy—that is, the relative standing of the clans in the phratries, and of the individuals in the clans, that of the hereditary chiefs, the elected war chiefs, the seniors, the women and children, the shamans, witches, and doctors—interesting though sometimes conflicting evidence has been obtained.

(2)

But a brief mention can be made here of the various topics that may conveniently be included under the heading of Huron social dynamics, namely: the function of the phratries, clans, and individuals in their social system, and customs and laws connected therewith; their rituals, ceremonials, and other practices; their mythology and folk-lore; and their language.

The Hurons were governed by their tribal and clan councils, the jurisdiction of neither of which conflicted with the other, that of the tribal council being strictly confined to matters of general concern, and that of the clan to affairs of internal and local interest, as each clan had one or more villages of its own. The phratries, the function of which was essentially concerned with tribal government and marriage regulations, were the constituent elements of the tribal council; the clan councils, on the other hand, were mere aggregates of individuals. A consequence of this was that while, in the tribal council, each clan had but one vote, in the clan council the same right was extended to every individual with the exception of those not of mature age. The function of the clan totems was not only connected with various traditional events and associated customs, but also with the graphic and symbolic representation, in the form of a communal crest or emblem, of the people of the clan. It is interesting to note that very little evidence to the same effect obtains regarding the phratry totems, the Big Turtle, and the Deer.

A host of ethnographic data bearing upon the traditional laws regulating the councils and their proceedings, marriage, the formal transfer of clan rights, and other customs, notwithstanding their importance, may scarcely be alluded to here. Matrilinear inheritance of clan rights has been the rule down to the present day in Wyandotte (Okla.) and Anderdon (Ont.), and very few exceptions may be found. The advanced decadence of the Lorette Hurons, having caused this rule, however, to fall into almost complete oblivion, the rigid outlines of the clans have long faded away; a result of which is that, while in Oklahoma very few violated the taboo prohibiting inter-clan marriage, no such taboo is known to the Lorette people. Many interesting customs and ceremonials have lingered almost to the present day in connexion with the ritual of conferring individual names to children or adults in conformity with the rules of matrilinear inheritance, and in connexion with the adoption of distant relatives or of strangers with a view to having them fill the vacant places of direct descendants and thus maintaining the integrity of the clans.

Though an adequate study of the rituals and customs of the Hurons is out of the question at this late day, it has been gratifying to get extensive accounts of rituals and ceremonials performed in the course of feasts, designed either for the fulfilment of rigid traditional duties towards superior beings, the maintenance of clan traditions and integrity, or meant for the ceremonial healing of disease, or merely for social entertainment. Some of these ceremonials have been witnessed, others have been explained by competent informants or described in the myths of folk-lore. Only two of the commemorative feasts have been satisfactorily studied with informants who have often participated, years ago, in their actual performance: the annual fasts of the Snake clan and of the White Lion fraternity. The original directions relating to the rituals of these societies are also respectively embodied in two myths obtained in text form; they are also explicitly referred to in about twenty songs, all of which have been carefully recorded.

The periodical feasts intended to provide for the giving of clan names, the "raising" of hereditary or elected chiefs, and the adoption of foreigners, have been responsible for the preservation, up to recent years, of interesting rituals and customs. At Lorette, Que., the last of the so-called "Sagamité" feasts, in the course of which honorary Huron names were given to distinguished visitors, took place about fifteen years ago; the traditional "Sagamité" supper, songs, and dances, and other ancient customs have, therefore, in this connexion, been saved from entire oblivion; about sixty Lorette Huron dancing songs have been recorded in text and on the phonograph. The same kind of feast has been studied to better advantage in Oklahoma, owing to the annual observance of these ceremonials in their primitive form up to about fifty years ago; a still larger number of naming songs, of which each clan has its own, and of dancing songs connected therewith. have been collected.

The other Huron feasts and ceremonials may be classified, with regard to their various aims, as follows: (1) the new corn or green corn feast, complex in character but primarily a thanksgiving feast; (2) the war dances; (3) the pipe or peace-making dances, connected with warfare; (4) the annual suppers given for the dead by their own clan; (5) a ghost or adoption feast; (6) several ceremonial performances for healing diseases, (*a*) the singing of ritualistic songs, either in choruses by parties assembled by the patient and to whom a supper is subsequently given, or by a masked shaman accompanied by a chorus with the concomitant 'false-face' songs and the scattering of coals and ashes; and (*b*) the lacrosse game, considered until about fifty years ago as an effective remedy; (7) feasts meant for mere entertainment, with accompanying songs, dances, and sometimes games, such as the moccasin, seed, lacrosse, and foot-ball games (besides the game of "la chêvre" at Lorette), gambling being an element of these games. Besides these feasts and ritualistic customs, many others are described implicitly or explicitly in the myths and folk-lore; the most interesting of these are such as relate to puberty seclusion and the getting of "mana" from a manitou, to witchcraft, and to warfare.

Notwithstanding many necessary lacunæ, the study of the mythology and folklore of the Hurons has developed, especially in Oklahoma, into gratifying proportions. Their former beliefs are embodied either in myths and tales or in amorphous popular sayings and recollections. From the data yielded by these various sources a fairly good reconstruction of the ancient pantheon of the Hurons is now possible. It reveals plainly the nature of the following categories of superior beings or semi-deities: (1) the human deities of the beginning of the Huron world; (2) the semi-personal deities connected with many phenomena of nature; (3) the giants and dwarfs; (4) the ruling manitous, either monsters or animals (a definite number of animals, classified into a hierarchy, being possessed of "mana," according to arbitrary notions).

The myths seem to be of two kinds: myths of origin and etiological myths. The origin myths give an account of : (1) the origin of the world (two imperfect, although extensive, versions of which have been recorded); (2) the origin of the "mana" or powers of clans and of individuals; the bear, the turtle, the wolf, the white lion, and the two different snake myths, not to speak of many others of lesser importance, belong to this second category. A few etiological myths account for the fantastic origin of many phenomena of nature, such as thunder, earthquakes, autumn, and colour, and form of various animals and birds.

A number of interesting tales have been collected, some meant to be recited by the fireside in winter only, others being devoid of any such restriction. In the present connexion may be mentioned the tales of the Fox and the Racoon, constituting a series of episodes; the many stories relating the deeds and contests of notorious witches and sorcerers of the past, and of Tuñe'tawi'ndi'a; the seven brothers transformed into buffaloes; two other tales dwelling on the ordeals of many adventuıous suitors, and a number of others referring to monstrous snakes and other animals, dwarfs, giants, and so on.

It goes without saying that, for lack of time, the study of Huron linguistics, as such, has scarcely been entered upon, notwithstanding that considerable attention has been directed to it.

(3)

The survey of the technology (notwithstanding its not having been completed on account of lack of time) has proved the most fertile field of ethnographic research among the Hurons. As more than half of the time at disposal has been devoted to it, about two hundred specimens have been purchased or ordered for the Museum and explained; descriptive accounts have also been taken down of such other illustrations of their technology, pertaining to the utilitarian and aesthetic arts, that could not be actually secured or conveniently represented in a museum.

