SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR

1915

PRINTED BY ORDER OF PARLIAMENT.

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OTTAWA
PRINTED BY J. DE L. TACHÉ, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1916

To the Hon. P. E. BLONDIN, M.P.,
Minister of Mines,
Ottawa.

SIR,—I have the honour to transmit, herewith, the summary report of the operations of the Geological Survey for the calendar year 1915.

I have the honour to be, sir,

Your obedient servant,

R. G. McCONNELL,
Deputy Minister, Department of Mines.

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SUMMARY REPORT

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DEPARTMENT OF MINES

FOR THE CALENDAR YEAR, 1915.

INTRODUCTORY STATEMENT.

The operations of the Geological Survey during the year 1915, as in past years, covered a very wide field. Summary reports on the work of all the divisions are given in the following pages, in which the economic side is given prominence, in order to bring before the public in preliminary form information that will be included in more extended reports to be issued at a later date.

Although geological investigations and topographical mapping naturally occupied the first place in the work of the Survey, attention was also given to investigations in other branches of science coming within the sphere of its operations. These branches included Botany, Zoology, Anthropology, Archæology, and their various subdivisions.

The publication of memoirs and bulletins containing the results of the various investigations was continued, and the work of the Victoria Memorial Museum was broadened by increasing the number of lectures and lecturers available for the educational courses established last year. The necessary draughting and photographic divisions were maintained, and staffs of preparators were continuously employed in Museum work in mineralogy, palæontology, biology, anthropology, and archæology.

A description of the work of the various divisions follows.

DISTRIBUTION DIVISION.

The Geological Survey, in addition to the Annual Summary Report of the year's operations, publishes more extended reports from time to time as the work is completed, on particular areas and subjects.

These reports include memoirs and bulletins relating to geology, biology, and anthropology, and are distributed to the principal libraries, universities, and educational institutions in Canada, and to many institutions outside Canada.

Notices are also sent of all reports published to a large number of individuals, at intervals of about a month, and to these the reports are mailed on request.

Wyatt Malcolm, chief of the distribution division, furnishes the following statement of the number of reports distributed during the year:

During the year 1915, 51,405 publications of the Geological Survey were distributed in compliance with written and personal requests, and 66,365 were sent to addresses on the regular mailing lists, making a total distribution of 117,770 publications. This is exclusive of French editions.

STAFF.

The following changes have taken place in the staff of the Geological Survey during the year 1915.

Appointments: Jean Charles Dessaint, clerk; Everend Lester Bruce, junior geologist; Joseph Edouard Paquet, draughtsman; Katherine Frances MacGibbon, stenographer; and Leslie Yorke Clarke, assistant wet plate photographer.

Promotions: William McInnes, to be "Directing Geologist" from April 1, 1915; W. H. Collins, from subdivision B to subdivision A of the first division; C. W. Drysdale, J. J. O'Neill, R. M. Anderson, H. C. Cooke, and M. Y. Williams, from subdivision A of the second division to subdivision B of the first division. F. W. Waugh and James Hill, from subdivision B to subdivision A of the second division; Catherine A. McDonald, from subdivision B to subdivision A of the third division.

Resignations: Albert E. Willis, messenger.

GEOLOGICAL DIVISION.

The work of the staff, dealt with in the order of location from west to east of the fields of work, is briefly summarized below:

D. D. Cairnes spent the early part of the season revising his previous geological mapping of Wheaton map-area in the southern portion of Yukon Territory and at the same time paid particular attention to the various occurrences of mineral deposits within the district, especially to those containing antimony-bearing ores which, under present conditions, are the subject of much interest. Later in the season Mr. Cairnes made a preliminary examination of the placer and lode deposits of a district in the vicinity of Mayo, on Stewart river, Yukon Territory. The same officer, towards the close of the season, investigated the placer mining possibilities of certain streams (Scroggie, Barker, Thistle, and Kirkman) heading south of Stewart river.

G. A. Young examined certain deposits of hydromagnesite occurring in the vicinity of Atlin, northern British Columbia.

J. D. Mackenzie devoted the field season to an examination of the areal geology and mineral resources of the basin of Telkwa river which is a tributary of Bulkley river and is adjacent to the Grand Trunk Pacific railway in British Columbia. Mr. Mackenzie also investigated a deposit of bog iron ore on a tributary of Zymoetz river and visited various coal-bearing basins situated in the general region.

C. Camsell during the month of September made a rapid reconnaissance through a part of a region in northern British Columbia embracing the basins of Stuart, Trembleur, and Takla lakes, the headwaters of Omineca, Manson, and Nations rivers and including the Omineca placer mining district. During the early part of the field season, Mr. Camsell made an examination of a district about the east end of Lake Athabaska, Saskatchewan, where discoveries of high grade silver ore were reported to have been made, but no evidence could be obtained of the occurrence of any such ore.

C. W. Drysdale during the main part of the field season was engaged in geologically mapping the Bridge River area, Lillooet mining division, British Columbia; special attention was paid to the working mines of the district and other mineral occurrences of prospective value. At the close of the field season, Mr. Drysdale spent a short time examining a few of the main mining properties of the Highland Valley copper camp situated about 27 miles southeast of Ashcroft, British Columbia. Mr. Drysdale also spent a few days in an examination of a locality near Savona, British Columbia, where a human skeleton was discovered in 1911 in beds alleged to be of Glacial age. Mr. Drysdale is of the opinion that the remains are of modern origin.

O. E. LeRoy during the greater part of the season was engaged in work in his capacity of chairman of the committee inquiring into the iron industry of Canada. Mr. LeRoy also visited the Slocan silver-lead mines, and spent a short time gathering information regarding molybdenite occurrences in southern British Columbia, and making an examination of the mineralized belt on Grenville mountain near Paulson.

S. J. Schofield completed the detailed investigation of the Ainsworth mining camp on the west side of Kootenay lake, British Columbia, including, also, an examination of the Bluebell mine on the east shore of the lake, opposite Ainsworth. In addition, Mr. Schofield carried on geological investigations in several districts with a view to correlating the formations of these districts. Mr. M. F. Bancroft, under Mr. Schofield's supervision, engaged in geological studies of a district bordering the east side of Kootenay lake.

L. D. Burling, during the field season, examined two geological sections, one along the Canadian Pacific railway, between Banff, Alberta, and Golden, British Columbia; the other in the vicinity of Mount Robson on the Grand Trunk Pacific railway.

J. A. Allan spent a short time completing the field work in connexion with his study of a geological section across the Rocky mountains in the vicinity of the main line of the Canadian Pacific railway.

D. B. Dowling besides undertaking the general supervision of the various field parties engaged in western Manitoba and southern Alberta, devoted most of the field season to a study of the conditions relating to the water supply of southeastern Alberta.

B. Rose spent the field season conducting a detailed investigation of the geology and coal resources of the Blairmore map-area, Alberta.

F. H. McLearn devoted the season to a stratigraphical study of a part of the geological section exhibited in the Blairmore map-area.

J. S. Stewart spent the field season in an examination of a district in southern Alberta, in the foot-hill area and extending northward from the International Boundary. The main object of the work was the determination of the structure in view of possible operations in connexion with the search for coal, gas, or oil.

S. E. Slipper during the greater part of the year was engaged in the systematic collecting and correlating of data obtained from wells sunk in the search for oil in Alberta.

E. L. Bruce continued his examination of a district lying to the north of Saskatchewan river, in adjoining portions of Saskatchewan and Manitoba. In this general area, gold-bearing quartz veins have been discovered in many parts.

A. MacLean during the field season engaged in geological field work in Pembina Mountain district in southern Manitoba and completed the investigation of this area which had been initiated during the preceding year.

F. J. Alcock conducted an exploratory geological survey in northern Manitoba of the lower part of Churchill river from Southern Indians lake to Hudson bay.

W. H. Collins spent the field season in continuing a study, begun in 1914, of the geological formations of portions of the district bordering the north shore of Lake Huron for the purpose of securing information necessary for the elucidation of various problems that have arisen in Sudbury, Cobalt, and other economically very important districts.

W. A. Johnston spent the early portion of the field season completing his study of the geology of the Lake Simcoe district, Ontario. The remainder of the season save for a short interval spent in Rainy River district in connexion with the International Joint Commission's investigation regarding water levels of Lake of the Woods, was devoted to the mapping and study of the soils and superficial deposits of the neighbourhood of Ottawa.

M. Y. Williams during the past field season, completed his study of the Silurian of southwestern Ontario, covering various matters of economic interest in the districts entered upon.

J. Stansfield made a study of the superficial deposits of the London district, Ontario, and carried on investigations relating to the occurrence of oil, materials used in clay-working industries, and water supply problems.

L. Reinecke continued his work in connexion with an investigation of the sources of supply of materials suitable for road-making in Ontario and extended his work into districts in Quebec bordering the north shore of Ottawa river from Ottawa eastwards towards Montreal.

M. E. Wilson, during the field season, completed the geological investigation of a district in Quebec bordering Ottawa river, in the general vicinity of Buckingham. Special attention was given to the mica-apatite, graphite, and feldspar deposits of this area.

A. Ledoux spent the field season in a study of the occurrence of the varied and important economic minerals in the East Templeton district, Quebec.

T. L. Tanton during the past field season extended his geological reconnaissance of the Harricanaw River basin in northwestern Quebec, commenced in the preceding year, westward to the Ontario boundary. Districts containing indications of the possible occurrence of mineral deposits of economic value, were examined.

H. C. Cooke continued his explorations of a region in northwestern Quebec drained by Broadback and Nottaway rivers.

R. Harvie commenced a study of a district embracing Thetford and Black Lake in southeastern Quebec. This work is being primarily undertaken to aid as far as possible, the important asbestos and chromite industries of the district.

J. A. Dresser spent the field season in a district southeast of and adjoining Lake St. John, Quebec, conducting an investigation of the general resources and economic possibilities of the region.

A. O. Hayes continued his study of the St. John City map-area, New Brunswick, commenced in previous years. The problems investigated bear directly on many important questions relating to the general and economic geology of the Maritime Provinces. A short interval of the field season was spent at New Glasgow, Nova Scotia, arranging for the commencement of a study of the Pictou coal field.

W. J. Wright continued his investigations of the geology and economic resources of a district extending south from Moncton, New Brunswick. Special attention was directed to the question of sources of supply for road-making materials. The deposits of oil-shale, gypsum, and manganese and the occurrences of natural gas and oil make the district one of economic importance.

E. R. Faribault during the field season continued the geological mapping of the northwestern part of Queens county, Nova Scotia, and extended this work into the immediately adjoining northeastern portion of Shelburne county. A detailed survey was also made of Whiteburn gold district and a special survey was made of the deposits of infusorial earth discovered on Liverpool river.

W. A. Bell spent the field season on work connected with the development of the Carboniferous rocks in Nova Scotia; he devoted a major portion of his time to work in the Sydney coal field.

J. J. O'Neill who is attached as geologist to the Canadian Arctic expedition, made his temporary headquarters on the main land side of Dolphin and Union strait which leads east into Coronation gulf. Mr. O'Neill has now extended his geological observations over a very considerable portion of the Arctic coast from the Alaska boundary east to the foot of Coronation gulf and besides has made a number of inland traverses of varying lengths.

VERTEBRATE PALÆONTOLOGY.

L. M. Lambe, apart from the superintendence of the section as a whole, has been engaged principally in the study of the vertebrate Cretaceous fauna of western Canada, especially the recently discovered dinosaurian forms of the Belly River formation of Red Deer river, Alberta. During the year further dinosaurian specimens have been placed on exhibition.

C. H. Sternberg, preparator and collector, assisted by C. M. Sternberg, spent a portion of the field season exploring the Cretaceous rocks of the Milk River district, Alberta, hoping to find there satisfactory dinosaurian and other reptilian material, but the material proving to be scattered and fragmentary, the party removed to the Red River district where in 1914 such good results were obtained. A second collecting party, under the charge of G. F. Sternberg, spent the season collecting from the beds of the Edmonton formation on Red Deer river. Besides their work in the field Mr. C. H. Sternberg and his assistants have made notable progress in preparing material for exhibition and other purposes.

STRATIGRAPHICAL PALÆONTOLOGY.

E. M. Kindle besides conducting the work of the section in his charge spent considerable time in the field, obtaining data for a popular guide to the palæontology of Rocky Mountains park, and investigating the Devonian as exposed in sections at Wardner, British Columbia, Nordegg, Alberta, and at various points in Jasper park. He, also, for a time, resumed the investigation of the problems of sedimentation in Lake Ontario.

L. D. Burling engaged in field work as noted on a previous page.

Miss A. E. Wilson, with the assistance of Miss Godwin and W. Cross, has been engaged in preparing a card index of the older collections of invertebrate fossils belonging to the Geological Survey.

E. J. Whittaker assisted Mr. Kindle with the field work in connexion with the investigation of problems of sedimentation and, during the absence of Mr. Kindle, was entrusted with the direction of this work. During the office term, Mr. Whittaker has performed the duties of preparator to the section.

PALÆOBOTANY.

W. J. Wilson spent the year chiefly in preparing and studying various palæobotanical collections brought in by members of the staff.

MINERALOGY.

R. A. A. Johnston, throughout the year, was largely engaged in supplying information regarding the occurrences of economic minerals in Canada. Much time was also given to the examination of and reporting upon mineral specimens, and to duties in connexion with the management of the section.

E. Poitevin besides engaging in routine work of the section, paid particular attention to the study of the large suite of mineral specimens collected in 1914, in localities in Coleraine, Thetford, and Megantic counties, Quebec, and revisited some of these localities during the past season.

A. T. McKinnon devoted his time to the collecting and preparing of materials for the educational collections of minerals and rocks.

BORING RECORDS.

E. D. Ingall continued his work of collecting records of boring operations throughout Canada and of furnishing to inquirers information necessary to the prosecution of drilling operations.

J. A. Robert and H. N. McAdam assisted Mr. Ingall in carrying on the work of the section.

CANADIAN ARCTIC EXPEDITION.

R. M. Anderson, Executive Head of the southern party of the Canadian Arctic expedition, reports the progress made by the expedition from September 12, 1914, to July 29, 1915. Besides dealing with administration, the report includes an itinerary of the expedition during the period dealt with, and gives interesting details of Mr. Anderson's zoological work and collections. The topographical work of K. G. Chipman and J. R. Cox is noted, as well as the valuable ethnological investigations of D. Jenness among the Eskimos and the biological work of Fritz Johansen. The geological investigations of J. J. O'Neill form the subject of a separate report.

TOPOGRAPHICAL DIVISION.

W. H. Boyd besides carrying out the routine work connected with the supervision of the division, visited various parties in the field and made a reconnaissance survey of a district embracing the headwaters of Zymoetz river, British Columbia.

A. G. Haultain mapped the Mayo map-area in the Stewart River basin, Yukon Territory.

F. S. Falconer completed the mapping of the Revelstoke map-area, British Columbia.

D. A. Nichols mapped the Pekisko map-area, British Columbia and Alberta. This map-area is the third of a series extending northward from the International Boundary and embracing the Rocky Mountain coal fields.

C. H. Freeman completed the mapping of the Sheep River map-area, Alberta.

B. R. Mackay completed the survey of Lake Athabaska, Alberta and Saskatchewan.

E. E. Freeland commenced work on the Sudbury map-area, Ontario, one of a proposed series covering the nickel-bearing region.

W. E. Lawson surveyed the coast of James bay from Rupert House north to Fort George, Quebec.

S. C. McLean extended the chain of secondary triangulation commencing at the International Boundary, northward through the Crowsnest and Pekisko map-areas, British Columbia and Alberta. He also carried a triangulation control over the Sudbury district, Ontario.

K. G. Chipman and J. R. Cox, attached as topographers to the Canadian Arctic expedition, are still in the north and have succeeded in doing much valuable geographical work.

BIOLOGICAL DIVISION.

BOTANY.

John Macoun spent his time in the vicinity of Victoria, Sidney, and Comox, collecting and studying the cryptogamic flora of Vancouver island, British Columbia.

J. M. Macoun, during the year, was mainly engaged in the routine work of the section. As usual, many collections were sent in for determination from local botanists and collectors throughout Canada, and the work in connexion with these collections has been given precedence over all other. During the field season, seven weeks were spent in the neighbourhood of Comox, Vancouver island and three weeks on Texada island, investigating the flora of these districts.

H. St. John spent the field season in a botanical reconnaissance of the north shore of the Gulf of St. Lawrence, Saguenay county, Quebec.

ZOOLOGY.

P. A. Taverner besides engaging in the routine work involved in the general superintendence of the division, has published various papers and has made considerable progress on a popular work on the "Birds of Canada." During the field season, accompanied by C. H. Young, C. L. Patch, and C. Johnson, Mr. Taverner spent some time in zoological work in the neighbourhood of Percé, Quebec. Later on, leaving Mr. Patch and Mr. Johnson to complete the work at Percé, Mr. Taverner and Mr. Young were enabled through the courtesy of the Department of Marine and Fisheries, to cruise along the north shore of the Gulf of St. Lawrence.

C. W. Townsend spent the season cruising along the north shore of the Gulf of St. Lawrence between Natashkwan and Blanc Sablon for the especial purpose of studying the birds of the region.

R. M. Anderson, officer-in-charge of the southern party of the Canadian Arctic expedition, reports that extensive work in zoology has been carried on throughout the year.

C. H. Young, except while in the field, has been engaged in arranging and cataloguing the zoological collections.

C. L. Patch and his assistant, C. Johnson, have been engaged in preparing exhibits for the museum.

ENTOMOLOGY.

C. Gordon Hewitt, Dominion Entomologist, who has accepted the appointment of Honorary Curator of Entomology, states that considerable additions have been made to the national collection.

ANTHROPOLOGICAL DIVISION.

ETHNOLOGY AND LINGUISTICS.

E. Sapir besides supervising the work of the division, continued work along various lines of research.

C. M. Barbeau spent three months at Port Simpson, British Columbia, on Tsimshian field work; he spent in Kamouraska county, Quebec, a shorter period collecting French Canadian folk-lore. Mr. Barbeau is preparing a popular guide-book to the study of the Indians formerly inhabiting the region of the Rocky Mountain parks in Alberta and British Columbia.

F. W. Waugh spent two months in field work among the Iroquois of Six Nations reserve, Ontario.

P. Radin continued to work upon Ojibwa data secured in former years among the Ojibwa of Ontario and adjoining regions.

J. A. Teit spent four months extending his ethnological reconnaissance among the Athabaskan tribes of British Columbia and Yukon Territory.

D. Jenness, anthropologist attached to the Canadian Arctic expedition, has accomplished a great deal of work among the hitherto little known group of Eskimos in the Arctic coast region of western Canada.

ARCHÆOLOGY.

H. I. Smith in addition to the general supervision of archæological work, inspected sites and collections at various localities in British Columbia, and conducted a reconnaissance up the Skeena and Bulkley valleys, British Columbia.

W. J. Wintemberg spent about one month continuing the work of excavation at the prehistoric Iroquoian village site near Roebuck, Ontario. He also carried on field work in Prince Edward county, Ontario.

W. B. Nickerson was engaged in archæological field work in Manitoba during the space of two months, exploring various mounds and groups of mounds.

PHYSICAL ANTHROPOLOGY.

F. H. S. Knowles continued his research into the physical characteristics of the ancient Iroquoian tribes. He prosecuted his anthropometric work among the modern Iroquois, visiting the Six Nation reserve in Brant county, Ontario, and the Tonawanda reserve, New York, for this purpose.

GEOGRAPHICAL AND DRAUGHTING DIVISION.

C. Omer Sénecal, geographer and chief draughtsman, reports the completion during the year of the compiling of 3 maps, besides which there are 25 maps in various stages of preparation. During the year 142 sketch maps, diagrams, text figures, and miscellaneous drawings were prepared.

PHOTOGRAPHIC DIVISION.