(*a*) While the usual concerns of the men constitute certain aspects of the utilitarian arts of the Hurons, others are the result of the occupations of the women. It was the duty and function of the men to build houses, to hunt, to go to war, to trade with foreigners, and to provide for the means of transportation. In regard to their structure, many varieties of houses have been studied, namely: the long log-house, for permanent use; the open log-house; the "sugar-camp" house; the round bark house; and a small triangular structure built by hunters, in the woods, for temporary use. The methods of hunting and fishing have been examined with advantage at Lorette, where six or seven varieties of traps, not to speak of such weapons as bows and arrows and darts, have been used by hunters almost to the present day. The technology of their means of transportation and conveyance consists in the making of two kinds of sled, of many varieties of canoes (the bark canoe, the dug-out, and the skin or emergency canoe), of snow-shoes of five or six different types, and of cradle-boards. Their methods of warfare are illlustrated in the folklore, and especially in the relation of two ancient war adventures, one of which has been recorded in text and translated.

The functions of the women, with regard to technology, were confined to the following industries: agriculture, the making of maple-sugar, the preparation and preservation of food, the dressing and tanning of hides, and the making of dresses and costumes, of baskets, bark-vessels, and other articles of household use.

Other activities, as political, medical, and shamanistic arts, were of a neutral nature and were practised indifferently by men or by women.

(*b*) The non-utilitarian or aesthetic arts of the Hurons consist mainly of their decorative arts, and their music and dances, not to speak of their games. Many of the branches of their decorative arts, with the exception of moose-hair embroidery, could not be satisfactorily studied, on account of their advanced decadence. Moose-hair and porcupine-quill embroidery, ribbon and bead work (or the trimming of garments with fancy ribbon and bead appliqués, were among the attainments of the women, as compared with those of the men, namely: wood carving, silver work, painting, and the making of wampum. Moose-hair embroidery has been illustrated with comparative advantage at Lorette, especially with old Mrs. Etienne Groslouis and her daughters. A few other informants having also been consulted, over twenty-five specimens of various moose-hair patterns have been prepared for the Museum. Fancy ribbon trimming, only a few specimens of which could be secured, is spoken of by the Anderdon and Oklahoma informants as having been a characteristic art of their people.

The songs, over two hundred of which have been recorded on the phonograph, explained, and written down phonetically, illustrate extensively the interesting musical art of the Lorette and Oklahoma Hurons. Most of these songs—with the exception of some satirical, bacchic, flute, and a few ancient folk-lore and ritual songs—are accompanied by various kinds of dances. These dancing songs are either mythological, ritual (as the war songs, the peace-making or pipe songs, the naming, the medicine, and other songs), or simply meant for social entertainment.

It may be noted, in concluding this short account, that it seems advisable, and even most urgent, that the present research should be completed in the near future, and an attempt be made to exhaust the sources now easily accessible.

(*b*)

ON IROQUOIS WORK, 1911.

(*A. A. Goldenweiser.*)

In the course of the summer, 1911, I spent six weeks—from July 6 to August 20—at Tuscarora, Brant county, Ontario, among the Iroquois tribes of that district. My main informant as well as interpreter was John Gibson, head chief of the Seneca tribe. Notwithstanding his total blindness, the result of an accident some thirty years ago, his knowledge of the social organization and history of the Iroquois proved extensive and accurate, and I have had no occasion, so far, to question his reliability. In view of the limited time at my disposal I restricted my investigations, so far as was possible, to the subject of social organization. Most of my information was obtained from or with the assistance of Chief Gibson; the conclusions reached must thus be regarded as provisional pending the verification of the data through information from other Indians. The material secured consists, in the main, of facts referring to the clan system, of individual names, and of genealogies. A complete list of clans was obtained for each of the five tribes: Mohawk, Onondaga, Seneca, Oneida, and Cayuga. The list only partly corresponds to that given by other observers. A separate list of clans refers to the period before the formation of the Iroquois League. A tentative analysis of the clan names seems to indicate that, although most of the clans were named after animals, these names were not used except on a few special occasions. The clan names in constant use were generally expressed by a collective term referring to some characteristic of the eponymous animal. As to the number of the clans, my information to date indicates that the Mohawk and Oneida had eight each instead of the three generally attributed to them. This point, most interesting, if true, awaits verification.

The functions of the phratries, the two groups into which the clans were segregated, were manifold; specific data were obtained as to the part played by these social units in camping, burial, feasts, ceremonies, and games. At councils, on the other hand, the phratric division broke down. Instead, the clans (in the tribal councils) and the tribes (in the League Councils) were divided into three groups, one of which had the deciding voice. The elections of chiefs, especially with reference to the part played in them by women, were described by Chief Gibson with considerable detail.

Personal names of men and women, some eight hundred in all, were obtained, in each of the five tribes. The names were taken down in phonetic spelling, and provisional analysis and translation into English were attempted. Each clan, as is well known, was found to own a special set of personal names, but no connexion of these names with the eponymous animal of the clan could be discovered. A list was secured of the fifty "lords" sachems of the Iroquois. The list is interesting in so far as it reveals the dialectic variations of the five languages. It also shows some other peculiarities. Fifty, instead of forty-eight, "lords" seem to have always existed and are still found among the Iroquois tribes of the district investigated. Chief Gibson repudiates the oft-cited tradition of the two seats in the League Council which were left vacant to honour the two mythical founders of the League.

A record of about four hundred marriages, in the form of genealogies, was secured with the assistance of Chief Gibson. The genealogies cover roughly one century, but a few extend a hundred and fifty years back. The genealogies and marriages disclose many interesting facts, although a complete analysis of them will not be attempted until further data are secured. The prohibition of marriage within the clan is still adhered to, although not rigidly, and in varying degrees in the different tribes. A list of the classificatory terms of relationship was secured and partly verified by the genealogies.

Several myths and part of the Bean festival were taken down in text. A fair amount of miscellaneous information on social organization, ceremonies, customs, and other matters was secured, the value of which may appear at later stages of the investigation.

Little attention was paid to material culture, but I purchased for the Victoria Memorial Museum some twenty-five specimens, among them one false face of unusual merit.

(*c*)

ON MICMAC WORK, 1911.

(*C. MacMillan.*)

I spent the summer months of 1911 engaged in field work among the Micmac Indians of eastern Canada. The period of my researches extended from the middle of May to October 1. The territory covered included Prince Edward Island, Nova Scotia (including Cape Breton), and part of New Brunswick.

The Micmac Indians are scattered in groups throughout the three Maritime Provinces. In numbers varying from fifty to three or four hundred they occupy reservations at different points, always close to sea, or lake, or river. For my investigations I selected the oldest and most thickly populated of these settlements. The intermixture of the Micmacs with the French, English, and Scotch inhabitants of the eastern provinces has been of long duration. For a period they have been under civilizing forces; and while much of their past still remains for the investigator, much has irrevocably disappeared. Yet, if at best, one can be but a gleaner in this particular field, one's results are nevertheless not inconsiderable.