The photographic division, under the supervision of George G. Clarke, has completed during the year a large amount of work of the very highest quality. This included enlarging, printing, copying, etc., for the topographical and draughting divisions, developing and printing photographs taken by field parties, and the preparation of illustrations for reports.

LIBRARY.

Besides taking care of new publications received and discharging the usual routine work of the library, the library staff has made considerable progress in the work of indexing and cataloguing.

MUSEUM.

Additions of importance have been made during the year to the collections in all the divisions of the Museum. In the division of vertebrate palæontology a large amount of dinosaurian material was added from the Belly River and Edmonton formations of Alberta, including one almost complete skeleton and numerous skulls and portions of skeletons. In the division of invertebrate palæontology large collections were added, notably from the national parks of Canada in Alberta and from the Palæozoic rocks of British Columbia. The collections of minerals were very considerably augmented by accessions from various parts of Canada. Large additions were made to the zoological collection, including fine sets of skins and eggs from the Arctic and from the Gulf of St. Lawrence. Important accessions have been added also to the collections in the ethnological and archæological divisions.

The accessions to the museum during the year are given in greater detail in the reports of divisions.

MUSEUM LECTURES.

During the past year a lecture room was improvised on the upper floor of the Victoria Memorial Museum and various organizations and institutions were notified that preparations had been completed to give on request illustrated lectures on topics related to the work of the Museum and of the Geological Survey. For various reasons it was deemed advisable for the time being to offer to present these lectures only to organized bodies; later, when facilities and resources become more adequate, invitations to attend may be given to the general public. In response to the notices sent out, thirty-seven requests for lectures were received and it proved possible to accede to thirty-four of these. In all cases the organizations asking for the lectures were permitted to choose the topic for the lecture. Of the thirty-four audiences, seven came from the Normal School, six from the Collegiate Institute, seventeen from the Public Schools, and four from the Flower Guild.

The topics of the various lectures delivered and the names of the lecturers, are as follows: "Glaciers," twice by S. J. Schofield, and once by L. D. Burling; "How the Rocky Mountains were made," once by S. J. Schofield and once by L. D. Burling; "The story of iron," by A. O. Hayes; "Mines and minerals of British Columbia," by Eugene Poitevin; "Fossils," by L. D. Burling; "Winter birds," five times by M. Y. Williams, once by C. Patch; "Some common Canadian birds," by Miss W. K. Bentley; "Indians of Canada," by Edward Sapir; "Eskimo" by Harlan I. Smith; "Prehistoric people of British Columbia," by Harlan I. Smith; "Ranch life in Wyoming," by Harlan I. Smith; "Irrigation," four times by L. D. Burling, once by Harlan I. Smith; "Uses of the Museum" twice by Harlan I. Smith, once by C. Patch.

The results so far obtained seem to indicate that this line of effort is much appreciated; one lecture topic, for instance, was asked for six times. The direct educational value of the lectures warrants the continuation of the work and perhaps this local experiment may ultimately result in the distribution of lectures and lantern slides throughout Canada.

The Museum being a national institution, it becomes a duty of those more directly connected with its work and also of the Geological Survey staff in general, to offer such aid as lies in their power to any public museums in Canada requesting services that may be legitimately granted. In pursuance of this policy many services have been rendered in the past to various Canadian museums and, during 1914, Harlan I. Smith spent four weeks carrying on the work, begun in 1913, of reorganizing the Rocky Mountains Park Museum maintained at Banff, Alberta, by the Parks Branch of the Department of the Interior. A guide book to the exhibits of this museum was prepared by Mr. Smith several years ago; this book consisted of the matter of the general descriptive labels and the individual labels of the exhibits. When the general labels were printed for the museum at Banff, thirty duplicate sets were secured by the national museum for the use of other Canadian museums. Already requests for certain of the labels have been received from seventeen museums. The labels during preparation were offered for criticism to specialists in the subjects being treated in order to ensure that the labels should be both authoritative and suited to their purpose. This co-operative method of preparing labels has the advantage of being more accurate and economical and of yielding better general results than the usual plan under which the curator of each museum prepares and has printed such general labels as he may require from time to time.

GEOLOGICAL DIVISION.

MAYO AREA.—SCROGGIE, BARKER, THISTLE, AND KIRKMAN CREEKS.—WHEATON DISTRICT: YUKON TERRITORY.

(D. D. Cairnes.)

Mayo Area.

INTRODUCTION.

After completing the geological mapping and investigation of Wheaton district[1], the writer proceeded to Mayo on Stewart river and thence made a preliminary examination of the mineral resources of Mayo area. Not only is this one of the most important placer gold-producing districts of Yukon Territory, but valuable lode deposits have been recently discovered there from one of which shipments of high grade silver ore have been made.

The town of Mayo is situated on the right bank of the Stewart near the mouth of Mayo river which joins the Stewart 168 miles above its point of confluence with the Yukon—the mouth of the Stewart being 70 miles above Dawson. During the past summer (1915) A. G. Haultain of the topographic division of this department made a photo-topographic survey of an area that was intended to include the more valuable of the known mineral deposits along the upper tributaries of Stewart river; and it so happens that nearly all the important discoveries that have been made in this region, occur within a limited area in the vicinity of Mayo, which includes the town of Mayo, all of Mayo river, and a westerly portion of Mayo lake, the largest body of water known within the entire drainage basin of Stewart river. Thus the name Mayo[2] seemed the most appropriate to be applied to this particular area, and consequently in this report the term Mayo area is quite an arbitrary one, and refers to the particular portion of Yukon mapped during the past season. It extends to the south to include a portion of Stewart river, and the town of Mayo, and reaches thence northward a distance of 40 miles to include Haggart creek and Dublin gulch; it also extends to the east to include the upper portions of Duncan and Lightning creeks, and reaches thence to the west about 38 miles to embrace the mouth of Johnson creek, a tributary of McQuesten river. Practically all of the area lies within the western portion of Duncan Creek mining district.

During the summer of 1900 R. G. McConnell made a geological examination of Stewart valley from Fraser falls down to the mouth of the Stewart[3]—Fraser falls being between 30 and 35 miles above Mayo. Joseph Keele, also, during the summer of 1904, made a reconnaissance survey and geological examination of a portion of Duncan Creek mining district, including Mayo area, and his report[4] contains a great amount of very valuable information concerning this district. During 1905 Mr. Keele continued his mapping and investigations to the east of Mayo area.[5] In addition Mr. T. A. McLean, on behalf of the Mines

[1] Cairnes, D.D., "Wheaton district, Southern Yukon": Geol. Surv., Can., Sum. Rept. for 1915.
[2] The name Mayo was given to the lake and river by a prospector named Alexander McDonald, after Mr. Frank Mayo one of the partners of the trading firm of Harper, McQuesten, and Company. McDonald prospected in this district during the summer of 1887.
[3] McConnell, R. G., "Stewart river": Geol. Surv., Can., Ann. Rept., Vol. XIII, 1900, pp. 39A-43A.
[4] Keele, Joseph, "The Duncan Creek Mining district"; Geol. Surv., Can., Sum. Rept. for 1904, pp. 18A-42A.
[5] Keele, J., "A reconnaissance survey on the Stewart river"; Geol. Surv., Can., Sum. Rept. for 1905, pp. 32-36. "Upper Stewart River region, Yukon"; Geol. Surv., Can., Ann. Rept., Vol. XVI, Part C.

Branch of this department, examined the lode deposits on Dublin gulch in 1912.[1] With these exceptions, practically no authentic information had been published concerning the geology and mineral resources of Mayo area, and Mr. Keele's reports contain practically all the information that was available concerning the

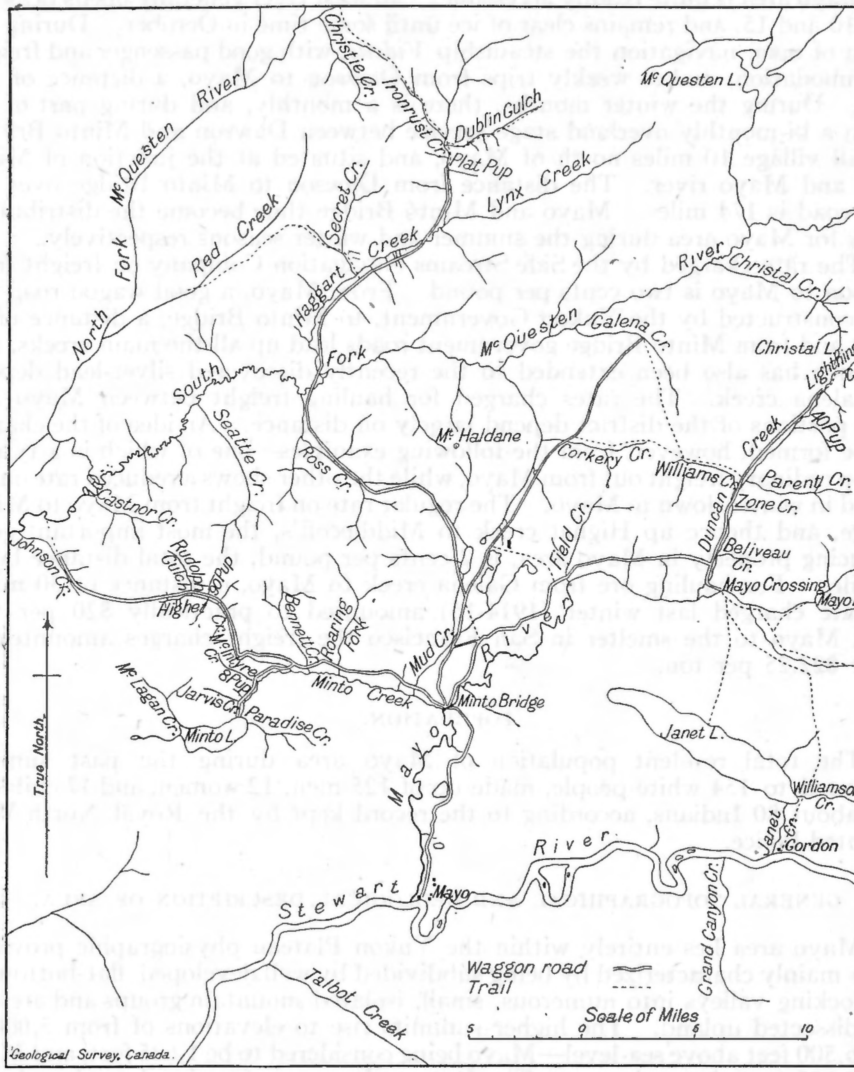

Figure 1. Mayo area, Yukon Territory.

geology, topography, and placer deposits of the district. A number of important discoveries had been made since 1904 and it was, therefore, decided to make a detailed geological examination of Mayo area. During the past season the topographical mapping was completed, and a preliminary examination was made of the mineral resources of the area. After the completion of the topo-

[1] McLean, T. A., "Lode mining in Yukon"; Mines Branch, Dept. of Mines, Can., 1914, pp 127-159.

graphical map it is proposed to proceed with the detailed geological mapping, using the topographic sheet as a base.

TRANSPORTATION AND ACCESSIBILITY.

Mayo area is quite readily accessible. Stewart river generally opens between May 10 and 15, and remains clear of ice until some time in October. During the season of open navigation the steamship *Vidette*, with good passenger and freight accommodation, makes weekly trips from Dawson to Mayo, a distance of 238 miles. During the winter months, there is a monthly, and during part of the season a bi-monthly overland stage service between Dawson and Minto Bridge, a small village 10 miles north of Mayo, and situated at the junction of Minto creek and Mayo river. The distance from Dawson to Minto Bridge over the stage road is 174 miles. Mayo and Minto Bridge thus become the distributing points for Mayo area during the summer and winter seasons respectively.

The rate charged by the Side Streams Navigation Company on freight from Dawson to Mayo is two cents per pound. From Mayo, a good wagon road has been constructed by the Yukon Government, to Minto Bridge, a distance of 10 miles, and from Minto Bridge government roads lead up all the main creeks, and a branch has also been extended to the recently discovered silver-lead deposit on Galena creek. The rates charged for hauling freight between Mayo and other portions of the district depend largely on distance. An idea of the charges can be formed, however, from the following examples—one of which is a typical rate on ordinary freight out from Mayo, while the other shows a reduced rate on ore hauled in winter down to Mayo. The regular rate on freight from Mayo to Minto Bridge, and thence up Highet creek to Middlecoff's, the most important gold-producing property in Mayo area, is 2 cents per pound, the total distance being 22 miles. For hauling ore from Galena creek to Mayo, a distance of 30 miles, the rate charged last winter (1914-15) amounted to practically $20 per ton. From Mayo to the smelter in San Francisco the freight charges amounted to about $22.25 per ton.

POPULATION.

The total resident population of Mayo area during the past summer amounted to 154 white people, made up of 125 men, 12 women, and 17 children, and about 80 Indians, according to the record kept by the Royal North West Mounted Police.

GENERAL TOPOGRAPHICAL AND GEOLOGICAL DESCRIPTION OF AREA.

Mayo area lies entirely within the Yukon Plateau physiographic province, and is mainly characterized by being subdivided by well developed, flat-bottomed, interlocking valleys into numerous, small, isolated mountain groups and areas of well dissected upland. The higher summits rise to elevations of from 5,000 to over 6,500 feet above sea-level—Mayo being considered to be 1,625 feet, and Mayo lake 2,000 feet above the sea. The former plateau surface has been largely destroyed in this district, and the shapes of the land forms, except where modified by glaciation, are for the most part dependent on bedrock structure. The district has, however, been intensely glaciated. The glacial ice, at one time, extended over practically the entire area, enveloping all except possibly the highest summits. As a result, the valley walls have become smoothed, planated, and steepened, giving to the valleys, typical U-shaped cross-sections. In addition, all the main valley floors have been deeply covered with large amounts of glacial detritus which has, in post-Glacial times, been trenched and in part removed by the streams of the district. Thus on the sides of the present stream channels, terraces have been produced, which in places are wide and are characterized by innumerable kettle holes, irregular mounds and piles, and other erratic forms typical of an old glacial floor. The entire Mayo area is drained by Stewart river and its tributaries.

The geological formations outcropping throughout the area are dominantly old schistose rocks, including mainly mica schists, quartz schists, and schistose quartzites, with also some crystalline limestones. These correspond to the old schistose rocks of the Klondike[1] and other portions of Yukon and Alaska, and belong to the Yukon group[2] which is thought to be of Pre-Cambrian age. In a few localities, these old schistose members are intruded by granitic rocks which appear to be mainly grey biotite granites, probably of Mesozoic age. Occasional dykes of rhyolite, and greenstones resembling in general appearance andesites and diabases, also occur in a few places.

MINERAL RESOURCES.

General Description.

The mineral resources of Mayo area include mainly, so far as is known, gold-bearing gravels, and lode deposits, of which the gravels have, up to the present, proved to be of much greater importance. Coarse gold was found on Haggart creek in 1895, and since that time there has been more or less continuous prospecting for placer deposits within the area; and since 1898 or 1899 the district has each year yielded an important production of gold. As to the lode deposits, ore has actually been shipped from only one vein, shipments aggregating between 1,200 and 1,300 tons. This ore was high grade, and its discovery has given a great impetus to the lode mining industry of the district. The lode deposits of Mayo area, therefore, although they are not of the same immediate importance as the gold gravels, owing to the present high transportation costs and other causes, nevertheless constitute a very valuable future asset to the district.

Gold-bearing Gravels.

General Statement. The Stewart was one of the first rivers in Yukon Territory to attract the attention of miners. In the year 1883, and for several years following, gold was found in paying quantities on the bars along this stream, and it is estimated that during 1885 and the two succeeding years, the yield amounted to about $100,000. Since then the production has been small, but a certain amount of bar mining is performed each year. Bars have, in the past, been worked from the mouth of Mayo river down almost to the mouth of the Stewart. Steamboat bar, which is situated about 4 miles below the McQuesten, and is the richest ever discovered on the Stewart, is reported to have yielded for some time at the rate of $140 per day per man, as worked with a rocker. The gold-bearing gravels are rarely over 2 feet in thickness, and are generally less than one foot. This extreme shallowness of the auriferous deposits, combined with the fact that in most places they were confined to small areas near the head of each bar, accounts for the rapid exhaustion of the Stewart River diggings.

Two dredges were installed on Stewart river to more rapidly work these bar deposits, and, it is believed, with the hope of obtaining coarser gold nearer bedrock. One of these dredges worked for only a few months in 1910 and 1911,

[1] McConnell, R. G., "Report on the Klondike Gold fields"; Geol. Surv., Can., Ann. Rept., Vol. XIV, Pt. B., 1905, pp. 12B-15B.
[2] Cairnes, D.D., "The Yukon-Alaska International Boundary between Porcupine and Yukon rivers"; Geol. Surv., Can., Memoir 67, pp. 38-44, 1914.

and the other for only about four months altogether, during 1911 and 1912. The dredging operations proved for various reasons to be a decided financial failure.

Even yet, however, a few men engage each summer in bar mining along the Stewart between Mayo river and Lake creek; and the miner experienced in this class of work can make from $3 to $5 per day or occasionally even more, when the water is low, which is generally from about the first week in August until the freeze-up. During the past autumn (1915) about twelve men were so engaged.

In 1895 coarse gold was first discovered on the streams tributary to the Stewart, and from that time until the present, new discoveries of importance have been made from year to year, with the result that for a number of years past, the placer mining industry in the district has been one of considerable importance. Mr. George P. Mackenzie, Gold Commissioner of Yukon Territory, has estimated that to the close of 1914 the Duncan Creek mining district produced about $658,000.[1] Practically all of this yield came from Mayo area, except that obtained from the Stewart River bars. This estimate is thought to be very conservative, since considerable amounts of gold were mined in the early days of which there is now no official record. The main streams within Mayo area from which placer gold has been produced are Highet creek, Duncan creek, Haggart creek, Minto creek near Minto lake, and Johnson creek. These will be briefly described in order commencing with Duncan creek on the east, and proceeding toward the west.

Stream Gravels. For a clear understanding of the gold-bearing gravels of Mayo area, a general knowledge of the geological history from late Tertiary times until the present, is necessary. Before proceeding with the description of the gravels along the individual creeks, therefore, the succession of geological events within the district will be briefly reviewed as far as they have a direct bearing on the placer mining industry.

In late Tertiary times, as a result of the general uplift of the Yukon plateau, including Mayo area, a new erosion cycle was initiated, and deep V-shaped valleys were rapidly eroded, and well-defined drainage ways became again established throughout the district. This erosion period was of long duration, and continued until the streams had gradually acquired more and more gentle gradients, much more gentle, owing to their greater degree of maturity, than those traversing Mayo area at present. Consequently the gravels deposited along the stream courses of this period were very well worn and sorted, and as the softer more destructible materials were removed, they became limited dominantly to quartz and other resistant materials. The accumulations of this time are represented in the Klondike by the famous White Channel gravels, and in Mayo area by remnants of higher channels along the benches of certain streams.

This long erosion interval was terminated by the initiation of a period of deep-channel cutting which has been generally attributed to a somewhat extensive and gradual upwarp or uptilt of the land surface. This uplift apparently amounted to several hundred feet in places, and gave the streams renewed head and vigour enabling them to quickly sink deep channels in the former valley floors. The bottom of the deep channel on Duncan creek produced at this time is over 100 feet below the level of the present stream; also Minto lake is reported to be over 300 feet deep, and Mayo lake is said to be still deeper.

This period of rapid valley deepening was brought to a close by an epoch of glaciation and aggradation which followed; but it is somewhat uncertain whether or not all the aggradation is attributable to the ice invasion, as the

[1] Personal communication.

deposits still filling the deep channels have not been carefully investigated. All of these accumulations that are exposed, including the uppermost deposits, are, however, either directly or indirectly of glacial origin. During the Glacial period, ice accumulated until all, except possibly the higher summits, became enveloped. The ice also scoured and planated the valley walls, and in places, the floors as well, and must have destroyed, to a great extent at least, the various remnants of the old stream deposits left clinging to the valley sides. Thus the pre-Glacial gravels with their gold content were, to a great extent, transported to form erratic, unsorted, morainal accumulations. During the time of the actual occupation by the ice, vast quantities of glacial debris were irregularly deposited over the valley floors, and to some extent along the walls of the various depressions; also, great quantities of glaciofluvial sediments were rapidly deposited within the valleys, in a bedded condition. Gradually, however, with the complete disappearance of the ice, the sedimentation became less, the streams resumed more normal proportions, and instead of aggrading their courses, commenced to re-excavate channels through the accumulations deposited in the valleys. In so doing they became in many places diverted from their original channels and, in come cases, were deflected from their former valleys completely. Occasionally, they became superimposed over rock spurs, and the work of cutting down through these was of necessity very rapid in order to keep pace with erosion through the softer materials below the spurs. Thus the numerous, deep, narrow, rock canyons which characterize most of the streams of Mayo area became incised. Both pre-Glacial and post-Glacial gravels occur in places at various elevations along the walls of the drainage ways of the district, and they mark former positions occupied by the streams in the process of sinking their channels either to the deep-channel or present-channel levels.

In Mayo area, there are thus six main types of stream gravels.[1]

High-level gravels.
Terrace gravels—pre-Glacial.
Deep gravels.
Glaciofluvial deposits.
Terrace gravels—post-Glacial.
Present gravels.

The high-level gravels correspond to the White Channel gravels of the Klondike, and are of pre-Glacial age. In Mayo area they have been to a great extent carried away by subsequent stream action, as well as by glacial erosion, but remnants undoubtedly still remain. These gravels must have originally contained placer gold in very considerable amounts, and wherever the old channels containing them are preserved, the gold must still remain.

Deep gravels, which are also pre-Glacial, are known to occur along Duncan, Haggart, and Highet creeks, and elsewhere, but, excepting those on Highet creek, have been very slightly prospected. Where bedrock was reached on Duncan creek on No. 53 below Discovery, the gravels on bedrock are reported to have been quite rich. Gold was undoubtedly originally concentrated in the deep gravels, and it must still remain in them, except where they have been disturbed by glaciation. The deep channels on all the gold-bearing creeks will doubtless eventually be prospected and in all probability the contained gravels will be mined in many places; but up to the present it has been found impracticable to prospect these deep channels along most of the streams owing to the fact that near bedrock the gravels are not frozen, and when these thawed deposits are pierced, water comes into the shafts so rapidly that further work is impossible. No doubt this difficulty will, however, some day be overcome.

[1] The term "gravels" is here used in a general placer mining sense, to include all gravels and sands occurring in the various stream channels.

The glaciofluvial deposits include the gravels, sands, and silts deposited by streams, during the Glacial period. These deposits accumulated very rapidly; sufficiently so, at least, to aggrade the stream courses, and, therefore, it is not to be expected that any great amount of placer gold has been concentrated in them. Locally, however, on Duncan and Minto creeks and elsewhere, occasional beds of gravel having this origin, contain gold in workable quantities. These deposits are older than both the post-Glacial terrace, and the present gravels.

The terrace gravels of both pre-Glacial and post-Glacial age were deposited by the various streams in the process of sinking their channels to the levels of the deep-channels or present channels, respectively. They thus occur at various elevations along the walls of their respective valleys—the post-Glacial deposits being necessarily higher than the level of the present streams, but the pre-Glacial deposits being at any elevation above the bottoms of the deep channels. The positions of these terrace deposits are often indicated by more or less well defined terrace forms. Along Highet creek, especially opposite Rudolph pup, apparently pre-Glacial terrace gravels have proved to be very rich; and along Duncan creek, prospecting has revealed the fact that post-Glacial terrace gravels occur at various elevations above the present stream, and, in the places discovered, they contain important amounts of gold. The benches along the various creeks should thus be carefully prospected, not only for the pre-Glacial high-level channels, but also for these terrace gravels, as it seems altogether probable that a very considerable portion of the placer gold remaining in Mayo area, which can be economically mined at present, occurs in these bench deposits.

It is the gravels along the present stream bottoms, however, that have been mainly worked in this district, owing largely to the fact that they are shallow and can be relatively easily prospected. The gold in the present gravels has been for the greater part reconcentrated from higher gravels and other unconsolidated deposits, and is, therefore, liable to be somewhat unevenly distributed. These gravels are thus generally richest, just opposite or immediately below points where higher gold-bearing channels have been tapped, either by the main stream itself or by its tributaries, provided, of course, that in such places the underlying bedrock is of a nature to hold the gold.

Duncan Creek.[1] Duncan creek is one of the larger streams of Mayo area. It is about 14 miles in length, and follows a general southwesterly course, joining Mayo river about 6 miles below Mayo lake. The present stream flows throughout a considerable portion of its course in a decidedly constricted channel, and in places is even confined within rock canyons with almost perpendicular walls. In many places where both banks are not so steep, one of the walls is an abrupt rock scarp, showing the channel to be quite recent. On either side of the channel, a well-defined, wide-topped terrace follows along Duncan creek throughout the greater portion of its course, being most pronounced on its left side (limit). The top of the terrace has much less grade than the creek bottom, and ranges in elevation from about 200 feet above Duncan creek, opposite the mouth of Lightning creek, to over 300 feet near Mayo river. About 12 miles from its mouth, Duncan creek forks, the larger branch, called Lightning creek, continuing in the same general course as the main creek, while the tributary, known as Duncan or Upper Duncan creek, comes in from the southeast at about right angles to this course. Commencing about 500 yards above the forks, Upper Duncan creek flows through a rock canyon about three-fourths of a mile long, with walls over 100 feet in height. A deep channel, in most places about 100 feet below the level of the present creek, follows down Lightning creek to the forks, and thence down the main or Lower Duncan creek.

[1] Keele, Joseph, "The Duncan Creek Mining district": Geol. Surv., Can., Sum. Rept. for 1904, pp. 25A-29A.

The bedrock top of the terrace along Duncan creek evidently represents a portion of the old floor of the pre-Glacial stream. Subsequent to the uplift of the district, the creek cut down through this former valley bottom, and eroded the deep channel along Lightning and Duncan creeks. Later, the entire Duncan-Lightning valley was filled, largely at least, with glacial and glaciofluvial deposits to above the level of the main terrace, after which the stream began to re-excavate its course and, following the direction of least resistance, only in places became superimposed over its former channel. Thus the present creek channel with its canyons, rock scarps, and other recent features, was produced. Remnants of the old, high-level, pre-Glacial gravels probably remain on top of the terrace, but at only one point—on Makela's property[1]—have deposits resembling them been as yet found. The glaciofluvial deposits are very conspicuous both on the benches and along the valley bottoms. Along the lower portion of Duncan creek, in particular, the stream cuts through heavy deposits of glacial and glaciofluvial gravels, sands, and silts. Deposits of glaciofluvial origin are at present being hydraulicked along Upper Duncan creek, and terrace deposits containing important amounts of gold are known to occur in places along Lower Duncan creek. The deep gravels have also been somewhat prospected. It is mainly the present stream deposits, however, that have been worked along this stream.

Gold is believed to have been first discovered on Duncan creek in 1898, in the canyon just above the forks, the discovery being made by three Swedes, a father and two sons, named Gustaveson. They were apparently very energetic prospectors, and it is claimed that, working their ground secretly and undisturbed for two or three years, they took out gold to the value of $30,000 or more. Being in such a remote and secluded locality, however, they did not think it necessary to stake their claims or record their discovery. As a result, on September 12, 1901, during their absence, a discovery was staked in the canyon by four other prospectors, Duncan Patterson, Colin Hamilton, Allan McIntosh, and Jake Davidson—Duncan Patterson giving his name to the creek. This discovery and the other claims located covered the ground formerly worked by the Swedes. During 1902, Duncan creek was staked from its headwaters to Mayo river, cabins were built on many of the claims, and active preparations were made for developing the ground. A number of shafts were sunk along Lower Duncan to a depth of over 100 feet, and 130 feet was reached on No. 104 below Discovery,[2] without getting to bedrock. The depth alone would not have prevented the miners from sinking farther, but in every case they were forced to abandon their shafts on account of heavy water encountered when certain layers of unfrozen gravels were pierced. During the summer of 1903, a shaft sunk on No. 53 below Discovery, at some distance from the creek on the left limit, reached bedrock at a depth of 98 feet. During the winter, drifting was continued toward the creek, the rock bottom yielding gold in small quantities. The water entering the drift during the progress of the work was pumped out, but the flow finally increased beyond the capacity of the pumps, and operations had to be abandoned just as good pay is reported to have been struck. The total clean-up from this working is variously reported at from $800 to $1,200. At a few other points, small amounts of gold have been obtained from Lower Duncan creek; but since 1904, very little mining has been done below the forks. Upper Duncan has, however, been worked continuously.

During last season (1915) three men were working on Lower Duncan, one man was prospecting on Parent creek, a tributary of Lower Duncan, one man was working on Lightning creek, one man was hydraulicking on the left bench

[1] See description on subsequent page.
[2] Discovery claim was on Upper Duncan at the lower end of the canyon.

of Duncan just below the forks, and five were working on Upper Duncan—a total of eleven men on Duncan creek and its tributaries.

The gravels along the creek bottom of Upper Duncan, from below the canyon upstream to No. 22 above Discovery, have been all worked over, and mining operations are at present limited to the deposits on the left bench of the creek. Last season when the creek was visited, two parties were hydraulicking on this bench. John Turner, an old-timer on Duncan creek, was working with one associate, Thomas Williamson, just below No. 8 above Discovery, and was intending to continue the working of this bench downstream. David Sparks was also hydraulicking on No. 8 immediately above Mr. Turner. Mr. Sparks has been practically continuously engaged on this creek since 1903, and holds the ground from No. 8 up to No. 17 above Discovery. He was working with two associates Sam. Rae and R. S. McLean. The gravels being worked by Turner and Sparks are mainly or entirely of glacial or glaciofluvial origin, and are coarse and composed mainly of the schistose rocks of the district. They are also fairly well bedded in places, and exhibit a certain amount of sorting, but they are also decidedly clayey in places, and include a great many foreign boulders of greenstone and pyroxenite, up to 4 feet or more in diameter. In fact, large boulders are so numerous there, that the handling of them is a serious item in the mining of the deposits. Where Mr. Turner was working, the gravel has a thickness of as much as 35 feet, and in places, on this bench, it is believed to approach more nearly 100 feet in thickness, and is nearly everywhere overlain by a considerable thickness of muck. The greater part of the gold appears to be within 10 feet or so of bedrock, but it is very erratically distributed, and is just about sufficient in amount to pay expenses with the present methods of working.

Elmer Makela was also engaged in hydraulicking on the left bench of Lower Duncan just below the forks, his property adjoining the claims of Sparks and Turner. Mr. Makela has been engaged in prospecting operations in this vicinity for about three years, and with his own labour has built a ditch for hydraulic purposes, and has installed 1,500 feet of 10-inch pipe, and a monitor, with which to explore and mine the gravels on this bench. At the point where he was working, gravels similar to those on the Sparks and Turner properties occur, but in addition a heavy bed of very different, much finer gravel was also encountered. In the top of the latter a well preserved portion of a mammoth tusk was found, this being the first mammoth or mastodon remain that is known to have been discovered on Duncan creek. This gravel deposit is as much as 100 feet thick in places and consists mainly of quartz pebbles with no large boulders. It is uniformly fine and evenly textured, and exhibits well defined bedding. In fact, the deposit very much resembles the old White Channel gravels of other localities. Insufficient work had been done, however, to show whether the gravel overlies or underlies the glacial deposits. Very encouraging amounts of gold are reported to have been obtained from prospect shafts sunk in this deposit; in the hydraulic operations, however, bedrock has not yet been reached. If the gravel proves to be a remnant of the old pre-Glacial, high-level gravels, and the central portion of the channel is preserved, important amounts of gold are to be expected.

On Lower Duncan creek, three partners, J. A. Walsh, W. L. Bramley, and John Adair were engaged in mining the creek gravels. They hold the claims from No. 4 to No. 20 above Duncan Creek bridge, and were operating mainly on No. 10. During the latter part of 1913, and the spring of 1914, they prospected the gravels of the present stream channel with a Keystone drill, the depth to bedrock of ten holes sunk being from 10 to 16 feet. Encouraging results were obtained, and mining operations were commenced. A well constructed, covered bedrock drain was built, and an efficient plant for open-cut work was installed, consisting of a boiler, engine, and self-dumping, slip scraper.

The gravels being worked show very imperfect sorting, and appear in general as a jumbled mass of large boulders filled in between with sand and other fine material, boulders 3 to 5 feet in diameter being quite common. These gravels contain a great amount of material, including greenstone boulders, and hematite and jaspilite pebbles, that are foreign to the Duncan Creek drainage area, and evidently have been transported by glacial ice. In fact the present gravels along Duncan creek are dominantly a concentrate or residual product from the glacial and glaciofluvial deposits that the stream has transported and re-sorted in post-Glacial times; and the gold they contain is mainly a result of this sorting and concentrating action. When last visited during the first week in September (1915) Mr. Walsh and partners had just completed the initial dead work necessary in mining operations of this description, and had only commenced to handle the pay gravel.

A certain amount of prospecting has also been done on the left bench of Duncan creek in the vicinity of the workings of Mr. Walsh and partners, and has shown that stream gravels occur at various elevations up the face of the terrace to the top, and that in places they contain gold in encouraging amounts. Certain terrace deposits in particular between 30 and 50 feet above the present creek have been found to contain important amounts of gold. It is thus evident that these bench deposits should be more carefully prospected.

During the past summer John Salin was prospecting on Parent creek about one mile from its mouth. Parent creek is a tributary of Duncan creek, joining it from the east about 6 miles above Mayo river.

On Lightning creek a shaft was at one time sunk in the valley bottom just above the forks, and reached bedrock at a depth of 105 feet. From the bottom of this shaft, drifts were run to crosscut the deep channel at that point, but no important amounts of gold were found. This is about the only work that has been performed on Lightning creek itself, but one man, Martin Malesich, has mined for the past 6 or 7 seasons on Thunder gulch, which joins Lightning creek about 5 miles above its point of confluence with Duncan creek. Mr. Malesich is engaged mainly in ground-sluicing, using pipe and nozzle.

It is very difficult now to determine the total amount of gold that Duncan creek has yielded. Mr. George Mackenzie, Gold Commissioner of Yukon Territory, estimates that to the close of 1915, Duncan creek has produced $55,000 and its tributary Lightning creek, an additional $2,000. Figures obtained from various old timers in this vicinity would tend to indicate that the total production considerably exceeded this amount, their estimates reaching about $75,000 for Duncan creek without including the gold obtained by the three original Swedes who are claimed to have obtained $30,000 or more. The assay value of Duncan Creek gold is generally between $16.50 and $16.60 per ounce.

Haggart Creek. Haggart creek is one of the principal tributaries of the McQuesten, having a length of over 20 miles; it has a general southerly to southwesterly course, and joins the South fork of McQuesten river, about 13 miles above its confluence with the North fork. The general characteristics and geological history of Haggart creek are much the same as those of Duncan creek. The present stream follows a recent, somewhat constricted channel; and an older deep channel also has been encountered in shafts sunk both above Dublin gulch, and along the lower portions of Haggart creek. One shaft to bedrock above Dublin gulch is 90 feet deep, and another near the mouth of Lynx creek is 140 feet deep. Stream gravels are also known to occur on the benches along Haggart creek, but these have been very slightly prospected; however, gravels containing important amounts of gold have been found on the left bench, several hundred feet back from the stream, and only a few claims below Dublin gulch. Glacial and glaciofluvial deposits at one time filled the valley bottom to above the top of the present main terrace or bench, but have since been transported to a considerable extent by the present stream. Vast amounts of boulder clay and related deposits still remain, however, and are to be seen wherever sections of the superficial, unconsolidated deposits are exposed.

The only gravels that have been actually mined along Haggart creek are those occurring along the present stream channel. They are shallow, in most places, being less than 10 feet thick along the creek bottom. They consist dominantly of the schistose rocks of the district, but include also boulders and pebbles of greenstone and granitic rocks. These gravels, however, nowhere contain such large boulders as are contained in the gravels along Duncan creek. The largest boulders are generally between 1 and 3 feet in diameter and those exceeding 1 foot are somewhat exceptional. Along both sides of the creek's present course, the gravels are frozen throughout, but in the creek bed, they remain thawed near bedrock even during the winter. Drifting operations are, therefore, possible only along the sides of the stream, the creek bottom being worked in summer by open-cut methods. The gold occurs mostly close to or in the bedrock, and is mainly limited to 2 feet or less of gravel and the underlying 3 feet of bedrock, 2 to 3 feet of bedrock being taken up in places in the course of mining operations.

The gravels at present being worked along Haggart creek are in places overlain by a few feet of boulder clay, but sufficient evidence has not yet been obtained to determine whether the boulder clay was originally deposited over these gravels, or has since slid over them from the banks. If the boulder clay was originally deposited over the gravels, they must represent a high pre-Glacial channel, approximately 100 feet above the lowest known channel in Haggart creek; in which case it follows that along the portion of the creek where mining is being prosecuted, the present stream has by chance not only become superimposed directly over an old channel, but has succeeded in re-excavating its course down to practically the same level as this former depression.

Gold is reported to have been first found on Haggart creek in 1895[1], and in 1896 the creek is known to have been prospected by Thomas Nelson who found gold in the canyon 4 to 4½ miles from the mouth; after him the stream was named Nelson creek. In the same year Thomas Haggart built two cabins on the creek, and one on Dublin gulch, from which to prospect and mine. In 1898 Thomas Haggart, Thomas Nelson, Peter Haggart, and Warren Hiatt started from Dawson for Nelson creek, but *en route* separated into two parties, and Peter Haggart and Warren Hiatt, reaching their destination first, staked Discovery, and renamed the stream after Peter Haggart. Since then there has each year been more or less mining and prospecting along the creek.

During the summer of 1915, about 14 men were engaged in placer mining on Haggart creek, and an additional 3 men were working on Dublin gulch, a tributary which joins it from the northeast about 14 miles from its mouth. The properties being worked on the creek all lie between Dublin gulch and No. 20 below Discovery—the upper end of Discovery claim reaching up to just about the mouth of Dublin gulch. Some prospecting was done in the past above Dublin gulch, and a number of shafts were sunk, but no pay gravels were found. The lower portion of Haggart creek, also, has been prospected, but no one has worked there since 1912.

The lowest operations on Haggart creek during 1915 were being conducted by three partners, C. E. Kinsey, John Mawhinney, and C. E. Merriman, who hold nearly all the ground from No. 11 to No. 20 below Discovery, and also 1,500 feet up Gill gulch. They have built a ditch about three-fourths mile long,

[1] Keele, Joseph, "The Duncan Creek mining district": Geol. Surv., Can., Sum. Rept. for 1904, p. 19A.

including 300 feet of flume, which takes water for mining purposes from Claim No. 9 below Discovery, have constructed a covered bedrock drain about 1,200 feet long, and a 600-foot waste ditch, and have installed a boiler, engine, and self-dumping scraper. When visited during the latter part of August they had completed this installation and removed a certain amount of overburden, and were commencing to handle their pay gravel.

W. Abbott, N. Abbott, and W. Portlock, who own about five claims from No. 4 to No. 8 below Discovery, were also engaged in open-cut work, employing three men in addition to themselves. These partners have been mining on this property practically continuously for about five years, drifting mainly along the right rim of the creek, and open-cutting in the creek bed, the open-cut operations being possible only in summer. To work their property they have built a ditch about 2,000 feet long to supply water for washing the gravels, and also have constructed a covered bedrock drain about 600 feet long. They have also installed a boiler, engine, and self-dumping bucket outfit, an efficient plant for this class of mining. The pay gravels are there in most places from 50 to 70 feet wide, but in some places are considered to be nearer 200 feet in width; the gravels along the creek bed have an average thickness of from 6 to 7 feet. The ground being worked is believed to average from 30 cents to $1 per square foot of bedrock.