A careful study was made of the remaining folk-lore and mythology of the tribe. They still possess a great stock of stories. A large number of these were gathered, and local differences in the telling were carefully noted. The most notable figure in their mythology and folk-lore is Glooscap (Kulóscap or Klûskâbe), a kind of culture-hero. Of his doings I obtained a fairly complete record, telling how he created man and became his friend, how he made and named and subdued the animals, how he did many great deeds—victoriously fought and destroyed giants and monsters, brought the summer to Canada, and so forth—and at the last, when the world became evil, how he went away to a happy island, sailing in his canoe, and promising to come back some day. This tale has many points of resemblance with the Arthurian legends. Other stories of animals and birds, of dwarfs and giants, have a close approach to the European folk-tales.

A study was made of other phases of the old Micmac life. I noted, in more or less detail, old Micmac superstitions and religious beliefs, birth, marriage, and funeral customs, occupations and industries, games and amusements, ideas of social and political organization, ways of making dyes and medicines, methods of hunting and fishing, preserving meat and dressing skins, etc. While it is evident that many songs and dances existed among them, these have largely disappeared. I was able, however, to observe some of their dances, and a few of the songs that still remain were written out in text and translation. The highest limit of art among the tribe seems to have been reached in pictography on birch bark, in quill, and bead work. Their artistic sense seems to have expressed itself, too, in the ornamentation of their clothing with dyes and vari-coloured shells.

A slight attempt was made to do a little linguistic work. A considerable dialectic variation is noticeable according to localities. Verbal forms and grammatic and phonetic peculiarities were observed. The names of plants, and of birds, fishes, and other animals known to the tribe were carefully noted.

Specimens were obtained of typical basketry, bead and quill work, of old dice plates and counting sticks for gaming, and other objects. In places digging for stone implements was attempted, and was sometimes rewarded by a few stone axes, knives, and arrow-heads. Models were obtained of old-time spears and other implements for fishing and hunting, no longer in use among the tribe, but the shapes of which still exist in the memory of the old.

Altogether, the field, although long closed to civilization, offered a rich and interesting opportunity for investigation. I believe that very little work of a scientific nature had hitherto been attempted. The complete results of my summer's researches will be submitted as soon as possible.

(*d*)

ON MICMAC AND MALECITE WORK, 1911.

(*W. H. Mechling.*)

My field work for the summer of 1911 in New Brunswick and Quebec was among the Malecite and Micmac tribes. All the summer except one week was spent in New Brunswick, for there is only one Malecite village (Cacouna) in Quebec, and that an unimportant one. The following reservations were visited in the order named: Cacouna (Malecite), St. Anne de Restigouche (Micmac), St. Mary (Malecite), Oromocto (Malecite), Burnt Church, Big Cove, and Eel Ground (Micmac).

The greater part of the work was naturally spent on the Malecites, in order to complete the researches started in the summer of 1910. In the two seasons I have visited all the Malecite villages. The character of the work may be divided into the following heads: (1) collection of specimens and the making of phonograph records; (2) gathering of ethnological data; (3) linguistic work.

Seventy-five specimens were collected illustrating the life and culture of these people. Of these about twenty are Malecite and the rest Micmac. With those collected last summer and purchased by the Geological Survey, the Museum now possesses probably the largest collection from this area. The specimens of bark work are particularly good. During the summer about forty-five phonograph records were made, most of them Malecite. Many more Micmac records could have been made, but unfortunately the supply of blank records was exhausted and it was impossible to secure any more in time. However, the Malecite collection is a good one, as I was able to secure the services of the only three dance song leaders of the tribe. The best of these is in poor health and may die at any time. The younger generation are not able to sing the Indian songs, so that in all probability the music of the Malecite will die out with this generation.

Most stress was naturally laid on the collection of ethnological information. Part of the time was given to verification of the last summer's results, and further investigation was undertaken along lines suggested by last summer's work. All the more important ethnological topics received attention. It was found that the different aspects of their culture have been preserved with various degrees of tenacity. Mythology is preserved better than anything else except folk-lore and what is generally known as "superstitions." Aboriginal social organization and religion have long ago given place to white men's methods of government and to Catholicism; only suggestions of their former practices and beliefs could be obtained. Fortunately the social organization was simple and can probably all be reconstructed from the accounts of the early explorers, missionaries, and travellers. With their religion it is quite another story. The greater part of their material culture is still accurately preserved in the minds of the older people; in actual practice they differ at present little in this respect from their white neighbours. Much work can still be done on the folklore and mythology of the Micmacs.

My linguistic work consisted chiefly in recording texts of myths; some were secured in Micmac, but the greater part in Malecite. All myths recorded last summer were carefully gone over, both to ensure the accuracy of the texts and to get a better translation. Grammatical notes also received attention; furthermore the names of all objects and concepts of ethnological significance were recorded. I hope to receive during the winter of 1911-2 a great deal more linguistic material, as several Indians have been engaged to write down myths in Micmac and also make a translation of them.

(*e*)

WORK AMONG THE ARCTIC ESKIMOS.

(*V. S. Stefánsson.*)

Letters addressed to the Director have been received from V. S. Stefánsson, who has been continuing his researches among the Eskimos of the Arctic region between Mackenzie river and Hudson bay. They are dated August 12, October 14 (joint letter to the American Museum of Natural History and the Geological Survey), November 4, and December 4, 7, and 11, of 1910; and January 20 and April 20 of 1911. Under date of November 4 Mr. Stefánsson writes from Dease river, a northeast inlet of Great Bear Lake:—

"It gives me pleasure to report to you that we have completed the work entrusted to us by the Geological Survey of Canada and the American Museum of Natural History of New York three years ago—completed it in so far as the itinerary is concerned. The completeness of the work otherwise cannot be judged till we have the pleasure of laying our results before you after our return.

" . . . . On April 22 we left Langton bay to attempt reaching the Coronation Gulf district by sled and to search for hitherto undiscovered people that might inhabit Dolphin and Union straits. This was the last part of our itinerary as laid before you in Ottawa the winter 1907-8. April 27 we left Cape Lyon, the most easterly point at which Eskimo houses were seen by Dr. Richardson on his Franklin Search expedition and the most easterly point known to have been visited by the Western or Baillie Island Eskimos. Our outfit was three Eskimos and myself, one sled, six dogs, two week's provisions, and 960 rounds of ammunition for four rifles—besides some trade articles for the purchase of ethnological specimens from any people we might meet.

"We proceeded east slowly, as we were depending on seals for food, and although they were abundant on top the ice in Darnley bay April 25, they became rarer as we proceeded east—on account of the increasing severity of the weather. Our experience in winter quite agrees with Dr. Richardson's in summer as to the season's being a full month later at Cape Krusenstern than at Cape Parry. The first seals appeared on top the ice at Cape Bexley, May 17, 1910.

"May 13, we discovered the first people—the Akuliakattagmiut, whose winter home is in the middle of the straits north of Cape Bexley, but who hunt in summer south of Cape Bexley, inland on the lake A-ku-li-a-kat-tak, which is the source of the Rae river. This lake is said to be oval, roughly 20 miles north and south and 25 east and west, and is about due south of Bexley and due west of Back inlet. May 17 to 20 we visited the Haneragmiut, who live on the south shore of Victorialand and north of Cape Bexley, and then proceeded towards the Coppermine, making a portage south from a little unnamed bay southeast (true) from Liston island to the foot of Basil Hall bay. This route is partly over a chain of small lakes and is much used by the Eskimos. I made a rough sketch map of it. We entered the mouth of the Coppermine June 2, and June 6 were compelled by the thaw to end our sledding for the year some 8 miles south of Bloody fall and about equally far north of the northern limit of trees.