Three partners, John Maynard, Fred R. Gill, and A. Jahnke, who hold claims Nos. 1, 2, and 3 below Discovery, have also been working their ground for about seven years. During most of this time, they were engaged in winter drifting along the right rim of the creek, but during the past summer (1915), open-cut operations were commenced in the creek bottom. These partners have built a bedrock drain, about 1,000 feet long, and a ditch, to supply the necessary water for mining purposes. They have also installed a car into which the gravel is shovelled, and which is pulled up an incline and automatically dumped. The power installation on this property is both unique and economical: instead of the customary boiler, in a locality where fuel is somewhat scarce and expensive, they have installed an overshot waterwheel which supplies the necessary power for hoisting. The ground here is not thought to average more than 50 cents per square foot of bedrock along the creek bed, but along the right rim in places it runs up to 70 or 75 cents per square foot.

Three other partners, Louis Cantin, Frank Cantin, and Frank McKenna hold Discovery and three adjoining claims, which they have worked since 1909. During the past summer, only the Cantin brothers actually worked on their claims, and their operations were mainly limited to hydraulicking along the right rim of the creek, where the gravels are in most places from 6 to 10 feet in thickness. The creek bottom will probably be worked later, as the gravels there are thought to be probably richer than those being at present mined. However, hydraulicking along the side of the creek can be very cheaply performed, as the bedrock dips from this rim down to the middle of the channel, and so drains itself, and makes unnecessary the expensive bedrock drain, maintained in working the thawed gravels in the creek bottom. Also these slightly higher rim deposits can be moved to a great extent with the nozzle, so that very little pick and shovel work is necessary.

On Dublin gulch[1], John Suttles has been engaged in placer mining since 1898, and has been holding about 2,500 feet of ground near the mouth of the creek. His operations have been mainly restricted to hydraulicking the present stream gravels along the creek bottom, these deposits being in most places from 6 to 20 feet in thickness.

[1] Keele, Joseph, "The Duncan Creek Mining district": Geol. Surv.Can., Sum. Rept. for 1904, p. 33A.

The cost of mining along Haggart creek varies considerably, depending upon a number of factors; two of the most important are the thickness of the gravels, and their location—whether they are in the creek bed and partly thawed, or in the frozen zone to one side of the present channel. For working the partly thawed gravels in the creek bed, by means of a self-dumping equipment, when a bedrock drain has to be maintained, the actual operating costs average from 30 to 35 cents per square foot of bedrock, but if the cost of installation and the maintenance of the plant be included, the total cost amounts to about 50 cents per square foot. Hydraulic operations along the creek rim as performed by Cantin brothers, can be carried on for about 10 cents per square foot.

The gold production of Haggart creek is estimated by Mr. George Mackenzie, Gold Commissioner of Yukon Territory, to be about $47,000, which checks very closely with the figures obtained from various old-time miners familiar with this district from 1898 until the present. The gold from Haggart creek generally assays about $18.45 per ounce, and that from Dublin gulch about $17.80.

Minto Creek.[1] Prospecting and mining were carried on along Minto creek a number of years ago, and during the last few years Otto F. Kastner and James A. Scougale have done some work on the left bench of the creek a short distance below Minto lake.

During the period of deep-channel cutting in Mayo area, a deep, steep-walled depression was incised through the valley now occupied by Minto lake, and persisted along the upper part of the present valley of Minto creek; not far below Minto lake, however, this old channel apparently swung to the left of the present stream course. It is known that the channel must be very deep, in places 300 feet or more below the level of the present valley bottom, as Minto lake is over 300 feet deep, and shafts have been sunk in the valley of Minto creek to depths of from 70 to 130 feet without reaching bedrock. This deep channel cutting was followed by a period or periods of aggradation during which the deep depression was rapidly filled with various kinds of sediments to above the elevation of the terraces that extend along the side of the present Minto creek at heights of over 300 feet above the level of the stream. Following this aggradation interval which was related to and included the Glacial epoch, the present Minto creek began to trench its channel down through the deposits in its valley. This work of re-excavation was very rapid at first, but gradually the stream channel reached a somewhat graded or aggraded condition, and the creek has now become a small sluggish stream.

Previous to the purchase of the Kastner-Scougale property a few years ago, some prospecting had been carried on, but the greater part of the mining and development has been done during the past three years, while the property has been under the management of John A. Ross. The operations on the property have been limited to hydraulicking and to work connected with that class of mining. Three ditches, having an aggregate length of 8¼ miles, have been dug, which bring water for hydraulic purposes from McIntyre, McLagan, and Turnip creeks; and monitors, piping, sluice-boxes, and other equipment comprising an efficient hydraulic plant, have been installed.

The hydraulic operations have exposed a section which includes bedded sands, gravels, and clays, and also boulder clay, having an aggregate thickness of more than 200 feet. The lowest of these unconsolidated deposits exposed, rests on a low rock rim about 40 feet in elevation above Minto lake, and the uppermost beds are some 210 feet higher. These beds are in places nearly flat-lying, but for the most part dip toward the creek at angles rarely exceeding 10 degrees. For about 150 feet above the lowest beds exposed in the hydraulic cuts, bedrock has been encountered, and is seen to rise abruptly behind them, forming a rock

[1] Keele, Joseph, "The Duncan Creek Mining district"; Geol. Surv., Can., Sum. Rep. for 1904, p. 36A.

wall which constituted the valley side just previous to the period of aggradation during which they were deposited. Bedrock had not been encountered above this point when the property was visited in September last (1915). The bedrock formations consist dominantly of very old, probably Pre-Cambrian, schistose rocks which are mainly quartzite schists, but embrace coarser textured members, including some sheared conglomerates. These rocks are very micaceous in places and grade into mica schists. This schistose group of rocks is cut and invaded by reddish granite porphyry which is somewhat extensively exposed in the hydraulic cuts, and is thought to be of Mesozoic or early Tertiary age.

A small amount of gold was found on the low, bedrock rim above mentioned, and occasional bunches or pockets of gold-bearing gravels have been found erratically distributed throughout the uppermost sands which are evidently lake deposits, and are extensively developed along the top of the main terrace bordering Minto creek in this vicinity. Apparently these bunches of gold-bearing gravels were not originally deposited where they now occur, but represent bodies of gravel that were transported *en masse* by glacial ice, possibly by icebergs. They are, therefore, not very extensive or important as a source of placer gold. The only gravel so far encountered on this property, which gives any promise of constituting a workable deposit of any considerable extent, is a bed about 20 feet in thickness which occurs near the top of the workings. This is overlain by about 20 feet of fine, partly consolidated, bedded sands which are in turn covered by the sands above referred to, which contain the irregular bunches of transported gravels. The boulders or pebbles of this 20-foot bed of gravel are well rounded, and the gravel generally resembles a typical bar deposit. This gravel deposit is claimed by Mr. Ross to contain gold in sufficient quantity to pay well for mining, and it is hoped that it will prove to be sufficiently extensive to yield gold enough to at least pay for the past installation, development, and mining operations.

Highet Creek[1]. Highet creek is one of the small tributary streams draining the portion of deeply dissected upland lying between Mayo and McQuesten valleys. It has a general easterly to southeasterly course, is about 8 miles in length, and joins Minto creek about 2½ miles below Minto lake, or 7 miles above its point of confluence with Mayo river at Minto Bridge. The present mining operations on Highet creek are confined to about 3 miles of the creek, the uppermost workings being about opposite the mouth of Rodolph pup, which is 13 miles from Minto Bridge measured along the wagon road. The creek has been prospected in the past, both above and below this section, but little if any actual mining has been done.

Great amounts of boulder clay and gravel, overlain by sands or silts, were deposited in Highet valley during the Glacial period; and since the disappearance of the ice, the present stream has been re-excavating its channel in these accumulations, but has not as yet succeeded in reaching its pre-Glacial level. Thus along the portion of the creek at present being worked, the stream is flowing in a somewhat constricted channel bordered on either side by banks and terraces of boulder clay, gravel, slide material, sand, and silt, and remnants of these deposits are still clinging to the valley walls up to an elevation of 300 feet or more above the present creek bed.

The present mining operations are almost entirely concerned with the gravels in the creek bottom, although terrace deposits along the right bank of the creek have been mined in the past and are still being worked to a limited extent. The gravels being mined in the creek bottom underlie boulder clay and are evidently of pre-Glacial age; the portion of the present stream now being worked has thus quite fortuitously become superimposed almost directly over its pre-Glacial

[1] Keele, Joseph, "The Duncan Creek mining district": Geol. Surv., Can., Sum. Rep. for 1904, pp. 34A-36A.

position. The gravels being mined are dominantly coarse and include numerous large boulders of schist and granite. In places, also, they are fairly regular and are quite well sorted, but nearly everywhere both the gravels and the underlying bedrock exhibit evidence of having been formerly buried under an enormous weight of glacial ice which moved down Highet valley. The ice in places cut its way down to bedrock as evidenced by glacial striæ and grooving, but at other points, apparently, it over-rode the gravels which in places have lost all definite arrangement, and even include masses of soft bedrock that have been pushed several feet up into them. In places, the gravels are quite compactly cemented with a clayey matrix and grade up into the overlying boulder clay. The gold is, therefore, very erratically distributed, at some points occurring in the bedrock or within a few inches above it, and at others, in rearranged gravels lying several feet above bedrock.

Terrace deposits opposite the mouth of Rodolph pup have also been mined and have proved to be quite rich. They also appear to be pre-Glacial in character, and to represent position, occupied by the pre-Glacial stream in the process of cutting its way to its lowermost position.

Along Highet creek there appears to be very little frozen ground adapted to drifting, which is practically the only method that can be employed for mining these gold-bearing gravels in winter. Consequently the mining on the creek is done almost entirely during the summer months.

Gold was first actually mined on Highet creek in 1903, but the creek is named after Mr. Warren Hiatt, who found gold on or in the vicinity of claim No. 105 several years before 1903—the present spelling of the name having been adopted through an error made by the original recorder. In June, 1903, Rodolph Rosmusen, Warren Hiatt, and J. D. McRay staked claims on the upper part of Highet creek. Soon after George Edwards, Fred Wade, and others located; and in a short time these early stakers commenced actual mining operations. Since that time Highet creek has had an important gold production each year, and has to date yielded more gold than all the rest of Mayo area. Previous to June, 1903, nothing was known concerning the placer deposits of Highet creek, except as a result of Hiatt's early discovery; the lower part of the creek had been stampeded and staked, but no gold had been found.

The highest point at which mining was being performed on the creek during the past summer was on claim No. 108, nearly opposite the mouth of Rodolph pup. There, Frank McKenna, who also owns claims Nos. 106, 114, and 116, was engaged in hydraulicking the terrace gravels along the right bank of the stream. At this point two well defined upper channels are exposed, which contain typical terrace gravels which are well exposed and have been worked from claims Nos. 100 to 109, inclusive. These terrace deposits appear to run out into the present creek valley above No. 109, and a short distance below No. 100. On No. 108, bedrock underlying the lower of the two upper channels is about 17 feet in elevation above the level of the present creek, opposite, or about 35 feet above the bottom of the deep channel below the present creek. The higher of the upper channels is 8 feet above the lower. Important amounts of gold have been found on both of these terraces, but the upper one was much the richer. The total amount of gold that has been obtained from these terrace deposits is now difficult to correctly estimate, but from the best information available, it would appear to be between $100,000 and $140,000, and practically all of this came from claims Nos. 100 to 109 inclusive, the claims being 250 feet in length.

Mr. Elmer Middlecoff owns and mines about 2 miles of the creek next below. His operations have been and still are the largest in Mayo area. The mining equipment has been largely designed by Mr. Middlecoff to suit the peculiar conditions met with, and is both novel and efficient. One of the main considerations in connexion with any plant on this creek is to have it so designed as to make the best use of the limited amount of water available. On the Middlecoff property a large automatic dam has been constructed which is used for sluicing off the overburden during high water in spring. A specially designed self-dumping scraper has been installed, which is used largely for stacking the boulders encountered in sluicing the gravels. The gravels are conveyed into a line of sluice boxes by monitors. The sluice boxes are made of sheet steel and are lined along the sides with boards or slabs, the riffles in the bottom being of flat stones selected from the tailing piles. A clam-shell steam shovel disposes of the tailings, picking them up at the lower end of the sluice boxes and stacking them to one side. During the past summer, Mr. Middlecoff employed throughout the season an average of about eleven men, and mining operations were continued night and day. The average depth to bedrock was about 16 feet, and it was found that the gravels could be mined profitably for a width of 100 feet and in exceptional places to widths up to 200 feet. Mr. Middlecoff states that in his seven years mining in this vicinity, he has obtained gold to the value of nearly $250,000.

Adjoining Mr. Middlecoff's property, downstream, is a group of claims owned by a partnership, locally known as the "Little Gugs," made up of Geo. H. Miller, G. P. Godbout, M. P. Lindquist, Rodolph Rosmusen, and Charles Rockney. The "Little Gugs" own all except three of the claims from No. 60 to No. 75, and have been working this property for the past five summers. No mining has been performed below No. 60. Until the past summer (1915) the partners worked their claims by means of an automatic dam and a self-dumping bucket equipment. The automatic dam, which is 12 feet high and has a gate 12 feet wide, was used to sluice off the overburden during high water in the spring, and later in the season the underlying pay gravels were conveyed to the sluice boxes by means of the self-dumping bucket which was operated by an 8-horse-power engine and boiler. Last summer a self-loading, self-dumping, one-yard bucket known as a drag-line, cable-way excavator was installed, which is operated by a 30-horse-power engine. As the new equipment was late in arriving no actual mining had been done with it when the claims were visited about the end of August. The owners of the property have worked 750 feet of the creek bottom, and state that in so doing, they recovered gold to the value of over $80,000. The average depth of material worked was from 27 to 35 feet, and the width of the best pay was about 80 feet, to either side of which the gold becomes gradually less in amount.

The gold from Highet creek is heavy and well rounded, and that from the "Little Gugs" property is about one-tenth composed of nuggets worth from $1 to $10 each. The gold generally assays from $17.20 to $17.28 in gold and 7 to 8 cents in silver per ounce. It is difficult to form a close estimate of the total production of the creek. It would seem, however, from the information available, that it must amount to nearly $500,000.

Johnson Creek. Johnson creek is a small stream about 6 miles long, which heads with Highet creek, but flows in an opposite or northwesterly direction into the McQuesten, joining that river about 4 miles below the forks, or approximately 40 miles above its confluence with the Stewart. The valley of Johnson creek is a typical U-shaped depression, with the valley bottom and walls verdure and forest clad to the summits on either side.

Johnson creek is at present a "new creek," to use a term commonly applied in Yukon to a creek which has been recently stampeded and staked after gold has been found in it, and a discovery claim located. The stream is named after F. Johnson who prospected it and staked a Discovery claim in the lower part of the valley in the autumn of 1898. As a result of this discovery thirty-eight men are reported to have been on the creek that autumn, most of whom wintered there. The attempts that were made to prospect the stream at that time were unsuccessful, owing to the fact that unthawed ground was encountered in the shafts before bedrock was reached, and water consequently came in so fast that the sinking had to be abandoned. Since that time practically no prospecting had been done on the creek until the autumn of 1914. The earliest discoveries on Johnson creek were, however, made even before 1898. Johnson had found gold there some time previous to the autumn when he staked his Discovery; also in 1894 two Garrison brothers found gold on this stream and returned to Dawson for an outfit; but they remained there and later located claims on Eldorado, and not long afterwards died in the Klondike from fever.

In the autumn of 1914, Ogden Pickett Thomson moved to McQuesten valley, and built a cabin at the mouth of Johnson creek, from which to prospect the surrounding neighbourhood. He commenced work on Johnson creek, on what is now his Discovery claim, in November, and on January 1 first found pay gold. The creek was stampeded and staked during the latter part of January and in February. The discovery was thus due entirely to the untiring energies of Mr. Thomson, an old-timer who has been in Yukon continuously since 1898. When visited about September 1 (1915), he owned Discovery claim and No. 1 below Discovery.

Up to September, 1915, no actual mining had been done on the creek except on Discovery claim. Several holes or shafts had been started above Discovery, but in each case unfrozen ground was encountered, and sinking had to be abandoned. On Discovery claim the ground was frozen to bedrock along the edge of the creek where the mining was performed, but it is probably unfrozen under the creek channel. Mr. Thomson had leased portions of his ground, and about eight men were working on Discovery claim last summer. Three shafts, only a few feet apart, had been sunk on Discovery claim on the right side of the creek, in each of which bedrock was encountered at from 20 to 26 feet; and from the bottom of these shafts, the gravels on bedrock were drifted out, hoisted by windlass, and washed, the ground being thawed with steam points. The deposits exposed in these workings are largely of glacial origin, and consist mainly of coarse gravels containing numerous large boulders, and cemented by a clayey matrix. These deposits exhibit in most places very imperfect sorting, and many of the boulders are on edge. In places, close to bedrock, finer, heavier, more regular gravels occur which are gold-bearing.

The gold obtained from Discovery claim is massive, somewhat rough or angular, and fairly coarse, many single nuggets worth $2 to $3, and one valued at $8 having been obtained. The first gold recovered assayed $16.78 in gold and 5 cents in silver per ounce. Up to September 1 (1915), the total gold obtained from Johnson creek amounted to about $800. The results so far obtained from the creek have been very encouraging and should give a stimulus to placer mining on other creeks in the neighbourhood.

Lode Deposits.

General Statement. Lode deposits of various types are known to occur at a number of points throughout Mayo area. Most of the prospectors in the past, however, have been in search of placer deposits, very few quartz prospectors having as yet visited the district. In addition, throughout the greater part of the area, there is a heavy mantle of superficial deposits, which obscures the underlying bedrock in most places, and renders prospecting for lode deposits very difficult and uncertain. The discoveries that have been made were mainly due to accident, or to the deposits being exposed along some stream cutting. This area cannot thus be considered to have been more than very slightly prospected, and many other valuable mineral deposits may yet be found within it.

The lode deposits that have been discovered within Mayo area, include mainly a rich silver-lead vein on Galena creek, and a number of gold-bearing veins on Dublin gulch. Other veins are known to occur carrying gold, silver, lead, and zinc minerals; but in most cases they have not been at all developed, and very little is known concerning them. Also on Highet creek and elsewhere, scheelite is frequently obtained in the concentrates in placer mining, indicating that deposits of this mineral occur in the vicinity. As scheelite and other tungsten ores have taken on increased value and importance since the outbreak of the war, careful search should be prosecuted for deposits in which they occur.

Galena Creek. The silver-lead vein on Galena creek outcrops in the canyon about 3 miles from the mouth of the creek. Galena creek joins the South fork of the McQuesten approximately 25 miles above its confluence with the North fork. The Galena Creek property is reached by means of a wagon road constructed by the Yukon government, from Minto Bridge to the mine workings, a distance of about 20 miles.

The Galena Creek vein is believed to have been discovered and staked by H. W. McWhorter and partner about the year 1906, but the claim was afterwards allowed to lapse. The deposit was relocated in 1912 or 1913 by Mr. McWhorter who gave a lay on the ground to Jack Alverson and Grant Hoffman. These layees did the first real development on the property, and proved it to be of importance. They shipped 59 tons of ore to the smelter at Trail, B.C., the smelter returns for which amounted to $269 per ton, in gold, silver, and lead, the gold being very low, but the lead amounting to 45 per cent. In the spring of 1914 the property was acquired by Thomas P. Aitken and Henry Munroe, Mr. Aitken being the principal owner. During the winter of 1914-15 these owners shipped 1,180 tons of ore to San Francisco. The smelter returns for this shipment, according to a statement kindly furnished by Mr. Aitken, included $3 per ton in gold, and for about half of the ore, 39 per cent lead and 280 ounces of silver, and for the other half 23 per cent lead and 260 ounces of silver per ton.