"Our summer has been spent on the Coppermine river, on Dismal lake, and Dease river with bands of Eskimos of various sizes. We have seen, all told, some 250 Eskimos, representing a population of 700 or 800 between the Kent peninsula and Cape Bexley—people from these extremes were met on Dease river in August. Our routine work of anthropometric measurement, notation of ethnological information and of such geological and zoological information as could be gained has been steadily carried on. . . . ."

Under date of April 20 word was received from Coronation gulf (latitude 67° 40′ N., longitude 114° 35′ W., about 18 miles east of Coppermine mouth):—

" . . . . The ethnological collection being sent to your Museum embraces, so far as I know, every article of common use or wear except dance caps (seldom used here), mosquito hoods for summer wear, kayak, and sled. Of several articles there are two or more duplicates. Our programme for the summer has been completely changed by finding here the *Teddy Bear* trading schooner, whose captain, Joseph F. Bernard, has generously offered assistance which much simplifies for us the transportation problem. . . . .

"I am sorely tempted to devote the spring to completing the survey of the coast of northeast Victorialand from the 'Farthest' of the Amundsen expedition. It would be easy to get a feather for one's cap that way, but I do not feel justified in risking your disapproval and that of the Museum, for after all this of ours is an ethnological expedition, and it may be said that we have no business running off into a probably uninhabited country just to complete an outline survey of an island. In February I commenced a 'report to print' on our ethnological work of the year, to send you by your request. It is not completed, by reason of many interruptions for hunting and other work. Now the unexpected meeting with a ship here and the offer of equipment for summer work has decided me to turn north at once to Victorialand. I am asking Dr. Anderson to send the report to you nevertheless, uncompleted as it is. . . . ."

Three reports of an ethnological character have been received: one entitled, "Ethnological Report on the Eskimos of Coronation Gulf Region," dated Headwaters of Dease river, January 28, 1911; one containing map entitled, "Distribution and Seasonal Migrations of the Copper Eskimos," dated Langton bay, June 25, 1911; the third entitled, "Prehistoric and Present Commerce among the Arctic Coast Eskimo," dated the Parry peninsula, July 25, 1911. Two short Eskimo texts entitled, "The Girl Who Broke the Taboo" and "The Blind Boy and his Grandmother," with notes and English translation, have also been submitted, as well as a few negatives of ethnological interest.

PART II.

ARCHÆOLOGY.

(*Harlan I. Smith.*)

The archæological work of the Geological Survey from June 15, the date of my appointment, to the end of the calendar year has been divided into two main groups—the activities for diffusing archæological knowledge by such means as museum exhibits, guide books, and lectures, and those for increasing such knowledge, as by exploration, original research, and systematization.

All the archæological material of the Victoria Memorial Museum has been unpacked and sorted into groups corresponding to the divisions of the proposed museum exhibits equivalent to the five ethnological culture areas of Canada which have tentatively been adopted as archæological areas. The collection from the southern coast of British Columbia is found to be fairly representative, that from the southern interior of British Columbia is also representative; the collection from Ontario is large but lacks needed data. From Quebec and the Maritime Provinces there are hardly any archæological specimens possessed by the Museum, and the same is true of the Arctic, the Great Plains, and the northern part of the Plateau-Mackenzie region. Nine hundred and forty specimens from the southern interior of British Columbia, the entire collection from the region, have been numbered and catalogued.

A popular guide for the archæological collections from the interior of British Columbia has been prepared, another for the collections from the Pacific coast is nearly finished, and one for those from Ontario is well under way. General and topical labels have been prepared for the printer.

Casts of specimens to supplement the collections from the two western archæological areas have been secured by exchange with the American Museum of Natural History, New York. A small collection of archæological objects was obtained in field work with Mr. George E. Laidlaw and with Mr. W. J. Wintemberg in Ontario. Five specimens were received by gift, through Mr. Lawrence M. Lambe, from Sir James Grant, M.D., Ottawa. Stone beads collected at Yale, B.C., were presented by Mr. Charles Camsell, and a human skeleton, besides archæological objects, has been received among the results of field work by Mr. W. J. Wintemberg in Ontario.

A mould has been made of a large and interesting petroglyph from near Nanaimo, Vancouver island. From this a cast for exhibition purposes may be taken and duplicates may be made for loan to other museums throughout Canada. A selection has been made from our negatives. Lantern slides have been ordered from these selected negatives in order to develop a stock from which slides necessary for lectures on Canadian archæology may be chosen.

Turning to research work, attention has been given to the organization of an archæological survey of the Dominion. It has been found that we most sorely need archæological specimens and information from the northern part of the Plateau-Mackenzie area, the Great Plains, the Arctic, Quebec, and the Maritime Provinces.

A number of typical village sites in the vicinity of Washington, Ontario, were visited in company with Mr. W. J. Wintemberg, who was later employed to make an archæological survey of Blandford township, Oxford county, and to conduct other researches in Ontario. Village sites were also visited in company with Mr. George E. Laidlaw in the vicinity of Victoria Road, Ontario.

Photographs, for use chiefly in research work, were made of all the types of archæological objects from Ontario in the Provincial Museum at Toronto. All the collections available in Toronto, Montreal, and Quebec were inspected. Two collections which were offered for sale to the Geological Survey, one in Paris, the other at Waterdown, were visited. It is my opinion that the funds necessary for purchasing these might far better be spent in carrying on activities for the diffusion and increase of archæological knowledge and in securing material more sorely needed for these purposes.

Considerable attention has been given to systematizing and digesting scattered and incomplete archæological data. The co-operation of railway officials, members of the Northwest Mounted Police, and the explorers of the Geological Survey, has been enlisted to assist in the archæological survey.

MAPPING AND ENGRAVING DIVISION.

(C.-Omer Senécal.)

The staff of the mapping and engraving division is at present composed of a chief officer, thirteen map compilers and draughtsmen, and one clerk-typist.

The work assigned to this division is of a varied nature and consists mainly in the construction and drawing of original maps and diagrams of all descriptions to be issued separately or to illustrate geological memoirs. Some members of the staff are trained for special map compilation and others for the preparation and finishing of drawings intended for reproduction by engraving or photolithographic processes. Considerable attention is also devoted to the elaboration of map specifications for the use of the engravers who are under the control of the Printing Bureau. A saving of time and expenditure in proofing is calculated to be thus effectuated.

Four hundred and eighteen letters, memoranda, specification sheets, reports, etc., relating to the work of this division, were sent out during the past year, while four hundred and eighty-six were received.

Attention was also given to the work of the Geographic Board of Canada, the meetings of which were regularly attended. A considerable number of lists of place-names covering maps prepared during the year were, as usual, edited, then submitted to the board for discussion and approval. Lists of approved names are published in the annual report of the board, under the authority of the Department of Marine and Fisheries, and from time to time, in the *Canada Gazette*.