The vein outcrops in the walls of the canyon on Galena creek, but to either side along its strike is not exposed, being covered with a heavy mantle of drift. Thus all that is known concerning the vein is derived from the mine workings and the exposures in the canyon which at this point has a depth of about 70 feet. The vein occurs in a fissure, or in places really in a compound fissure traversing old altered sediments probably of Pre-Cambrian age. These where exposed in the canyon are greyish to greyish-green, schistose, quartzitic, sericitic rocks which in places occur in heavy massive quartzite beds with relatively little sericite, but also grade into more finely laminated phases that become typical sericite schists. All these rocks have been much contorted and broken, and contain a great amount of secondary quartz which occurs in lenses, stringers, and irregular bunches. These have been deposited for the most part along the planes of schistosity of the enclosing rocks; but in places stringers and veinlets occur intersecting the foliation surfaces at various angles.

The vein strikes about astronomic north 65 degrees east and dips to the southeast at angles ranging generally from 55 to 80 degrees, although in places it has an almost vertical attitude. The extension of this vein on the northeast side of the canyon comprises really a fault zone about 5 feet in thickness, which includes crushed and sheared wall rock interspersed with small quartz stringers, the most prominent of which is 6 to 8 inches in thickness and is only slightly mineralized. An adit 100 feet long has been driven in on this zone from an elevation only a few feet above the creek level, and along this adit, the quartz and all other evidence of mineralization gradually disappear, until at the end, there is only about 2 feet of barren, sheared, country rock.

On the southwest side of the canyon, the vein is very highly mineralized chiefly with galena and ruby silver, although a certain amount of iron pyrites also occurs, and in one place a band of zinc blende about 2 inches or even more in thickness, which contains about 30 per cent zinc, follows the foot-wall. An incline shaft on the vein had been sunk 185 feet below the level of the upper edge of the canyon walls, when the property was visited about the middle of August (1915); and from this incline, stopes had been opened up from which the ore was being mined. In the mine workings, one main shoot of highly mineralized rich ore had been encountered, which in most places consists mainly of galena and ruby silver with only subordinate amounts of quartz gangue; it is claimed to average over $150 per ton in gold, silver, and lead. This shoot dips to the northeast along the vein, is about 30 to 35 feet long, and has been found to persist downward to at least the level of the bottom of the incline, the lowest point reached by the mine workings in August. Near the middle, the shoot is 40 to 48 inches thick, but it narrows to 6 or 8 inches at the edges.

Another shoot or pocket of ore was encountered to the southwest of the main shoot, in a short drift run to the southwest from the bottom of the incline, during the writer's visit, and from the face of this drift two samples were taken. No. 1 was an average of the upper 22 inches of the vein, which there consisted of quartz containing considerable ruby silver. No. 2 is an average of the remaining 14 inches of the vein which was composed mainly of galena and ruby silver. These samples were assayed[1] and found to contain:

Sample No.	Gold		Silver		Total value per ton gold and silver	Lead percentage
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton		
1	Trace	....	306·00	$153.00	$153.00	2·53
2	0·16	$3.20	533·44	266.72	269.92	40·90

The property is equipped with two 40-horse power boilers, a compressor, pumps, and other machinery necessary to constitute an efficient plant for mining, hoisting, and pumping. Comfortable buildings have been erected and an assay laboratory established with a competent assayer in charge.

The cost of freighting the ore to Mayo over the snow in winter has been about $20 per ton; from Mayo to San Francisco the freight charges amounted to approximately $22 per ton; and the cost of treatment there was about $20 per ton, a total of possibly slightly over $62 per ton for freight and treatment.

As the vein is deposited along a well-defined fault fissure showing considerable displacement, it is certain to be quite persistent, and it is more than probable that other valuable shoots will be found within the vein. In a vein of this description the occurrence, unaccompanied by others, of one shoot so highly mineralized and so persistent vertically as this one, would be almost unparalleled in the history of ore deposits. Furthermore, fissure veins rarely if ever occur singly. In the various parts of the world where similar mineralized fissures have been investigated, they have been found almost without exception to occur two, three, or more together in fairly close proximity to each other; and since in the vicinity of Galena creek, bedrock is nearly everywhere covered with a heavy mantle of overburden, it is probable that other valuable veins will

[1] All assay returns given in this report were obtained from the Government assay office, Whitehorse, Yukon.

yet be discovered in the neighbourhood when the concealed ground is prospected. If future development exposes a reasonably large tonnage of ore, the owners would then be justified in erecting a concentrating plant on the property, which would greatly reduce freight and treatment charges, and would allow of grades of ore being treated which it does not now pay to ship.

Dublin Gulch. A number of mineral veins have been discovered in the vicinity of Dublin gulch, a small stream about 4 miles long, which is a tributary of Haggart creek and joins it from the northeast about 14 miles from its mouth. The veins so far found are for the most part distributed throughout a southwesterly trending belt, 2 to 3 miles in length and less than one mile in width, which, commencing near Haggart creek, extends up the left side of Dublin gulch about 2½ miles, and there crosses over to the right side of the gulch.

The geological formations in the vicinity of Dublin gulch include mainly old, probably Pre-Cambrian, schistose rocks, and granitic intrusives of possibly early Mesozoic age. The schistose members consist mainly of metamorphosed quartzites which, however, pass by a gradual transition into mica and sericite schists. All these older rocks are much distorted, sheared, and faulted. In the vicinity of Dublin gulch they have also been somewhat extensively invaded by the granitic intrusives, and it is near the contact of the older rocks with these later intrusives, that the veins occur, certain members being in the one formation, and certain ones in the other, some even passing from one rock to the other with little apparent change in mineralization. The veins in the granitic intrusives, however, are naturally much the more regular in form, as fractures traversing a firm, massive rock of this kind are much simpler and more persistent than those in the old, contorted, sheared, foliated schists.

The veins range in thickness from one inch or even less to 3 to 4 feet, but well mineralized deposits more than 2 feet thick are exceptional. They consist dominantly of a quartz gangue which is mineralized, chiefly with arsenopyrite (mispickel) and some iron pyrites; all the better mineralized portions of the veins, and particularly those found to carry important amounts of gold, are heavily stained with a greenish arsenate of iron. No attempt was made to thoroughly sample these veins to determine their gold content throughout, as Mr. T. A. MacLean had previously sampled all these deposits on behalf of the Mines Branch of this Department.[1] Occasional samples were taken, however, of typical portions of the veins wherever they were exposed. These samples in most cases were found to contain from $2 to $16 in gold per ton, with a general average of between $8 and $9. One sample from the Olive vein, however, ran $44.70 in gold. The silver content rarely exceeds one ounce per ton. A decided surface enrichment in gold occurs in connexion with these veins, the oxidized portions containing important amounts of free gold which can be recovered by panning.

It is evident from the sampling that has been done, that none of the deposits are of sufficiently high grade to pay for shipping to outside points for treatment, without previous concentration. If a small concentrating mill were erected in their immediate vicinity, however, considerable portions at least of some of the veins would pay for treatment, and the oxidized zone of many of them would yield important amounts of gold.

The various veins examined will be described in order, commencing near the head of Dublin gulch and proceeding downstream.

On the *Carscallen claim* two adits or drifts have been driven along the right side of Dublin gulch about 2½ miles above its mouth, on a claim owned by Frank Carscallen. The lower adit was caved in when visited, but is said to be about 25 feet long and to be driven on a promising vein. The upper adit, which is

[1] MacLean, T. A., "Lode mining in Yukon"; Mines Branch, Dept. of Mines, Can., 1914, pp. 127-159.

only about 150 feet from the creek bottom, is 90 feet long, and is driven in on a vein which strikes south 60 degrees west (astronomic), dips at about 60 degrees to the southwest, and has a thickness of from 6 inches to 3 feet. In addition to this main vein, a secondary parallel vein, having a thickness ranging from an inch to about 18 inches, is exposed along the northeast side of the drift. This secondary vein has a flatter dip than the main vein, and inclines toward the latter, apparently joining it a few feet below the floor of the drift. These veins occur in fissures in a greyish granitic rock which is considerably altered and decomposed for 2 or 3 feet on each side of them. The vein filling consists dominantly of quartz which is well mineralized in most places, chiefly with arsenopyrite (mispickel) and with some iron pyrites, and is heavily stained with a greenish arsenate of iron. The ore material in the secondary vein is very irregularly distributed and broken, and occurs largely as erratic, broken bunches. Two samples were taken from this adit.

No. 1 is an average of the main vein at the breast of the drift, where it has a thickness of 12 inches. No. 2 is an average across the main vein about halfway in the drift, at which point the vein has a thickness of about 3 feet. These samples were assayed and found to contain:

Sample No.	Gold		Silver		Total value per ton gold and silver
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
1	0·52	$10.40	4·48	$2.24	$12.64
2	0·42	8.40	3·35	1.67	10.07

The *Olive claim* is located on the left side of Dublin gulch, the main workings being 1,700 to 1,800 feet from Dublin gulch, and about 2 miles from Haggart creek, measured as the crow flies. The claim is also on the right side of Olive gulch, a small tributary of Dublin gulch, entering it from the left, about 2 miles above Haggart creek. The Olive claim was staked about the year 1908, has been since surveyed, and is owned by Robert Fisher. A well mineralized vein has been discovered on this property on which an adit or drift 100 feet long has been driven. This vein strikes north 74 degrees east (astronomic), dips 70 to 75 degrees to the southwest, and throughout the drift has a thickness of from 8 to 14 inches, being in most places about 12 inches thick. The vein occurs in a fissure in granite which is altered and somewhat decomposed and soft for 2 to 3 feet on each side. The vein material consists mainly of quartz which is heavily mineralized mostly with arsenopyrite. Some pyrite also occurs, and the vein filling is for the greater part heavily stained with a greenish arsenate of iron. Two samples were taken from this adit. No. 1 is an average across the vein at the end of the drift, where the vein has a thickness of 12 inches. No. 2 is an average across the vein where exposed in the roof of the drift at a point about halfway into the breast, at which point the vein is 10 inches thick. These samples were assayed and found to contain:

Sample No.	Gold		Silver		Total value per ton gold and silver
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
1	2·10	$42.00	5·40	$2.70	$44.70
2	0·80	16.00	1·70	0.85	16.85

A second parallel adit was also commenced a few feet above and to the left (northwest) of the one just described. When well under cover, however, this upper adit turned toward the lower workings, and encountered the vein there exposed in about 70 feet, and drifted along it for 20 feet.

The *Stewart-Catto group* embraces one unsurveyed fraction, and five claims and one fraction that have been surveyed and for which application has been made for crown grants. These claims are all located on the left side of Dublin gulch between Olive and Stewart gulches, and are owned by J. S. Stewart and Dr. William Catto. The claims have been held for about seven years, most of them having been staked in 1907; the Victoria claim of this group was the first claim staked on Dublin gulch. At least eight veins have been discovered on this property, but most of the development work has been expended on three of these which are designated the Cabin, Victoria, and Green veins. These three and a fourth exposed in the underground workings on the Victoria claim, were the only ones examined by the writer. The cuts, trenches, or other works exposing the other veins had so caved in that the veins could not be seen.

The Cabin vein, so called because it is situated just above Mr. Stewart's cabin, is exposed on the surface by a line of open-cuts. In addition, an adit or crosscut has been driven which encountered the vein after a distance of 132 feet. The vein strikes about south 44 degrees west (astronomic) and dips to the southeast at an average of about 65 degrees. It occurs in a fissure in the older schistose rocks of the district, and where encountered underground has a thickness of 5½ feet. It consists dominantly of quartz which is somewhat sparsely mineralized with arsenopyrite and pyrite. An average sample was taken across the vein from the end of the crosscut, which was assayed and found to contain:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
0·34	$6.80	0·66	$0.33	$7.13

On the Victoria claim an underground crosscut has been driven into the hill a distance of 140 feet, which encountered two veins at distances of 85 and 100 feet respectively. The first is called the Victoria vein, and the second will here for convenience be designated the No. 2 vein. On the Victoria vein a drift has been run to the right of the crosscut 27 feet, and to the left 30 feet. This vein strikes practically due east, and has an almost vertical attitude; it consists mainly of quartz which is well mineralized with arsenopyrite and some pyrite, and is heavily stained with a greenish arsenate of iron. In the right drift, this vein is particularly well mineralized, is porous and somewhat decomposed, and has a thickness of 12 to 18 inches. An average sample taken across the vein in the face of this right drift, where it is 18 inches thick, was assayed and found to contain:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton.	Value per ton	
0·69	$13.80	1·01	$0.55	$14.35

In the left drift this vein gradually becomes thinner until at the end of the 30 feet it is only 1 to 4 inches thick. It is near this point joined by No. 2 vein which is there over 4 feet in thickness, strikes south 43 degrees west (astronomic), and has an almost vertical attitude. No. 2 vein although thick in places is not, where exposed, as well mineralized as the Victoria vein, and where encountered in the main crosscut is irregular and mainly represented by a fracture zone including only 2 to 6 inches of quartz. These veins both occur in fissures in the typical schistose rocks of the vicinity, and like all other veins in this formation, are rather irregular in form. An average sample was taken at the end of the left drift, at the junction of No. 2 and Victoria veins, where the quartz is 4½ feet in width, but is only sparsely mineralized. This sample was assayed and found to contain:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
0·10	$2.00	0·15	$0.07	$2.07

The green vein is exposed in the left bank of Olive gulch opposite the Olive workings. A very considerable amount of development has been performed on this vein, including about 290 feet of underground work, as well as numerous open-cuts, trenches, and other surface openings. The underground work includes a crosscut or adit 60 feet long, which really drifts on the vein for about 50 feet. At the end of this crosscut, a drift is continued along the general strike of the vein for 130 feet, and from the end of this drift there is a 27-foot upraise. Also from the main drift two smaller drifts or crosscuts have been driven distances respectively of 40 and 30 feet. The vein was first encountered in these underground workings about 10 feet from the surface, and is there in the granitic intrusives. About 40 feet farther, however, it passes into the schistose rocks, and throughout the rest of the workings, remains in this formation. The vein in a general way strikes almost due east and west, the same as the Victoria vein, and like it, has an almost vertical attitude. It ranges in thickness from 10 to 36 inches, but is in most places 12 to 20 inches thick. It is also generally well mineralized, but is rather irregular in form and mineralization. The vein is joined by numerous stringers and veinlets, and in places consists for the greater part of fractured bunches or masses of quartz and sheared and somewhat mineralized wall rock, distributed along the general fault zones. Four samples were taken from these underground workings. No. 1 is an average across the vein where 2 feet thick, and where well mineralized, near the top of the upraise. No. 2 is an average across the vein where exposed in the end of the main drift, where the vein is 14 inches thick and well mineralized. No. 3 is an average across the vein in the breast of one of the small drifts where it is 12 inches thick and not well mineralized. No. 4 is an average across the vein zone near the beginning of the main drift. The fracture zone here is 24 inches wide, but is almost barren of apparent mineralization. These samples were assayed and found to contain:

Sample No.	Gold		Silver		Total value per ton gold and silver
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
1	0·40	$8.00	0·52	$0.26	$8.26
2	0·56	11.20	1·09	0.54	11.74
3	0·10	2.00	0·50	0.25	2.25
4	Trace	....	Trace	....	....

The *Blue Lead* and *Eagle groups* adjoin one another and consist each of eight unsurveyed claims which are owned by Messrs. Robert Fisher, B. C. Spragg, A. Aimes, and others, and were staked about the year 1910. The claims extend along the left side of Dublin gulch from Stewart gulch to near the valley of Haggart creek, there being, however, a group of four undeveloped claims owned by John Maynard, between the Eagle group and Haggart creek. Quite a number of veins have been discovered on these groups, which range from stringers about an inch thick to veins said to be 2 to 3 feet thick. All occur in fissures which are partly in the granitic intrusives and partly in the schistose rocks of the vicinity. The veins are very similar in character, and consist mainly of a quartz gangue which includes varying amounts of arsenopyrite with also some pyrite, and all the better mineralized deposits are stained with a greenish arsenate of iron. A considerable amount of prospecting development work has been performed on these claims, including numerous trenches, pits, and open-cuts, three adits, 38, 120, and 35 feet long, and a 35-foot shaft. The works were nearly all more or less caved in when visited, so that none of the more important veins was exposed. A considerable number of stringers 1 to 4 inches thick were seen, however. At one point on top of a narrow ridge a vein occurs which is said to be 2½ feet thick, and on which the 35-foot shaft is sunk. Around the top of the shaft were a number of fairly well mineralized pieces of vein material representing vein sections 6 to 10 inches in thickness. A fairly average sample of these larger pieces was taken. This was assayed and found to contain:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
0·10	$2.00	0·95	$0.47	$2.47

Other Localities. Important discoveries of other mineral veins have been reported from a number of points in Mayo area. A rich silver-lead vein was recently found not far to the south of the lower end of McQuesten lake. Quartz veins claimed to contain important amounts of gold and silver occur on Christal and Lightning creeks. A number of veins are reported to occur on Mt. Haldane, and on Duncan creek at least two important veins are exposed along the right bank of the stream a short distance above the forks. The lower of the two, outcrops on Discovery placer claim just below the canyon, and about 40 feet above the creek level. It is apparently 3 or 4 feet thick, but is claimed by men who have stripped it to be 5 feet in thickness. When visited it was very poorly exposed, and its thickness, dip, and strike were thus largely obscured. The vein consists mainly of sphalerite (zinc blende) with some chalcopyrite and pyrite, and subordinate amounts of quartz and calcite. An average sample was taken across the exposure and was assayed for gold and silver, but owing to an error was not assayed for zinc, its most important constituent. The gold and silver content is as follows:

Gold		Silver		Total value per ton gold and silver
Ozs. per ton	Value per ton	Ozs. per ton	Value per ton.	
0·08	$1.60	7·12	$3.56	$5.16

The other vein occurs higher up in the canyon and is similar in general appearance, but appears to be narrower than the one just described. It was, however, poorly exposed, and was so weathered and oxidized on the surface, due to a spring of water in the vicinity, that no satisfactory sample could be at all readily obtained.

Summary and Conclusion.

The stream gravels of a number of the creeks within Mayo area have been found to carry considerable amounts of placer gold, and the available evidence would indicate that the gravels along numerous other streams within the district will also be found to be gold bearing to an important extent. The recent discovery of coarse gold on Johnson creek is an example of what will yet probably happen in many other places when the creeks of the district are more thoroughly prospected, as the geological conditions are very similar throughout the district. In most places, only the present stream gravels have as yet been worked, and it seems probable that the amount of gold still contained in the deep and bench gravels is as great or greater than that in present creek deposits. The placer gold yet to be derived from this area will thus probably amount to much more—possibly many times more—than that already recovered.

Valuable lode deposits as yet unknown will undoubtedly also be discovered throughout Mayo area, but until transportation facilities are greatly improved, they will constitute for some time mainly a future asset to the district, except where they are very rich as is the Galena Creek ore.

Scroggie, Barker, Thistle, and Kirkman Creeks, Yukon Territory.

Introduction.

After completing the geological work for the season in Duncan Creek mining district, described in previous pages, about ten days were spent in investigating the gold-bearing gravels, and placer mining possibilities on Scroggie, Barker, Thistle, and Kirkman creeks. These streams all head near one another in the divide between Stewart and Yukon rivers, to the south of the Stewart; but in their courses they radiate out from the central area in which they have their source, and flow in northerly, westerly, and southerly directions—Scroggie and Barker to join the Stewart, and Thistle and Kirkman to Yukon river.