The following twenty-five maps, plans, etc., are, at this date, in the hands of the King's Printer. Several editions are expected to be issued shortly.

MAPS in hands of King's Printer, December 31, 1911.

Series A.	Publication Number.	Title.	Sent to King's Printer.
17	1123	Southeast Vancouver island, B.C	Aug. 29, 1911
19	1147	Lardeau Topographical map, B.C	Sept. 3, 1911
26	1162	Bathurst Topographical map, N.B	June 1, 1911
27	1163	Bathurst Geological map, N.B	" 1, 1911
29	1167	Mother Lode and Sunset mines, B.C., Topographical map	Mar. 24, 1911
30	1168	" " " Geological map	Nov. 17, 1911
31	1177	Larder Lake district, Ont	" 14, 1911
35	1181	Parts of Albert and Westmorland counties, N.B	July 26, 1911
38	1184	Danville Mining Area, Quebec	Oct. 6, 1911
39	1185	Geological Map of Nova Scotia	Aug. 31, 1911
40	1210	Bighorn Coal Basin, Alta	Oct. 17, 1911
45	1195	Tulameen Topographical map, B.C	Aug. 29, 1911
46	1196	" Geological map, B.C	" 29, 1911
47	1197	Law's Mining camp, Tulameen, B.C	" 29, 1911
49	1199	Orillia Topographical sheet, Ont	Oct. 17, 1911
50	1200	Portland Canal Mining area	" 17, 1911
51	1201	Geological map of Alberta, Saskatchewan, and Manitoba	Sept. 9, 1911
52	1202	Northeast part of Serpentine Belt, Quebec	Oct. 6, 1911
53	1208	Southeast Nova Scotia	Sept. 26, 1911
......	339	Northwestern Manitoba, 2nd edition	Aug. 5, 1911
......	964	Part of Algoma and Thunder Bay, Ont., 2nd edition	" 22, 1911
......	......	Goldenville Gold district, N.S.; Libbey fissure vein	Oct. 20, 1911
......	......	" " " Plan and section	" 20, 1911
......	......	Oldham Gold district, N.S.; Plan and section	" 20, 1911
......	......	Brookfield Gold district, N.S.; Plan	" 19, 1911
		Also a large number of zinc-cut illustrations for reports	

A list of the maps, diagrams, etc., published during the past year, is appended herewith:—

LIST of Map Editions received from the King's Printer, during the year 1911.

Series A.	Publication Number.		Title.	Number of accompanying Memoir.	Remarks.
28	1164	British Columbia.	Portland Canal Mining district. Scale 2 miles to 1 inch.	Summary Report 1910.	Sketch geology.
15	1135	"	Phoenix map. Scale 400 feet to 1 inch.	21	Geology.
16	1136	"	Phoenix map. Scale 400 feet to 1 inch.	21	Topography.
20	1148	"	Victoria sheet, Vancouver island; Scale, $\frac{1}{62,500}$		"
21	1149	"	Saanich sheet, Vancouver island. Scale, $\frac{1}{62,500}$		"
		"	Nanaimo sheet, Vancouver island. Scale, $\frac{1}{62,500}$		Topography, advance edition.
		"	Duncan sheet, Vancouver island. Scale, $\frac{1}{125,000}$		" "
		"	Sooke sheet, Vancouver island. Scale, $\frac{1}{125,000}$		" "
		"	Tulameen map, Yale district. Scale, $\frac{1}{62,500}$		" "
48	1198	"	Tulameen coal area. Scale ½ mile to 1 inch.	26	Economic geology.
	921	"	Graham Island coal-field. Scale 1 mile to 1 inch.		" " 2nd edition.
		"	Portland Canal coal mining area. Scale, $\frac{1}{125,000}$		Topography, advance edition.
		"	Beaverdell map, Yale district. Scale, $\frac{1}{62,500}$		" "
		Alberta.	Bighorn coal basin. Scale, $\frac{1}{125,000}$		" "

....	....	"	Jasper park .... Scale, $\frac{1}{62,500}$		" "
....	....	Ontario.	Orillia sheet, Simcoe county .... Scale, $\frac{1}{62,500}$		" "
....	....	"	West Shiningtree area, Sudbury district .... Scale, 1 mile to 1 inch.		Economic geology, advance edition.
18	1066	Ontario and Quebec.	Lake Timiskaming Mining region .... Scale 1 mile to 1 inch.		Areal geology.
....	....	" "	Larder lake and Opasatika lake .... Scale 2 miles to 1 inch.		Topography, advance edition.
23	1154	Quebec.	Thetford Black Lake Mining district .... Scale 1 mile to 1 inch.		Economic geology.
34	1180	"	Vicinity of National Transcontinental Ry. between Levis and Temiscouata .... Scale 8 miles to 1 inch.		Geological reconnaissance
....	....	"	Danville Mining area .... Scale 1 mile to 1 inch.		Cadastral compilation, advance edition.
24	1155	New Brunswick.	Millstream iron ore deposit, Gloucester county .... Scale 400 feet to 1 inch.	18	Economic geology.
25	1156	"	Nipisiguit iron ore deposit, Gloucester county .... Scale 400 feet to 1 inch.	18	" "
13	1133	Nova Scotia.	Kingsport, Sheet No. 84, Hants and Kings county .... Scale 1 mile to 1 inch.		Areal geology.
....	....	"	Gaspereau, Sheet No. 85 .... Scale 1 mile to 1 inch.		Topography, advance edition.
....	....	"	New Ross, Sheet No. 86 .... Scale 1 mile to 1 inch.		" "
....	....	"	Lakeview, Sheet No. 97 .... Scale 1 mile to 1 inch.		" "
....	....	"	Berwick, Sheet 98 .... Scale 1 mile to 1 inch.		" "
22	1153	"	Index map of the Province .... Scale 12 miles to 1 inch.	16	" "
			Also 32 zinc cut sketch maps, diagrams, and illustrations for various reports.		

LIBRARY.

(Jane Alexander, Acting Librarian.)

During the calender year, 2,981 publications were received as gifts or exchanges, including—besides periodicals—maps, reports, and publications of foreign Geological Surveys, together with memoirs, transactions, and proceedings of the scientific societies of Canada and other countries.

306 volumes were added by purchase, costing $1,241.60.

242 volumes were bound during the year.

104 periodicals were sub cribed for.

217 letters relating to the work of the library were sent out, with 597 acknowledgments of publications received as gifts.

Though the removal of the library to its new quarters in the Victoria Memorial Museum took place early in the year, it was not until the month of September that a systematic re-arrangement and classification of the books was begun. A modified form of the Cutter system is being used, and good progress has been made with the work. Many volumes—which for want of shelf room had been stored away—are now available.

PUBLICATIONS.

The following reports have been published since January 1, 1911:—

No.

1006. Report on a Traverse through the Southern part of the North West Territories, from Lac Seul to Cat lake, 1902. By A. W. G. Wilson. Published January 10, 1911.

1080. Report on a Part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers. By W. McInnes. Published January 10, 1911.

} Bound together.

1064. Report on the Geology of an Area adjoining the East Side of Lake Timiskaming. By Morley E. Wilson. Published May 1, 1911.

1110. Memoir No. 4: Geological Reconnaissance along the Line of the National Transcontinental Railway in Western Quebec. By W. J. Wilson. Published June 26, 1911.

1113. Memoir No. 16–E: The Clay and Shale Deposits of Nova Scotia and Portions of New Brunswick. By Dr. Heinrich Ries and J. Keele. Published July 18, 1911.

1115. Memoir No. 8: Preliminary Report on the Edmonton Coal Fields. By D. B. Dowling. Published February 13, 1911.

1130. Memoir No. 9: Bighorn Coal Basin. By G. S. Malloch. Published July 18, 1911.

1137. Memoir No. 10: An Instrumental Survey of the Shorelines of the Extinct Lakes Algonquin and Nipissing, in Southern Ontario. By J. W. Goldthwait. Published June 20, 1911.

1141. Memoir No. 12: On Tertiary Insects of British Columbia. By Anton Handlirsch. Published January 30, 1911.

1143. Memoir No. 14: Description of Shells collected by John Macoun at Barkley Sound, Vancouver Island, B.C. By Messrs. W. H. Dall and Paul Bartsch. Published January 16, 1911.

1150. Memoir No. 15: On a Trenton Echinoderm Fauna at Kirkfield, Ont. By Hon. Frank Springer. Published May 16, 1911.

1170. Summary Report of the Geological Survey for the Calendar Year ending December 31, 1910. Published June 20, 1911.

Special Reprint.

Note on the Parietal Crest of Centrosaurus Afertus, and on a Proposed New Generic name for Stereocephalus Tulus. By Lawrence M. Lambe. The Ottawa Naturalist, December, 1910. Published January 10, 1911.

No.

FRENCH TRANSLATIONS.

(*M. Sauvalle.*)

1035*a*. Coal Fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia. By D. B. Dowling. Published March 17, 1911.

1072. Summary Report, 1908. Published January 17, 1911.

ACCOUNTANT'S STATEMENT.

The funds available for the work and the expenditure of the Geological Survey for the fiscal year ending March 31, 1911, were:—

Details.	Grant.	Expenditure.
Amounts voted by Parliament..	$391.889 00	
Civil list salaries..		$103,502 94
Explorations in British Columbia..		26,352 37
Topographical surveys in British Columbia.		39,766 30
Explorations in North West Territories..		8,710 84
Explorations in Ontario..		6,708 78
Topographical surveys in Ontario.		4.061 82
Explorations in Quebec..		4,904 39
Topographical surveys in New Brunswick.		5,858 67
Explorations in New Brunswick..		344 78
Explorations in Nova Scotia..		4,549 49
Explorations in general..		2,931 49
Publication of maps..		13,993 93
Publication of reports..		9.787 55
Instruments and repairs..		9,841 80
Specimens for Museum..		9,066 35
Miscellaneous..		6,237 28
Printing and stationery..		5,209 35
Wages of temporary employes..		2.081 35
Travelling expenses..		1,752 67
Library..		1,598 76
Photo supplies..		1.298 14
Removal to Victoria Memorial Museum.		1.171 94
Legal fees..		1,563 20
Balance unexpended and lapsed..		120,594 81
	$391.889 00	$391,889 00

JNO. MARSHALL.

All of which is respectively submitted.

I have the honour to be, Sir,

Your obedient servant.

(Signed) R. W. BROCK.

INDEX

A

B

CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

Hon. ROBERT ROGERS, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

SELECTED LIST OF REPORTS AND MAPS

(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

PUBLISHED BY

THE GEOLOGICAL SURVEY.

Report of the Mines Section:—

No. 245.	Report of Mines Section,		1886.	No 662.	Report of Mines Section,		1897
272	"	"	1887.	698	"	"	1898
*300	"	"	1888.	718	"	"	1899
301	"	"	1889.	744	"	"	1900
334	"	"	1890.	800	"	"	1901
335	"	"	1891.	835	"	"	1902
360	"	"	1892.	893	"	"	1903
572	"	"	1893-4	*928	"	"	1904
602	"	"	1895.	971	"	"	1905
625	"	"	1896.				

Mineral Production of Canada:—

No. *414.	Year 1886.	No. *422.	Year 1893.	No. 719.	Year 1900.
*415	" 1887.	*555	" 1894.	719a	" 1901.
*416	" 1888.	*577	" 1895.	813	" 1902.
*417	" 1889.	*612	" 1896.	861	" 1903.
*418	" 1890.	*623	" 1886-96.	896	" 1904.
*419	" 1891.	*640	" 1897.	924	" 1905.
*420	" 1886-91.	*671	" 1898.	981	" 1906.
*421	" 1892.	*686	" 1899.		

Mineral Resources Bulletin:—

No. *818.	Platinum.	No. 860	Zinc.	No. 881.	Phosphate.
851.	Coal.	869.	Mica.	882	Copper.
*854.	Asbestos.	872.	Molybdenum and Tungsten.	913.	Mineral Pigments.
857.	Infusorial Earth.	*877.	Graphite.	953.	Barytes.
858.	Manganese.	880.	Peat.	984.	Mineral Pigments (French).
859.	Salt.				

Report of the Section of Chemistry and Mineralogy:—

No. *102.	Year 1874-5.	No. *169.	Year 1882-3-4.	No. 580.	Year 1894.
*110	" 1875-6.	222	" 1885.	616	" 1895.
*119	" 1876-7.	246	" 1886.	651	" 1896.
*126	" 1877-8.	273	" 1887-8.	695	" 1898.
*138	" 1878-9.	299	" 1888-9.	724	" 1899.
*148	" 1879-80.	333	" 1890-1.	821	" 1900.
*156	" 1880-1-2.	359	" 1892-3.	*958	" 1906.

* Publications marked thus are out of print.

REPORTS.

GENERAL.

745. Altitudes of Canada, by J. White. 1899.
*972. Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.
1073. Catalogue of Publications: Reports and Maps (1843-1909)
1085. Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1086. French translation of Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1107. Part II. Geological position and character of the oil-shale deposits of Canada, by R. W. Ells.
1146. Notes on Canada, by R. W. Brock.

YUKON.

*260. Yukon district, by G. M. Dawson. 1887. Maps No. 274, scale 60 m. = 1 in.; Nos. 275 and 277, scale 8 m. = 1 in.
*295. Yukon and Mackenzie basins, by R. G. McConnell. 1889. Map No. 304, scale 48 m. = 1 in.
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. Map No. 688, scale 2 m. = 1 in.
884. Klondike gold fields, by R. G. McConnell. 1901. Map No. 772, scale 2 m. = 1 in.
*909. Windy Arm, Tagish lake, by R. G. McConnell. 1906. Map No. 916, scale 2 m. = 1 in.
943. Upper Stewart river, by J. Keele. Map No. 938, scale 8 m. = 1 in. } Bound together.
951. Peel and Wind rivers, by Chas. Camsell. Map No. 942, scale 8 m. = 1 in. } Bound together.
979. Klondike gravels, by R. G. McConnell. Map No. 1011, scale 40 ch. = 1 in.
982. Conrad and Whitehorse mining districts, by D. D. Cairnes. 1901. Map No. 990, scale 2 m. = 1 in.
1016. Klondike Creek and Hill gravels, by R. G. McConnell. (French.) Map No. 1011, scale 40 ch. = 1 in.
1050. Whitehorse Copper Belt, by R. G. McConnell. Maps Nos. 1,026, 1,041, 1,044-1,049.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.
1011. Memoir No. 5 (Preliminary): on the Lewes and Nordenskiöld Rivers coal-field, Yukon, by D. D. Cairnes. Maps Nos. 1103 and 1104, scale 2 m. = 1 in.