These creeks were all discovered[1] and staked in 1898 and since then placer mining has been in progress on them, with the result that between $200,000 and $300,000 in gold has been produced. Very little authentic information, however, was available concerning the geological conditions and mining possibilities along these creeks or throughout the district in which they occur. Practically the only published information available was that contained in a report by R. G. McConnell who visited Thistle creek in 1901 and briefly described the conditions prevailing there[2]; at that time, however, very little mining had been done.

These creeks all occur within the older schistose belt, the rocks exposed being dominantly schists, gneisses, and limestones of possibly Pre-Cambrian age, similar to those so extensively developed in the Klondike and other prominent placer mining camps in Yukon and Alaska. The locality lies outside the glaciated zone, which is greatly in its favour as a placer gold district, since whatever gold has been concentrated in the stream gravels remains practically undisturbed,

[1] In Yukon when gold is found on a creek and a "Discovery" claim is staked, the creek is said to be "discovered."
[2] McConnell, R. G., "Thistle creek"; Geol. Surv., Can., Ann. Rept., Vol. XIV, 1901, pp. 31A, 32A.

except where it has been reconcentrated by more recent stream action; and, furthermore, the gold-bearing gravels are not overlain by vast accumulations of glacial detritus, as is the case in many glaciated localities.

Prominent, wide terraces or benches extend along these creeks, the bedrock of which is overlain by stream gravels which on Barker and Thistle creeks have proved to be important sources of placer gold. The bench gravels are almost entirely unprospected not only along Scroggie and Kirkman creeks, but also along the greater part of Barker and Thistle creeks. The benches, along each stream, represent a former, higher position of the creek, and should consequently be carefully prospected, as it is probable that the gravels on the benches are as important as those on the creek bottoms or more so, especially in places where the benches have not been destroyed by the creeks in sinking their lower more recent channels. A brief description of the four creeks follows and a detailed report is in preparation.

Scroggie Creek.

Scroggie creek flows in a westerly to northwesterly direction, and joins Stewart river about 25 miles above its confluence with the Yukon. When visited during the past summer, about twenty men were engaged in placer mining along the stream and its tributary Mariposa creek, and during the winter months in recent years, an average of from forty to fifty men are reported to have been there employed. Mining operations have been entirely confined to the gravels in the creek bottom, which have been worked by both underground drifting and open-cut methods. In most places, the mining has been performed by drifting, and as this method can be pursued during the winter months, a greater number of men work on this creek in winter than in summer when many other kinds of work are available, and when other forms of placer mining and prospecting can be conducted to best advantage. The total amount of gold that has been produced from Scroggie creek and its tributaries is generally estimated to be between $50,000 and $75,000, but some claim it to be between $75,000 and $100,000.

Barker Creek.

Barker creek has a general northerly course, and joins Stewart river about 2 miles below the mouth of Scroggie creek or 23 miles above the mouth of the Stewart. When visited during the past summer (1915) only seven men were living on Barker creek, who were engaged in mining, but of these one man was holding, for mining purposes, about 5 miles of the creek, commencing 8 miles above the mouth. Both the bench and creek gravels along this stream have been worked to a limited extent; the bench gravels, however, have proved up to the present to be the more remunerative, and the development to date would warrant their thorough investigation, and would indicate that they are likely to prove of considerable importance. The creek gravels have been worked mainly by underground drifting, and the bench deposits by the hydraulic method. It is estimated that between $25,000 and $30,000 in gold has been obtained from this creek.

Thistle Creek.

Thistle creek follows a general westerly course, and joins the Yukon about 20 miles above the mouth of Stewart river. Thirteen men were engaged in placer mining on this creek when it was visited, but a few who spend most of their time there, had gone over to Kirkman creek temporarily. The mining operations along Thistle creek have been restricted mainly to the bench gravels which are hydraulicked during the summer months. The creek gravels have also been worked to a limited extent, mainly by drifting, and are still so mined, especially during the winter months, when hydraulic and open-cut methods are impossible. In all, it is believed that about $125,000 in gold has been produced from this creek which has thus been the most productive of the four creeks considered in this report.

Kirkman Creek.

Kirkman creek flows in a general southerly direction, and joins Yukon river 8 miles above the mouth of Thistle creek, or 28 miles above the confluence of the Stewart and Yukon. Although Kirkman creek was discovered in 1898, and has been prospected at different times since, no actual mining took place until after April, 1914, when J. C. Britton and William Haas made a discovery which caused a stampede to the creek. During the following winter (1914-15), an average of about forty men were engaged in mining along this stream, and throughout the ensuing summer about thirty men were employed. More men engage in mining along these creeks in winter than in summer, owing to the fact that the creek gravels along these streams can be worked by the drifting method which may be pursued to advantage during the winter, when very little other work is available in Yukon, and when prospecting and practically all other forms of placer mining are impossible. Between the date of discovery in April, 1914 and October, 1915, it is estimated that about $8,000 in gold was produced from Kirkman creek, the mining operations being mainly confined to two miles of the creek commencing about 5 miles above the mouth, or just above a portion of the creek channel that is somewhat constricted, and is locally spoken of as the "canyon."

Wheaton District, Southern Yukon.[1]

INTRODUCTION.

The early part of the past season (1915) was spent in Wheaton district, southern Yukon. During the summer of 1909, the writer made a photo-topographic survey of this area, and at the same time made a geological examination of the district. The geological mapping was, however, necessarily of only a preliminary nature, owing to the fact that at the time no topographic map was available upon which to plot the various geological formations, and all geological outcrops, contacts, etc., had to be recorded in note form only, which is at best very unsatisfactory. The topographic work performed by the writer in 1909 was compiled by the topographic division of this Department, and advance sheets suitable for field work became available last spring, affording thus an opportunity to revise the previous geological mapping in a satisfactory manner, using this map as a topographic base. Another important reason for performing geological work in Wheaton district at this time, was that a number of important deposits of antimony minerals were known to occur within the area, which have been more or less developed since 1909, and since the war there has been an increased demand for antimony and its price has advanced greatly. The writer accordingly received instructions to revise the geological mapping of Wheaton district, and to make an examination of the mineral deposits occurring within its boundaries, particular attention to be paid to those containing antimony minerals.

[1] For further information concerning the geology, mineral resources, topography, and other features of Wheaton district, the reader is referred to the following more detailed report:
Cairnes, D. D., "Wheaton district, Yukon Territory"; Geol. Surv., Can., Memoir No. 31, 1912.

The topographic map upon which the geology was plotted is published to a scale of $\frac{1}{62500}$, or approximately one mile to the inch, and every care was taken to have the geological mapping performed so as to be consistent with this scale.

The writer was ably assisted in this work by William Cockfield.

LOCATION AND AREA.

Wheaton district is situated in the southern portion of Yukon Territory, its southern edge being from 12 to 15 miles north of the 60th parallel of latitude (the British Columbia-Yukon boundary). The area included is approximately

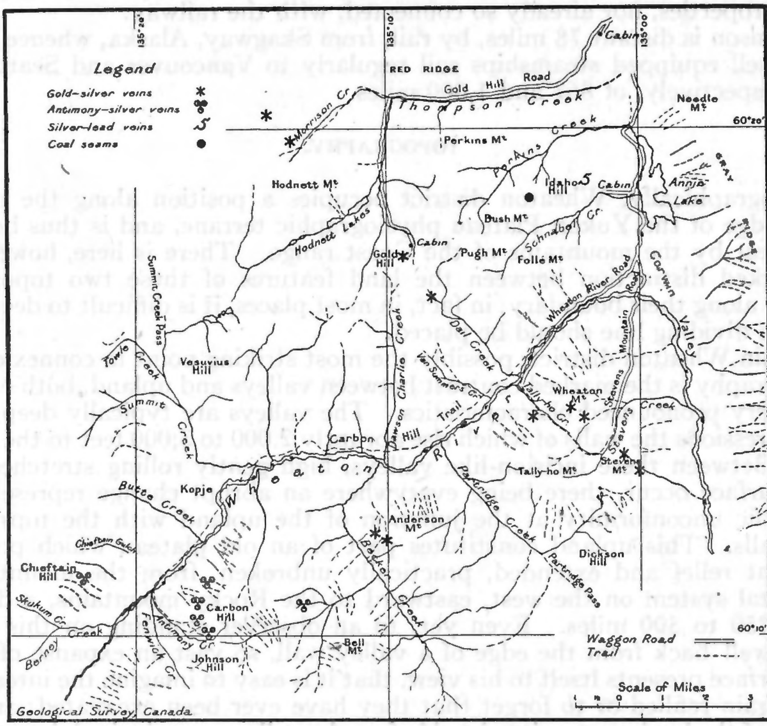

Figure 2. Wheaton district.

20 miles long in an east and west direction, and 15 miles wide from north to south. The district is flanked on the west by the eastern slopes of the mountains of the Coast range, and extends thence eastwards to longitude 135° 53′, or to within a distance, as the crow flies, of 6 miles from the White Pass and Yukon railway. Wheaton river which has given its name to the area, flows, throughout the lower portion of its course, in a general direction almost due south, and empties into Lake Bennett; 12 miles above its mouth, however, the river turns abruptly to the west forming what is known as the "Big Bend" of the Wheaton, and throughout the portion of its course from the Big Bend to near its headwaters, the stream flows in a general easterly to northeasterly direction. Wheaton district, as the term is here used, includes only the particular area mapped in 1909; this area extends along both sides of Wheaton river from above 6 miles below the Big Bend, to about 18 miles above it.

MEANS OF COMMUNICATION.

Wagon roads have been constructed by the Yukon government, from Robinson on the White Pass and Yukon railway, to various parts of the district. One road extends along Wheaton river to Carbon hill which is situated in the most westerly portion of the area, about 30 miles distant from Robinson; and a branch from this main road has been built to Stevens camp near the summit of Mt. Stevens. Another road 20 miles long, has been constructed from Robinson to Gold hill which lies 3 to 4 miles north of Wheaton river, and midway between that stream and Watson river. All parts of the district are thus easily accessible, and only short, easily constructed branch roads are necessary to connect all the mineral properties, not already so connected, with the railway.

Robinson is distant 78 miles, by rail, from Skagway, Alaska, whence several lines of well equipped steamships sail regularly to Vancouver and Seattle, distances, respectively, of 867 and 1,000 miles.

TOPOGRAPHY.

Topographically, Wheaton district occupies a position along the extreme western edge of the Yukon Plateau physiographic terrane, and is thus bordered on the west by the mountains of the Coast range. There is here, however, no very marked distinction between the land features of these two topographic provinces along their boundary; in fact, in most places, it is difficult to decide just where the dividing line should be placed.

Within Wheaton district, possibly the most striking point in connexion with the topography is the marked contrast between valleys and upland, both of which possess very pronounced characteristics. The valleys are typically deep, steep-sided depressions the walls of which rise abruptly 2,000 to 3,000 feet to the upland above. Between these incision-like valleys, high gently rolling stretches of an upland surface occur, there being everywhere an abrupt change representing a topographic unconformity at the junction of the upland with the tops of the valley walls. This upland constitutes part of an old plateau which possessed only slight relief and extended, practically unbroken, from the mountains of the Coastal system on the west, eastward to the Rocky mountains, a distance of from 250 to 300 miles. Even yet, to an observer standing on this upland surface, well back from the edge of a valley wall, so vast an expanse of gently rolling surface presents itself to his view, that it is easy to imagine the intersecting valleys again refilled or to forget that they have ever been excavated; and thus a picture of the landscape as it existed before the valleys were incised, is presented.

This plateau is generally conceded to represent a maturely eroded surface, that was reduced by ordinary normal erosion processes to a nearly plain-like condition, during a long period throughout which this portion of the earth's crust remained relatively stable. The erosion interval was interrupted, however, in what is thought to be late Tertiary time by a regional uplift which in Wheaton district amounted to about 3,600 feet, and as a result of this crustal movement a lowland tract became a highland surface. The uplift gave renewed life and energy to the streams which were thus soon able to cut deep, V-shaped incisions into the new upland, and these now constitute the main valleys of the district. At a later period glacial ice invaded Wheaton district, and occupied all the main depressions which as a result of ice action, became both widened and deepened, and gradually assumed pronounced U-shaped cross-sections. Also, such well known glacial forms as cirques, hanging valleys, roches moutonnées, and kettle-holed valley floors were produced. The morainal and other materials which were deposited in the valley bottoms, blocked the stream courses in different places to such an extent that even yet the drainage is very imperfect, and lakes or ponds, many of them surrounded by muskeg or tundra, now occupy important depressions, through which large and important streams once flowed.

Since the retreat of the ice, V-shaped incisions have been etched in the valley walls, and at the margins of the upland surface, resulting in the production between them of pronounced facetted forms. The main streams have also sunk their channels to some extent in the unevenly distributed deposits strewn over the valley floors, so that occasional sand, gravel, silt, or boulder-clay banks, 200 feet or more in height, have been produced. Disregarding these relatively slight changes, however, the topography of Wheaton district is as the ice left it, and the forms or features which were produced by glaciation still exist in a marked state of preservation.

GENERAL GEOLOGY.

General Statement.

Wheaton district is situated, as before mentioned, along the eastern edge of the Coast range, and practically the entire area is believed to be underlain by the granitic rocks of the great Coast Range batholith; which outcrop throughout by far the greater part of the area. A study of the geology of Wheaton district thus involves throughout, that of this important granitic terrane. In addition to the granitic intrusives, however, which are of Cretaceous or Jurassic age, numerous other rock types occur, including igneous, sedimentary, and metamorphic varieties which range in age from possibly Pre-Cambrian to Recent.

In the eastern portion of Wheaton district, the present upland surface very nearly coincides with the original top of the Coast Range batholith, so that there, numerous remnants of the former roof of this igneous mass are still preserved. The older rocks also constitute walls separating subjacent portions of this vast granitic body; in addition, numerous small isolated masses of the older invaded formations remain, which are distinctly seen to be inclusions in the granitic intrusive, occurring as they do throughout it at various elevations. Toward the west, nearer the centre of the batholith, the older rocks gradually disappear, as the central portion which was originally the highest has been more deeply eroded than the rest and, as a result, the overlying and included older rocks, all of which were originally mainly at or relatively near the surface of the batholith, have been to a great extent removed.

Throughout Wheaton district the geology is complicated and intricate, due in part to the great diversity in age and character of the various formations that occur, but more particularly to the fact that the area has been subjected to a number of intense volcanic invasions. As a result of each invasion the older rocks have been cut, pierced, and in some cases buried by the invading volcanics, and so each successive period of volcanic activity added to the geological complexity of the region.

Table of Formations.[1]

Era	Period	Formation	Lithological character
Quaternary		Superficial deposits	Gravel, sand, clay, silt, soil, muck, volcanic ash, ground-ice, slide rock, and morainal materials.
	Probably mainly about Pliocene, but may include older members, and may also continue up into the Pleistocene		Rhyolite, granite-porphyry, and related volcanics, with their associated tuffs and breccias. Some granitic types also occur.
Tertiary			Andesite, basalt, and related dyke rocks and other volcanics, with their associated tuffs and breccias.
Mesozoic	Cretaceous to Jurassic	Coast Range intrusives	Granitic rocks ranging in composition from granite to diorite, with associated porphyritic phases.
	Probably Lower Cretaceous		Andesite, diabase, basalt, and related volcanics, with associated tuffs and breccias.
	Lower Cretaceous or Jurassic	Laberge series	Argillite, metargillite, shale, sandstone, arkose, greywacke, conglomerate, and breccia.
	Jurassic	Probably corresponds to the Kootenay	Conglomerate with sandstone, shale, and seams of coal.
Palæozoic	Carboniferous(?)		Limestone, more or less dolomitic.
	Devonian (?)		Pyroxenite mainly—probably peridotite and related rocks also occur.
Pre-Cambrian (?)		Mt. Stevens group	Chiefly sericitic and chloritic schists, mashed basic to semi-basic volcanics, gneissoid quartzite, hornblende gneiss, and limestone.

Summary Description of Formations.

The oldest rocks known to occur in Wheaton district are included in the Mt. Stevens group, and are chiefly sericite and chlorite schists, mashed basic volcanics, gneissoid quartzites, hornblende-gneisses, and limestones. These occur in a number of localities, but in most places constitute only small isolated outcrops representing remnants of the roof of the Coast Range batholith, or inclusions in that igneous mass. In the eastern part of the district, however, one particularly extensive development of these rocks occurs, constituting a long, deep wall dividing subjacent portions of the granitic batholith; this wall has been cut by Wheaton

[1] The rocks of Wheaton district have been here somewhat differently subdivided and classed than in the writer's previous work to which reference has been made. This change has been found advisable after a number of years further geological study in Yukon—one of the chief reasons for the rearrangement being that by grouping the rock terranes as here shown, they may be much more readily correlated with the rock formations now known to occur elsewhere in Yukon as well as in northern British Columbia and Alaska.

river to a depth of nearly 3,000 feet, and it appears to persist to still greater depth. All the members of the Mt. Stevens group suffered prolonged dynamic metamorphism, were much disturbed, broken, contorted, and plicated, and were afterwards subjected to long periods of erosion, concerning which relatively little is known. They are thought to be, in all probability, of Pre-Cambrian age.

More recent than the members of the Mt. Stevens group are certain pyroxenites with which are probably associated peridotites and related rocks. Outcrops of the pyroxenites were seen only in one small area situated on the southern portion of Tally-Ho mountain, and at this point they cut the members of the Mt. Stevens group. No other definite information was obtained in the district concerning the age of these rocks, but from their lithological similarity to rocks in other portions of Yukon and in northern British Columbia, they are thought to be probably of about Devonian age. In the writer's former report on this district, these rocks were included in the Perkins group, a name the use of which it is now considered advisable to discontinue.

At a few points, mainly along the west face of Needle mountain, and on Idaho hill, small isolated masses of limestone occur, which rarely exceed 100 feet in thickness, and are merely detached blocks that have been carried upward by igneous masses mainly by the Mesozoic andesitic rocks or by the Coast Range intrusives. On the south face of Mt. Bush a fairly persistent bed of limestone, apparently about 6 feet in thickness, also occurs underlying the coal-bearing conglomerates. The isolated limestone masses, as well possibly as the bed on Mt. Bush, are thought to be probably of Carboniferous age. None of this limestone, however, is of any particular areal importance.

In Mesozoic times a considerable thickness of arenaceous and argillaceous sediments was deposited in this portion of Yukon. In Wheaton district these have been for the greater part removed by erosion, but in the northeast corner of the area they are in part still preserved, and have there an aggregate thickness of 5,000 to 6,000 feet. These sediments are divisible into two groups or formations—the Laberge series, and a conglomerate series which appears to correspond to the Kootenay. The Laberge beds consist mainly of argillites, metargillites, shales, and sandstones, with also some arkoses, greywackes, conglomerates, and breccias. A few indefinite or poorly preserved invertebrate fossil remains have been found in these beds, which have been considered to be of either Lower Cretaceous or Jurassic age. The conglomerate series which in places has a total thickness exceeding 1,000 feet, appears to underlie the Laberge beds, but of this no absolute proof could be obtained, owing to the greatly disturbed condition of these sediments. The conglomerate formation consists prevailingly of a fine to medium textured, dark, cherty conglomerate, with also some sandstones, shales, and seams of coal. Fossil plants were collected from these beds during the past summer, which have been determined by Dr. F. H. Knowlton of the United States Geological Survey, to be of Jurassic age. Dr. Knowlton also states that some of the species have been found in the Kootenay or at least have been reported from that formation. Since, therefore, these beds contain coal seams, and are lithologically very similar to the Kootenay members farther south, they would seem in all probability, to belong to that formation.