BRITISH COLUMBIA.

212. The Rocky mountains (between latitudes 49° and 51° 30'), by G. M. Dawson. 1885. Map No. 223, scale 6 m. = 1 in. Map No. 224, scale $1\frac{1}{2}$ m. = 1 in.
*235. Vancouver island, by G. M. Dawson. 1886. Map No. 247, scale 8 m. = 1 in.
236. The Rocky mountains, geological structure, by R. G. McConnell. 1886. Map No. 248, scale 2 m. = 1 in.
263. Cariboo mining district, by A. Bowman. 1887. Maps Nos. 278-281.
*271. Mineral wealth, by G. M. Dawson.

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* Publications marked thus are out of print.

*294. West Kootenay district, by G. M. Dawson. 1888-9. Map No. 303, scale 8 m. = 1 in.
*573. Kamloops district, by G. M. Dawson. 1894. Maps Nos. 556 and 557, scale 4 m. = 1 in.
574. Finlay and Omineca rivers, by R. G. McConnell. 1894. Map No. 567, scale 8 m. = 1 in.
743. Atlin Lake mining division, by J. C. Gwillim. 1899. Map No. 742, scale 4 m. = 1 in.
939. Rossland district, by R. W. Brock. Map No. 941, scale 1,600 ft. =1 in.
940. Graham island, by R. W. Ells. 1905. Maps No. 921, scale 4 m. = 1 in.; No. 922, scale 1 m. = 1 in. (Reprint).
986. Similkameen district, by Chas. Camsell. Map No. 987, scale 400 ch. = 1 in.
988. Telkwa river and vicinity, by W. W. Leach. Map No. 989, scale 2 m. = 1 in.
996. Nanaimo and New Westminster districts, by O. E. LeRoy. 1907. Map No. 997, scale 4 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling.
1093. Geology, and Ore Deposits of Hedley Mining district, British Columbia, by Charles Camsell. Maps Nos. 1095 and 1096, scale 1,000 ft. = 1 in.; No. 1105, scale 600 ft. = 1 in.; No. 1106, scale 800 ft. = 1 in.; No. 1125, scale 1,000 ft. = 1 in.
1121. Memoir No. 13: Southern Vancouver island, by Charles H. Clapp. Map No. 1123—17 A, scale 4 m. = 1 in.
1175. Memoir No. 21: Geology and ore deposits of Phoenix, Boundary district, by O. E. LeRoy. Maps Nos. 1135 and 1136, scale 400 ft. = 1 in.
1204. Memoir No. 24–E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201–51 A, scale 35 m. = 1 in.

ALBERTA.

*237. Central portion, by J. B. Tyrrell. 1886. Maps Nos. 249 and 250, scale 8 m. = 1 in.
324. Peace and Athabaska Rivers district, by R. G. McConnell. 1890-1. Map No. 336, scale 48 m. = 1 in.
703. Yellowhead Pass route, by J. McEvoy. 1898. Map No. 676, scale 8 m. = 1 in.
*949. Cascade coal-fields, by D. B. Dowling. Maps (8 sheets) Nos. 929-936, scale 1 m. = 1 in.
968. Moose Mountain district, by D. D. Cairnes. Maps No. 963, scale 2 m. = 1 in.; No. 966, scale 1 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1035a. French translation of coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1115. Memoir No. 8-E: Edmonton coal-field, by D. B. Dowling. Maps Nos. 1117–5 A and 1118–6 A, scale 2640 ft. = 1 in.
1136. Memoir No. 9-E: Bighorn coal basin, Alta., by G. S. Malloch. Map No. 1132, scale 2 m. = 1 in.
1204. Memoir No. 24–E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201—51 A, scale 35 m. = 1 in.

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213. Cypress hills and Wood mountain, by R. G. McConnell. 1885. Maps Nos. 225 and 226, scale 8 m. = 1 in.
601. Country between Athabaska lake and Churchill river, by J. B. Tyrrell and D. B. Dowling. 1895. Map No. 957, scale 25 m. = 1 in.

* Publications marked thus are out of print.

868. Souris River coal-field, by D. B. Dowling. 1902.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1204. Memoir No. 24-E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201-51 A, scale 35 m. = 1 in.

MANITOBA.

264. Duck and Riding mountains, by J. B. Tyrrell. 1887-8. Map No. 282, scale 8 m. = 1 in.
296. Glacial Lake Agassiz, by W. Upham. 1889. Maps Nos. 314, 315, 316.
325. Northwestern portion, by J. B. Tyrrell. 1890-1. Maps Nos. 339 and 350, scale 8 m. = 1 in.
704. Lake Winnipeg (west shore), by D. B. Dowling. 1898. Map No. 664, scale 8 m. = 1 in. } Bound together.
705. Lake Winnipeg (east shore), by J. B. Tyrrell. 1898. Map No. 664, scale 8 m. = 1 in. } Bound together.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1204. Memoir No. 24-E: Preliminary Report on the Clay and Shale Deposits of the Western Provinces, by Heinrich Ries and Joseph Keele. Map No. 1201-51 A, scale 35 m. = 1 in.

NORTH WEST TERRITORIES.

217. Hudson bay and strait, by R. Bell. 1885. Map No. 229, scale 4 m. = 1 in.
238. Hudson bay, south of, by A. P. Low. 1886.
239. Attawapiskat and Albany rivers, by R. Bell. 1886.
244. Northern portion of the Dominion, by G. M. Dawson. 1886. Map No. 255, scale 200 m. = 1 in.
267. James bay and country east of Hudson bay, by A. P. Low.
578. Red lake and part of Berens river, by D. B. Dowling. 1894. Map No. 576, scale 8 m. = 1 in.
*584. Labrador peninsula, by A. P. Low. 1895. Maps Nos. 585-588, scale 25 m. = 1 in.
618. Dubawnt, Kazan, and Ferguson rivers, by J. B. Tyrrell. 1896. Map No. 603, scale 25 m. = 1 in.
657. Northern portion of the Labrador peninsula, by A. P. Low.
680. South Shore Hudson strait and Ungava bay, by A. P. Low. Map No. 699, scale 25 m. = 1 in. } Bound together.
713. North Shore Hudson strait and Ungava bay, by R. Bell. Map No. 699, scale 25 m. = 1 in. } Bound together.
725. Great Bear lake to Great Slave lake, by J. M. Bell. 1900.
778. East coast Hudson bay, by A. P. Low. 1900. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.
786-787. Grass River region, by J. B. Tyrrell and D. B. Dowling. 1900.
815. Ekwan river and Sutton lakes, by D. B. Dowling. 1901. Map No. 751, scale 50 m. = 1 in.
819. Nastapoka islands, Hudson bay, by A. P. Low. 1900.
905. The Cruise of the *Neptune*, by A. P. Low. 1905.
100[illegible]. Report of a Traverse through the Southern Part of the North West Territories, from Lac Seul to Cat lake, 1902, by A. W. G. Wilson. } Bound together.
1080. Report on a Part of the North West Territories, drained by the Winisk and Upper Attawapiskat rivers, by W. McInnes. Map No. 1089, scale 8 m. = 1 in. } Bound together.
1069. French translation: Report on an exploration of the East coast of Hudson bay, from Cape Wolstenholme to the south end of James bay, by A. P. Low. Maps Nos. 779, 780, 781, scale 8 m. = 1 in.; No. 785, scale 50 m. = 1 in.