More recent than these sediments, there occurs an important group of volcanic rocks including mainly andesites, diabases, basalts, and related volcanics, with their associated tuffs and breccias, which have extensively invaded the older rocks of the district. This volcanic group appears to represent the same period of volcanic activity as the "Older Volcanics"[1] of Upper White River district, and other portions of Yukon and Alaska.

[1] Cairnes, D. D., "Upper White River district, Yukon"; Geol. Surv., Can., Memoir 50, 1915, pp. 87-93.

These volcanics are in turn cut by the Coast Range intrusives, which constitute much the most important and most extensively developed geological terrane in the district. These intrusives range in composition from granite to diorite or may be even more basic in character; they appear to be dominantly, however, of about the composition of granodiorite, and have everywhere a pronounced granitic habit. These rocks were first thought to be all of Jurassic age, and when working in Wheaton district in 1909, boulders of these intrusives were found in the lower conglomerate beds of the Laberge series. The intrusives were considered, therefore, to antedate these sediments in age. Since that time, further work in other portions of Yukon as well as in northern British Columbia, where contacts between the Coast Range intrusives and the members of the Laberge series are better exposed, has shown that the intrusives also cut the Mesozoic beds, and are partly older and partly younger than these sediments.[1] In fact recent studies of the Coast Range batholith in different districts, have shown that this terrane represents several intrusive periods ranging from some time in the Jurassic to well into Cretaceous time. This has given rise to considerable difficulty and complexity in connexion with geological work in the vicinity of the Coast Range batholith. In Wheaton district, it is now known that these rocks are dominantly at least or perhaps entirely, more recent than the Mesozoic sediments, and are probably all of Cretaceous age. In the writer's former work in this district, certain andesitic and related volcanics were known to be older than the Coast Range intrusives, and were consequently believed to be older than the Mesozoic sediments, and were included in the Perkins group. Other similar andesites and related volcanics were known to be more recent than the Laberge members and were grouped separately under the name Chieftain Hill volcanics. All these andesitic and related volcanics are now regarded as belonging to the same formation, as just described, and as shown in the above table of formations.

Cutting the Coast Range intrusives, there occurs an important group of volcanic rocks comprising mainly andesites, basalts, and related volcanics, including various types of dyke rocks, with their associated tuffs and breccias. These rocks are quite extensively developed in the extreme western portion of the district, and are everywhere quite recent in appearance—lava flows in which the flow structure is still very marked, and beds of tuff and ashes, constituting probably the most prominent members. These rocks correspond to the "Newer Volcanics" of Upper White River district,[2] and other portions of Yukon, and include the Carmack basalts. They are considered to be of Tertiary and probably of late Tertiary age.

Another important group of volcanic rocks, includes mainly rhyolites, granite-prophyries, and related rocks, which are the most recent consolidated rocks of the district, and are of late Tertiary or possibly even in part of early Pleistocene age. These volcanics do not generally cover any very large individual areas, but occur rather as dykes and similar intrusive bodies. Innumerable dykes occur cutting the Coast Range intrusives and other older rocks, and in certain localities so extensive has been the invasion of these volcanics that they appear to be almost as prominent as the invaded formations. In places these volcanics have quite a marked granitic habit, and might locally be termed porphyritic granites or, possibly, granites. In the writer's previous work on Wheaton district, these rocks were divided into two groups: one including the rhyolitic members which were termed the Wheaton River volcanics, and the other the granite-porphyries, which were named the Klusha intrusives. This subdivision has since been found to be somewhat impracticable, particularly in adjoining

[1] Cairnes, D. D., "Atlin Mining district, British Columbia"; Geol. Surv., Can., Memoir No. 37, 1913, p. 59.
[2] Cairnes, D. D., "Upper White River district, Yukon"; Geol. Surv., Can., Memoir 50, 1915, pp. 97-101.

districts where every transition occurs between these two lithological phases of apparently the same rock magma.

Overlying all the consolidated rock formations of the district are the Pleistocene and Recent accumulations which include mainly gravels, sands, clays, silts, soils, muck, volcanic ash, ground-ice, slide rock, and morainal materials. These accumulations not only deeply cover all the main valley bottoms of the district, but in addition extend over considerable portions of the upland as well as of the valley walls.

MINERAL RESOURCES.

General Statement.

The mineral resources of Wheaton district embrace, mainly, ore deposits of different kinds, but also include coal. The ore deposits are of four principal types, viz:

(a) Gold-silver veins.
(b) Antimony-silver veins.
(c) Silver-lead veins.
(d) Contact-metamorphic deposits.

Of these varieties the gold-silver and the antimony-silver veins are of the most importance. The silver-lead veins are quite limited in extent, and the contact-metamorphic deposits, so far discovered, are too low grade, and are insufficient in size to be of any present economic importance. Coal has been found only in one locality, on Mt. Bush, and has been only slightly prospected. All these mineral deposits are described in the writer's report[1] on Wheaton district, and in most cases will not require to be more than briefly mentioned. Detailed descriptions are given of the antimony deposits, and of certain of the other deposits on which important development work has been performed since the previous examination in 1909.

Gold-Silver Veins.

General Statement. Veins of the gold-silver variety constitute the most widely distributed type of ore-deposit found in Wheaton district. The more important of these veins that have been so far discovered, occur on Mt. Anderson, Mt. Stevens, Wheaton mountain, Gold hill, and along the south side of Watson river to the north of Hodnett mountain. On the various deposits occurring on Gold hill, Hodnett mountain, and to the north of Hodnett mountain along the south side of Watson river, no development work has been performed, except possibly a slight amount of representation work, since they were visited by the writer in 1909.[2] On the south side of Gold hill, near the head of Dail creek, a vein occurs which is typical of the veins in this locality, and has not been before described. This vein occurs in a fissure in the Coast Range granitic rocks, strikes about 8 degrees south of east,[3] and dips at angles of from 75 to 85 degrees to the south; and where exposed in Dail creek has a width of from 8 to 20 inches, and is at an elevation of about 4,800 feet above sea-level, or 2,100 feet above the mouth of Dail creek. The vein consists mainly of white quartz which is somewhat iron-stained, and in most places contains disseminated galena, and occasional particles of a black telluride which appears to be sylvanite. Three samples were taken from the vein. Nos. 1 and 2 are averages across the vein where it has thicknesses of 14 and 20 inches respectively. No. 3 is an average of a number of particularly well mineralized specimens. These samples upon being assayed, were found to contain:[4]

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[1] Cairnes, D. D., "Wheaton district, Yukon Territory"; Geol. Surv., Can., Memoir No. 31, 1912, pp. 85-146.
[2] Ibid, pp. 111-113.
[3] All bearings given in this report unless otherwise mentioned are astronomic or true. The magnetic declination throughout the district averages about 32° 30′ east.
[4] All the assays quoted in this report were made at the Government assay office at Whitehorse.

Sample No.	Gold		Silver		Total value per ton gold and silver
	Ozs. per ton	Value per ton	Ozs. per ton	Value per ton	
1	0·25	$5.00	0·75	$0.37	$5.37
2	0·11	2.20	1·99	0.99	3.19
3	1·51	30.20	15·74	7.87	38.07

On Mt. Stevens as well as on Wheaton mountain, a number of claims are still held, but practically no development work has been performed since 1909, except the relatively small amount required by law to hold the properties, and several claims have been crown granted. On the Buffalo Hump group[1] on Mt. Stevens, several tons of rich quartz were at one time discovered, which contained galena, native gold, and sylvanite. This quartz was at first thought by the owners to be in place, but subsequent development work showed it to be transported. Since this quartz occurred in such quantity near the summit of the mountain, and showed no evidence of having been moved any considerable distance, it would seem most probable that it would be found in place somewhere on Mt. Stevens. Other smaller pieces of rich quartz have also been discovered at other points on the mountain. An adit was driven 90 feet into the hill underneath the rich quartz, and some 30 feet of crosscuts or drifts were driven from the adit, in the hope of finding the vein from which the gold-telluride quartz was derived; but, apparently, no more of the rich ore was encountered. It has been claimed though, that a galena-bearing vein was crosscut by the adit; on each occasion when this property was visited by the writer, however, the adit was filled with ice and could not be examined. In addition to this work and a 20-foot shaft on the McDonald fraction on Wheaton mountain, the only development work that has been performed on Mt. Stevens and Wheaton mountain consists of a number of open-cuts, trenches, and shallow pits. All the veins that have been discovered seem to carry very low average values. Possibly the most promising vein on Wheaton mountain is that exposed on the McDonald fraction.[2] This vein was fairly well exposed in an open-cut and several average samples were taken from it. Approximate average samples were also taken from the dump at the 20-foot shaft on this claim. These samples all assayed less than $1 per ton in combined gold and silver.

The thickest, most persistent, and apparently the best mineralized vein exposed on the Buffalo Hump group, occurs on the Sunrise claim. This vein occurs in a fissure in the Coast Range granitic rocks, strikes south 45 degrees east, and dips at angles of 20 degrees to 35 degrees to the northeast. It is composed dominantly of quartz which contains occasional disseminated particles of galena and pyrite. Several average samples from this deposit where it is exposed at the surface, were assayed, and found to contain less than $1 per ton in combined gold and silver. High assay values have undoubtedly been at times obtained from the veins of this locality, but the values are very erratically distributed. The rich float, also, has been derived, in all probability, from high grade pockets in veins similar to those already found; in fact, it is more than probable that it came from some of the veins already known to occur on Mt. Stevens.

On the Tally-Ho group[3] on Tally-Ho mountain, an important vein occurs on which considerable underground development work has been done though practically only representation work has been performed since it was last examined.

[1] Ibid, p. 107.
[2] Ibid, p. 108.
[3] Ibid, pp. 108-110

On Mt. Anderson, on the east side of Becker creek, a number of claims are owned by Becker and Cochran, on which an important amount of development work has been recently performed—this being really the only vicinity in which there have been any important mining operations in connexion with veins of the gold-silver type, since the district was formerly examined.

Becker-Cochran Property. A number of mineral claims owned by Theodore Becker and Howard Cochran have been located on the west face of Mt. Anderson, about 2 miles south of Wheaton river, measured as the crow flies. These claims comprise the Whirlwind and Mountain Sheep groups which adjoin one another, and consist of 6 and 5 claims respectively, including the old "Rip" and "Wolf" claims.[1] What appear to be two main veins, and one or more others of less importance, have been discovered on these claims, all of which occur in fissures in the Coast Range granitic intrusives. The veins extend along the face of Mt. Anderson for a distance of 2,000 feet or more, and outcrop at elevations of from 4,600 to about 5,050 feet above sea-level, the elevation of Wheaton river at the mouth of Becker creek, being slightly over 2,800 feet above the level of the sea. The greater part of the development has been performed on the Whirlwind group on what is termed the "lower vein" which strikes about north 68 degrees west and dips to the northeast at angles ranging from 80 degrees to nearly vertical. The vein consists chiefly of quartz which is mineralized with argentiferous galena. A striking feature in connexion with this vein is that it has been invaded by a basalt dyke about 2 feet in thickness, which persistently accompanies it throughout its entire length as far as explored. This dyke in places occurs along the hanging wall, and at other points follows along the foot-wall, but generally occupies an intermediate position within the vein; in places also the dyke branches into two or more portions all of which may be included within the quartz. A drift known locally as "No. 2 tunnel," has been driven in on this vein about 350 feet, throughout which distance the quartz has a thickness in most places of from about 8 inches to 4 feet, and maintains a general average exceeding 18 inches. At the entrance to the drift, the quartz has a total thickness of 6 feet, the basalt dyke occurring within 12 inches of the hanging-wall. About 150 feet below this drift, a crosscut 172 feet long has been driven to the vein and a drift from the end of the crosscut follows the vein for about 150 feet. The crosscut and drift together are generally termed by the owners "No. 1" or "the lower tunnel." Throughout this lower drift, the quartz has a thickness of from 6 inches to 4 feet with an average of perhaps 18 to 20 inches.

Continuing to the southeast along the face of Mt. Anderson, vein outcrops have been exposed by a number of pits, small open-cuts, or trenches, for a distance of, possibly, 2,000 feet. These vein outcrops show the same characteristics as the lower vein just described, and are persistently accompanied by the same basalt dyke or by a very similar one. They may be portions of two or possibly three additional veins, or may be a southeasterly extension of the lower vein, that has been successively offset in an easterly direction, farther and farther into the mountain by transverse faulting. A surveyed plan of all vein outcrops gives support to this theory, showing as it does three fairly definite and distinct lines of outcrops, all with similar strikes, but swinging successively more to the east as the south is approached, and each line of outcrops commencing practically opposite the last outcrop of the next line of exposures. On the Mountain Sheep group, in the most southeasterly of the three lines of outcrops, there occurs an important exposure, designated by the owners, the "big showing." There the basalt dyke is somewhat complex or irregular in form, but the quartz has an aggregate thickness of from 3½ feet to 4½ feet, and is well mineralized. About 100

[1] Ibid., pp. 110-111

feet past this showing, an adit or crosscut was driven into the hill during the winter of 1914-15, in a direction at right angles to the general strike of the vein at the "big showing," but no evidence of the vein was encountered, although the adit was driven some distance past the point where it would have been crosscut had it continued this far in regular fashion. Since the vein had persisted so far, and was strong and well defined within 100 feet of this crosscut, it would appear most probable that it has been further offset by a fault similar to those already indicated. All the available evidence is, therefore, in favour of the fault theory, though its truth can be established only by further development.

The lower vein in the lower drift has been carefully sampled throughout by the owners, and is claimed by them to average $10.60 per ton in gold, silver, and lead, mainly in silver and lead, there being 8·26 per cent lead which was computed at 4 cents per pound. The total average values in the upper drift are slightly less than $10. The gold as a rule is quite low, but exceptional samples have been obtained that carried as much as 3 ounces per ton, and particularly well mineralized samples occasionally contain gold, silver, and lead to the value of $60 to $80 per ton.

Approximately 200 feet in elevation above the outcrop of the lower vein at the entrance to the upper drift, an "upper vein" outcrops, which strikes about due east, and has an almost vertical attitude. This vein consists dominantly of quartz which carries more or less disseminated galena and pyrite with their oxidation products including lead carbonate which is quite prominent near the surface. An adit 35 feet long has been driven in to crosscut this vein, and from the end of the adit a drift has been run along the vein for about 75 feet in a southerly direction. The vein as exposed in the roof of the drift has a thickness of from 4 to 20 inches; and average samples taken across the vein at close regular intervals are claimed to contain from $5 to $18 per ton in gold, silver, and lead.

The ore material from these veins could not be shipped at a profit, as taken from the mine. It is, however, well adapted to concentrating operations and could be concentrated at least 7 to 1. The veins outcrop on the steep western face of Mt. Anderson between 1,300 and 1,800 feet above Becker creek opposite; and this hill-side affords a good site for a mill to which the ore could readily be conveyed from the mine workings by tramways or shoots. Becker creek affords ample water for milling and power purposes, and there is sufficient timber for all ordinary mining requirements for years to come in the valleys of Becker creek and Wheaton river, within a reasonable distance. A government wagon road has been constructed from Robinson on the White Pass and Yukon railway up Wheaton river, and a branch from this road continues up Becker creek to a point immediately below the outcrops of the veins on this property, a distance from Robinson of 25 miles. The railway has recently contracted to haul ore from the Whitehorse Copper belt to Skagway for $1.10 per ton, and the Whitehorse Copper belt is about 30 miles farther from Skagway than Robinson. From Skagway to the Tacoma or some other coast smelter, the rate on ore is from $2.00 to $2.50 per ton, making a total from Robinson of probably between $3.00 and $3.50 per ton. Additional haulage charges would have to be added for transport by road over the 25 miles from the mine to Robinson.

Antimony-Silver Veins.

General Statement. All the deposits of antimony ores that have been discovered in Wheaton district are appropriately included under the term antimony-silver veins, and mostly all of them occur on the western or northwestern slope of Carbon hill facing Wheaton river. One important vein of this type, however, occurs at the head of a tributary of Becker creek on the eastern side of Carbon hill, and two or three others have been found on Chieftain hill and in that vicinity, across Wheaton valley from Carbon hill. Most of these deposits have been previously described,[1] but since this district was last investigated, considerable development work has been performed on Carbon hill, and the deposits there are much better understood than formerly. Also since the outbreak of the war, the demand for antimony has so increased that it is considered advisable to summarize the information concerning these deposits.

The antimony in the antimony-silver veins occurs dominantly in the form of stibnite (antimony sulphide), although some jamesonite (an antimony lead sulphide) is also found, These minerals are accompanied by galena, grey copper, zinc blende, and in some cases by arsenopyrite, which occur in a gangue composed mainly of quartz but including also some calcite and barite. Some of the veins contain important amounts of silver, but these are in most cases low in antimony, and, those high in antimony are as a rule low in silver. In a few places, however, both silver and antimony occur together in important amounts. The veins all occupy fissures in the containing rocks which are for the most part the Coast Range granitic intrusives. Occasional veins, however, are found in the Mesozoic andesitic rocks which are older than the Coast Range intrusives.

By far the greater number of the antimony-silver veins of Wheaton district, occur on the western face of Carbon hill, and of these nearly all are covered by a group of claims, that is here designated the Fleming property. A few other veins have been located on this slope of Carbon hill. The deposit on the east side of Carbon hill occurs on a claim owned by Messrs. Becker and Cochran, which is here termed the Becker-Cochran property. The deposits occurring on Chieftain hill and in that vicinity will be here so designated.

Chieftain Hill and Vicinity. The only vein of any importance that is known to have been found on Chieftain hill, is exposed in a prominent draw on the eastern face of the mountain, about halfway to the summit. Two claims named respectively the Morning and Evening claims were formerly located on this deposit,[2] but these have lapsed, and other locations have been made. Some development work was at one time performed on this vein, but when visited this past summer (1915), the cuts or trenches had so caved in as to completely obscure the outcrop. The vein occurs in a fissure in andesitic rocks, strikes about due west, and has a nearly perpendicular attitude. The deposit also consists chiefly of quartz which is in places well mineralized with stibnite, and carries also subordinate amounts of zinc blende. At one point the vein is 5 feet in thickness, 2 feet of which appears to be composed almost entirely of stibnite. The vein, however, narrows rapidly in each direction from this point.

An important vein carrying antimony minerals is reported to have been recently discovered on Berney creek, a short distance to the southwest of Chieftain hill, but this was not seen by the writer.

Fleming Property. A group of six mineral claims situated on the western or northwestern face of Carbon hill, is owned by Mr. W. J. Fleming of Chicago, who also holds a timber tract of 160 acres at the base of the hill below these claims. This group includes the claims formerly described as the Porter group.[3]

Quite a number of veins have been discovered on this property, possibly between 15 and 20, the exact number being uncertain, due to the fact that in some cases insufficient development has been performed to make correlations sure, so that certain outcrops may belong to the same or different veins. The greater number of these veins occur in the Coast Range granitic intrusives, but a few are found in the Mesozoic andesitic rocks. The development includes not

[1] Cairnes, D. D., "Wheaton district, Yukon Territory"; Geol. Surv., Can., Memoir No. 31, 1912, pp. 113-129.
[2] Ibid, p. 129.
[3] Ibid, pp. 126-128.

only a considerable amount of systematic surface work, but also about 1,100 feet of underground crosscuts and drifts. The veins range in thickness, in most places, from a few inches to 3 feet, although for short distances, some may be more than 3 feet thick, but even 2 feet is somewhat exceptional. The vein material, in places, contains as much as 50 per cent antimony, but average samples across the veins rarely carry more than 20 to 25 per cent, and in most cases contain less than 20 per cent. The gold content is prevailingly small in amount, rarely exceeding $2 per ton, and being generally less than $1. The silver and lead values are, however, quite important. Average samples across the veins contain occasionally 50 ounces or more of silver to the ton, but from 15 to 30 ounces is more representative of the richer silver veins, and in most places the average silver content ranges from a trace to 5 ounces. The lead in average samples rarely occurs in greater amounts than from 7 to 15 per cent, and in most cases under 5 per cent, and often under 1 per cent. The combined values in gold, silver, and lead, amount in rare instances to $50 or more per ton, but from $10 to $20 is rather exceptional, and by far the greater number of average samples that have been taken from most of the veins run less than $5 per ton. The samples taken from one or two of the best veins such as the "big vein," however, average approximately $10 per ton in gold, silver, and lead, *i.e.* without allowing for the antimony. These results are computed as the result of the assaying of upward of 300 samples by the Department of Mines, Ottawa, by the government assayer at Whitehorse, and by others.