* Publications marked thus are out of print.

1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Ynkon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. = 1 in.

ONTARIO.

215. Lake of the Woods region, by A. C. Lawson. 1885. Map No. 227, scale 2 m. = 1 in.
*265. Rainy Lake region, by A. C. Lawson. 1887. Map No. 283, scale 4 m. = 1 in.
266. Lake Snperior, mines and mining, by E. D. Ingall. 1888. Maps No. 285, scale 4 m. = 1 in.; No. 286, scale 20 ch. = 1 in.
326. Sndbnry mining district, by R. Bell. 1890-1. Map No. 343, scale 4 m. = 1 in.
327. Hunter island, by W. H. C. Smith. 1890-1. Map No. 342, scale 4 m. = 1 in.
332. Natural Gas and Petrolenm, by H. P. H. Brnmell. 1890-1. Maps Nos. 344-349.
357. Victoria, Peterborough, and Hastings connties, by F. D. Adams. 1892-3.
627. On the French River sheet, by R. Bell. 1896. Map No. 570, scale 4 m. = 1 in.
678. Seine river and Lake Shebandowan map-sheets, by W. McInnes. 1897. Maps Nos. 589 and 560, scale 4 m. = 1 in.
723. Iron deposits along the Kingston and Pembroke railway, by E. D. Ingall. 1900. Map No. 626, scale 2 m. = 1 in.; and plans of 13 mines.
*739. Carleton, Russell, and Prescott counties, by R. W. Ells. 1899. (*See* No. 739, Quebec.)
741. Ottawa and vicinity, by R. W. Ells. 1900.
790. Perth sheet, by R. W. Ells. 1900. Map No. 789, scale 4 m. = 1 in.
961. Sudbury Nickel and Copper deposits, by A. E. Barlow. (Reprint). Maps Nos. 775, 820, scale 1 m. = 1 in.; Nos. 824, 825, 864, scale 400 ft. = 1 in.
962. Nipissing and Timiskaming map-sheets, by A. E. Barlow. (Reprint). Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m. = 1 in.
965. Sudbnry Nickel and Copper deposits, by A. E. Barlow. (French).
970. Report on Niagara Falls, by J. W. Spencer. Maps Nos. 926, 967.
977. Report on Pembroke sheet, by R. W. Ells. Map No. 660, scale 4 m. = 1 in.
980. Geological reconnaissance of a portion of Algoma and Thnnder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in.
1081. On the region lying north of Lake Snperior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in.
} Bonnd together.
992. Report on Northwestern Ontario, traversed by National Transcontinental railway, between Lake Nipigon and Stnrgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
998. Report on Pembroke sheet, by R. W. Ells. (French). Map No. 660, scale 4 m. = 1 in.
999. French translation Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1038. French translation report on the Transcontinental Railway location between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1059. Geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont., by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1075. Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.

* Publications marked thns are ont of print.

1082. Memoir No. 6: Geology of the Haliburton and Bancroft areas, Ont., by Frank D. Adams and Alfred E. Barlow. Maps No. 708, scale 4 m. = 1 in.; No. 770, scale 2 m. = 1 in.
1091. Memoir No. 1: On the Geology of the Nipigon basin, Ont., by A. W. G. Wilson. Map No. 1090, scale 4 m. = 1 in.
1114. French translation: Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in.
1119. French translation: On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in.
(1114 and 1119: Bound together.)

QUEBEC.

216. Mistassini expedition, by A. P. Low. 1884-5. Map No. 228, scale 8 m. = 1 in.
240. Compton, Stanstead, Beauce, Richmond, and Wolfe counties, by R. W. Ells. 1886. Map No. 251 (Sherbrooke sheet), scale 4 m.= 1 in.
268. Megantic, Beauce, Dorchester, Lévis, Bellechasse, and Montmagny counties, by R. W. Ells. 1887-8. Map No. 287, scale 40 ch. = 1 in.
297. Mineral resources, by R. W. Ells. 1889.
328. Portneuf, Quebec, and Montmagny counties, by A. P. Low. 1890-1.
579. Eastern Townships, Montreal sheet, by R. W. Ells and F. D. Adams, 1894. Map No. 571, scale 4 m. = 1 in.
591. Laurentian area north of the Island of Montreal, by F. D. Adams. 1895. Map No. 590, scale 4 m. = 1 in.
670. Auriferous deposits, southeastern portion, by R. Chalmers. 1895. Map No. 667, scale 8 m. = 1 in.
707. Eastern Townships, Three Rivers sheet, by R. W. Ells. 1898.
*739. Argenteuil, Ottawa, and Pontiac counties, by R. W. Ells. 1899. (*See* No. 739, Ontario).
788. Nottaway basin, by R. Bell. 1900. *Map No. 702, scale 10 m.=1 in.
863. Wells on Island of Montreal, by F. D. Adams. 1901. Maps Nos. 874, 875, 876.
923. Chibougamau region, by A. P. Low. 1905.
962. Timiskaming map-sheet, by A. E. Barlow. (Reprint). Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m.=1 in.
974. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. Map No. 976, scale 8 m.=1 in.
975. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. (French).
998. Report on the Pembroke sheet, by R. W. Ells. (French).
1028. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. Map No. 1029, scale 2 m.=1 in.
1032. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. (French). Map No. 1029, scale 2 m.=1 in.
1052. French translation report on Artesian wells in the Island of Montreal, by Frank D. Adams and O. E. LeRoy. Maps No. 874, scale 4 m.=1 in.; No. 375, scale 3,000 ft.=1 in.; No. 876.
1064. Geology of an Area adjoining the East Side of Lake Timiskaming, Que., by Morley E. Wilson. Map No. 1066, scale 1 m.=1 in.
1110. Memoir No. 4: Geological Reconnaissance along the line of the National Transcontinental railway in Western Quebec, by W. J. Wilson. Map No. 1112, scale 4 m.=1 in.
1144. Reprint of Summary Report on the Serpentine Belt of Southern Quebec, by J. A. Dresser.

NEW BRUNSWICK.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. Map No. 230, scale 4 m.=1 in.

* Publications marked thus are out of print.

219. Carleton and Victoria counties, by L. W. Bailey. 1885. Map No. 231, scale 4 m. = 1 in.
242. Victoria, Restigonche, and Northumherland counties, N.B., by L. W. Bailey and W. McInnes. 1886. Map No. 254, scale 4 m. = 1 in.
269. Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887-8. Map No. 290, scale 4 m. = 1 in.
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