Other Veins on the West Slope of Carbon Hill. The only other veins of any importance that are known to have been found on the west slope of Carbon hill, are the two parallel veins referred to in the writer's previous report as occurring on "Goddell's claims."[1] These veins occur about one mile to the north of the Fleming group, and are not more than 20 or 30 feet apart. They outcrop in a gulch and are distinctly exposed to view, extending up the mountain side for a distance of over 2,000 feet. They occur in the Coast Range granitic rocks, strike south 83 degrees west, and have an almost perpendicular attitude. The veins are 2 feet, and 2 feet 6 inches thick respectively, and consist chiefly of quartz which carries a certain amount of jamesonite and arsenopyrite, the antimony content being very low.

Becker-Cochran Property. A vein outcrop containing considerable stibnite is located on a claim owned by Theodore Becker and Howard Cochran, which is situated on the east side of Carbon hill, at an elevation of about 4,950 feet above the sea. This outcrop occurs near the head of a small northerly tributary of a creek locally known as Conglomerate creek which joins Becker creek from the west about 3 miles above its mouth. The vein is here possibly about 3 to 4 feet in thickness, but as it had not been stripped when visited and as the only work that had been performed had caved in, very little definite information was available. A number of large pieces of vein material from 1 foot to 2½ feet in thickness were scattered along the outcrop of the vein, some of which appeared to be composed almost entirely of stibnite, and all contained considerable of this mineral. Two samples were taken from these masses or vein fragments. No. 1 is intended as an average of all the vein material in sight. No. 2 is an average of all the better mineralized pieces. These samples were assayed and found to contain:

Sample No.	Gold	Silver	Antimony
1	Trace	Trace	21·20%
2	Trace	Trace	40·62%

[1] Ibid, pp. 128, 129.

Conclusions. At present exceptionally high prices are being paid for antimony minerals, also the White Pass and Yukon Railway Company is now offering very low rates on ore shipments to Skagway to encourage the lode mining industry of Yukon. The antimony-silver ore would of necessity have to be sorted or concentrated before shipping, but in places limited amounts of shipping ore could be obtained by merely hand sorting. For any considerable tonnage, however, the ores would require to be concentrated. On Carbon hill very favourable natural facilities are provided for the erection of a concentrating mill, and a government wagon road has been constructed from Robinson to Carbon hill a distance of 30 miles, with a down grade all the way to the railway. It would thus seem practically certain that some of these veins could now be worked at a profit, particularly if a concentrator were erected in the near vicinity; and it is hoped these deposits will become producers in the near future.

Silver-Lead Veins.

Veins of the silver-lead type are limited in their occurrence in Wheaton district, so far as is known, to one small area situated on the east slope of Idaho hill, facing Annie lake. These veins were formerly all located and covered by two groups of claims known as the "Union Mines" and "Nevada Mines." Practically no work has been performed on these deposits since they were last examined so the reader is referred to the writer's former report[1] for descriptions of these deposits. There is undoubtedly a certain amount of fairly good ore contained in these veins, but it is doubtful if any of it is sufficiently high grade to pay for mining, shipping, and treatment, without concentration before shipment, and the veins do not appear to be sufficiently extensive or persistent to warrant the erection of a concentrating mill in their vicinity.

Coal.

The only locality in Wheaton district in which coal has been found is on Mt. Bush. There, several seams of semi-anthracite have been discovered, ranging from 18 inches to 6 feet or more in thickness. These seams have been very slightly explored or investigated, and little is known concerning them. They are, however, known to be considerably disturbed by basaltic dykes, several of which intersect them; this might nevertheless not seriously interfere with the economic working of these deposits which should be of value for local consumption, when the demand arises. For further details concerning these coal measures, the reader is referred to the writer's previous report.[2]

[1] Ibid, pp. 129-139.
[2] Ibid, pp. 145-147.

HYDROMAGNESITE DEPOSITS OF ATLIN, B.C.

(*G. A. Young.*)

INTRODUCTION.

During August, 1915, a brief visit was paid to Atlin, in northern British Columbia, for the purpose of examining certain deposits of hydromagnesite occurring in the vicinity and which previously had been referred to by Gwillim.[1] Analyses of waters from neighbouring springs and notes on the hydromagnesite have been furnished by Hoffmann.[2] The deposits have also been described by Robertson.[3] Though the existence of the deposits has been known for a considerable number of years and although they are generally credited with being remarkably pure and outcrop at the surface without any overburden, yet they have remained practically unworked. In 1904, it is reported,[4] that approximately 200 tons of the material was shipped to San Francisco. It is understood, also, that a certain amount was sent to England. During the past season (1915), a trial shipment of above 500 tons was made to Vancouver, B.C., by the firm of Armstrong, Morrison, and Company of Vancouver. The writer is indebted to Mr. Armstrong for his assistance while examining the deposits.

The influences which have retarded the commercial development of the deposits are, doubtless, their remote situation and the consequent relatively high transportation and working charges which would have to be met. The district is easily accessible, however, by way of the White Pass and Yukon railway from Skagway, Alaska, to Carcross, Yukon Territory, and thence by a bi-weekly boat service on Tagish and Atlin lakes, maintained by the same corporation during the season of navigation. The hydromagnesite deposits are situated close to Atlin, the terminus of the boat service; one group of deposits lying on the southeast border of the town site while the other group occurs on the highway leading to Discovery and is distant only about half a mile from Atlin wharf. Besides these two main groups of deposits, the mineral, as stated by Gwillim, also occurs here and there in small patches over a distance of about 2 miles along a general course running northeastward from the lake shore at Atlin. These smaller, isolated patches, so far as seen, appear to be too small in extent, or too shallow or too impure to be of any commercial value.

DESCRIPTION OF THE DEPOSITS.

As a reference to the accompanying figure (page 51) will indicate, the more important hydromagnesite deposits form two groups. It is proposed to first describe the group situated about one-half mile from Atlin wharf and from which Messrs. Armstrong, Morrison, and Company made a considerable shipment in 1915. These deposits lie in a rather faintly marked depression opening, to the northwestward, into a swampy area. No solid rocks outcrop nearby, the country being floored by very thick deposits of coarse and fine unconsolidated materials. The group consists of one large and four small areas or beds. The surface of the

[1] Gwillim, J. C.: G.S.C., Summary Report for 1899, p. 72, 1900; G.S.C., Summary Report for 1900, p. 62, 1901; G.S.C., Report on Atlin mining district, British Columbia, pp. 47-48, 1901.

[2] Hoffmann, G. C.; G.S.C., Report of the section of chemistry and mineralogy (part R, Ann. Rept., vol. XI), pp. 10-12, 1900. G.S.C., Report of the section of chemistry and mineralogy (part R, Ann. Rept., vol. XIII), pp. 47-51, 1903.

[3] Robertson, W. F., Report of the Minister of Mines (B.C.) for 1904, pp. 82-83, 1905.

[4] Robertson, W. F., idem.

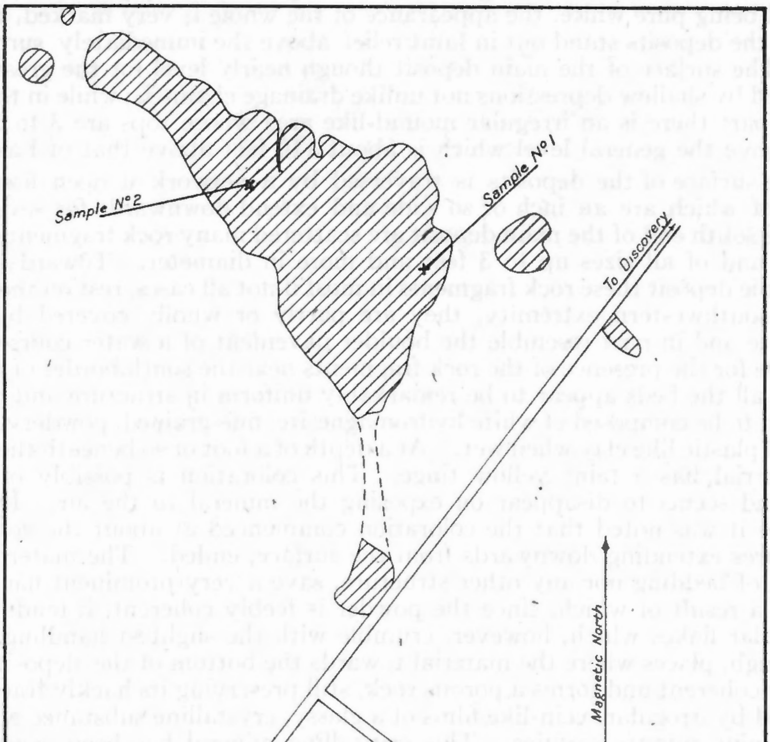

Figure 3. Atlin hydromagnesite deposits.

deposits is almost barren of vegetation, the edges are sharply defined, and, the material being pure white, the appearance of the whole is very marked, the more so since the deposits stand out in faint relief above the immediately surrounding land. The surface of the main deposit though nearly level for the greater part, is marked by shallow depressions not unlike drainage channels; while in the north-eastern part there is an irregular mound-like area whose tops are 3 to 5 feet or more above the general level which is about 110 feet above that of Lake Atlin.

The surface of the deposits is traversed by a network of open fissures, the largest of which are an inch or so wide and extend downwards for several feet. Over the south end of the main deposit are scattered many rock fragments, mostly angular and of all sizes up to 3 feet and more in diameter. Towards the east edge of the deposit these rock fragments in most if not all cases, rest on the surface. At the southwestern extremity, they are partly or wholly covered by hydromagnesite and in part resemble the boulder pavement of a water course.

Save for the presence of the rock fragments near the south border of the main deposit, all the beds appear to be remarkably uniform in structure and composition, and to be composed of white hydromagnesite, fine-grained, powdery, without grit, and plastic like clay when wet. At a depth of a foot or so beneath the surface, the material has a faint yellow tinge. This coloration is possibly of organic origin and seems to disappear on exposing the mineral to the air. In several instances it was noted that the coloration commenced at about the zone where the fissures extending downwards from the surface, ended. The material shows no signs of bedding nor any other structure, save a very prominent hackly fracture, as a result of which, since the powder is feebly coherent, it tends to break in irregular flakes which, however, crumble with the slightest handling. There are, though, places where the material towards the bottom of the deposit is more strongly coherent and forms a porous rock, still preserving its hackly fracture and traversed by irregular, vein-like films of a glassy, crystalline substance which also occurs lining minute cavities. This crystalline mineral has been examined by Mr. R. A. A. Johnston who suggests that it is a basic hydrous magnesium carbonate. The surface and upper parts of the deposit are usually dry and powdery. The lower parts are sometimes quite dry, also, but in many places the basal portion is wet and sticky. On exposure to the air, the excess moisture rather rapidly disappears.

The base of the deposits both along the edge and wherever penetrated within their borders, is sharply defined. There is no distinctly apparent variation of the hydromagnesite with depth nor is there any visible evidence of a transition to the underlying material which, wherever examined, consists of a clay-like soil either without grit or gritty from the presence of what appears to be very small rock fragments.

In the large, main deposit of this group, thirty-one pits and bore-holes were sunk and in nearly every case passed through the base of the deposit. They indicated that the main deposit varied in thickness from 6 feet to a little more than 1 foot except at the very edge of the bed, while even within distances of 10 to 50 feet from the margin, depths of $1\frac{1}{2}$ to 2 feet were found in various instances. The observed thicknesses varied, within the above-mentioned limits, rather rapidly from point to point; a considerable part of this variation is only an expression of the present differential relief of the deposit, and the general impression was obtained that if the hydromagnesite body were stripped away, a shallow, smoothly contoured, saucer-shaped depression or series of depressions, would be revealed.

From the various determinations of the depth of the main body, it would appear that the average thickness of the hydromagnesite is in the neighbourhood of 2 feet 8 inches; its area is very close to 18 acres. The volume of the hydromagnesite would be, therefore, about 80,000 cubic yards. If it be assumed that the material weighs 115 pounds per cubic foot, the quantity available in the main body is about 125,000 tons. The nearby small areas cannot contain much of the mineral; their aggregate area is about 2 acres and the depth of the material varies from 1 foot to 2½ feet; perhaps in all they contain about 9,000 tons.

Two sets of samples were taken from the main body and these were analysed by Mr. N. L. Turner of the Mines Branch; the results of the analyses are tabulated below. Samples 1A, 1B, and 1C were taken from a pit in the southeastern part of the main body where the total depth of hydromagnesite is 2 feet 2 inches; sample 1A was taken at a depth of 3 inches, sample 1B at a depth of 1 foot 1 inch, sample 1C at a depth of 1 foot 11 inches or 3 inches above the base. Samples 2A, 2B, and 2C were taken from a pit in the northern part of the main body towards the middle of the deposit and about 800 feet from the north end. At this place the hydromagnesite is 3 feet 6 inches thick; sample 2A was taken at a depth of 4 inches, sample 2B at a depth of 16½ inches, and sample 2C at a depth of 2 feet 4 inches or 9 inches above the base. Samples 2A and 2B were pure white and this material extended to a depth of about 21 inches where there was a rather quick change to a faintly yellowish material of a comparatively coarsely granular texture. Sample 2C is of this faintly yellow material taken from a depth of 7 inches below its upper limit.

Analyses Made on Material Dried at 105° C.

	1A	1B	1C	2A	2B	2C
SiO_2	1·86	0·90	0·54	1·22	1·96	9·22
Al_2O_3	0·67	0·10	0·17	0·67	0·14	0·94
Fe_2O_3	0·15	0·09	0·11	0·18	0·45	0·73
FeO	0·60	0·45	0·64	0·63	0·65	0·78
CaO	2·04	0·82	0·68	1·26	1·50	6·44
MgO	41·13	42·35	42·19	40·56	41·93	35·23
CO_2	35·98	36·10	36·17	35·96	36·04	37·70
H_2O (combined)	18·02	18·95	19·05	19·04	17·66	8·20
	100·45	99·76	99·55	99·52	100·33	99·24
Hygroscopic water; loss at 105°C	1·92	1·61	1·35	1·45	1·31	2·64

The second group of deposits is situated just east of Atlin and lies in marked depressions formed in unconsolidated materials. This group consists of three large bodies of hydromagnesite, two of which lie in a shallow valley extending in a northwest-southeast direction. The southwest side of this valley is broken, just at the northwest end of the northwestern hydromagnesite body, to form a connexion with a second valley running south to Atlin lake. The third deposit lies in this second valley. Both valleys are depressed 30 to 75 feet below the surrounding country.

The two beds of hydromagnesite in the valley trending northwest-southeast, appear to have formerly been connected and are now separated by an area partly occupied by isolated mounds of hydromagnesite. The mineral also occurs over part of the valley floor intermixed with earthy material or lying between large and small rock fragments. The third body of hydromagnesite, lying in the southerly trending valley, appears also to have occupied, at one time, a larger area and outlying bodies of the mineral occur in this valley also. On the accompanying figure the approximate limits of the areas supposed to have formerly been occupied by the deposits, are indicated by broken lines.

The surfaces of all three bodies are comparatively irregular and these irregularities are all interpreted as being due to erosion. On the whole the deposits are wetter than those of the first group already described, but otherwise the deposits of the two groups appeared identical.

The southeastern deposit lying in the northwest-southeast valley, has an area of about 4½ acres. Nine bore-holes sunk in it reveal a thickness varying between 1 foot and 5 feet. The average thickness may be assumed to be about 3 feet. On this basis, the volume would be about 21,400 cubic yards and the quantity about 33,000 tons. Two samples for analyses were taken from this body and the results of the analyses, as obtained by Mr. N. L. Turner, are given below. Sample 3 was taken at a depth of 1 foot 9 inches from the centre of the bed; sample 4 was taken at a depth of 1 foot 4 inches from a locality distant 100 feet from locality 3 and 25 feet from the east border of the bed. At both places the total thickness was about 3 feet.

Analyses Made on Material Dried at 105° C.

	3	4
SiO_2	0·74	3·48
Al_2O_3	0·35	2·85
Fe_2O_3	0·15	0·56
FeO	0·66	0·81
CaO	0·32	0·42
MgO	42·85	38·94
CO_2	36·35	34·31
H_2O (combined)	19·10	18·10
	100·52	99·47
Hygroscopic water; loss at 105°C	1·21	1·18

The northwestern deposit lying in the same valley as the deposit just described has an area of about three-quarters of an acre. Four bore-holes gave thicknesses varying from 3 feet to nearly 7 feet. The average thickness of hydromagnesite may be assumed to be 5 feet, indicating a volume of about 5,500 cubic yards or 8,600 tons. Two samples were taken from this bed. One, number 5, was taken from the northeast corner of the deposit and close to the edge; the hydromagnesite here had a depth of 5 feet 8 inches and the sample was taken from a depth of 1½ feet, the material being partly granular, partly sticky, clay-like with a few hard pieces of the size of a walnut and smaller. Sample number 6 was taken from the surface about midway along the eastern border where the depth of the deposit is over 6 feet. The results of the analyses of these two samples, as obtained by Mr. N. L. Turner, are as follows:

Analyses Made on Material Dried at 105° C.

	5	6
SiO_2	0·96	0·62
Al_2O_3	0·23	0·41
Fe_2O_3	0·12	0·09
FeO	0·53	0·36
CaO	0·16	0·26
MgO	43·04	43·45
CO_2	36.21	36·23
H_2O (combined)	19·26	18·95
	100·51	100·37
Hygroscopic water; loss at 105°C	9·34	1·21

The third body of hydromagnesite lies in the southerly trending valley and has an area of about 1 acre. Five bore-holes gave thicknesses varying between 1 foot and 3 feet. The average thickness may be assumed as being 2 feet and it follows that the volume present is about 2,900 cubic yards or about 4,500 tons. From the southern portion of this bed, where the material was about 2 feet thick, a sample, number 7, was obtained of the compacted material traversed by films of basic hydrous magnesium carbonate. This material came from a layer about 4 inches above the base of the deposit; on analysis it yielded the following results to Mr. N. L. Turner:

Analysis Made on Material Dried at 105° C.

	7
SiO_2	1·18
Al_2O_3	0·33
Fe_2O_3	0·10
FeO	0·71
CaO	0·48
MgO	42·12
CO_2	35·89
H_2O (combined)	19·42
	100·23
Hygroscopic water; loss at 105°C	21·77

In the two groups of deposits there is present, in round numbers, about 180,000 tons of hydromagnesite in the form of beds seldom more than 5 feet or less than 1 foot thick. The material is exposed directly at the surface without any overburden. Though in places saturated with water, yet the deposits are so situated that a relatively slight amount of trenching would suffice to drain the beds. The boundaries of the deposits are distinctly marked. There appears to be nothing to prevent the deposits being worked in a simple and, at the same time, efficient fashion.

To show the essential features in the variation of the composition of the material as indicated by the available eleven analyses, the results obtained by these analyses may be tabulated as follows.

	1A	1B	1C	2A	2B	2C	3	4	5	6	7
MgO	41·13	42·35	42·19	40·56	41·93	35·23	42·85	38·94	43·04	43·45	42·12
CaO	2·04	0·82	0·68	1·26	1·50	6·44	0·32	0·42	0·16	0·26	0·48
Fe_2O_3, Al_2O_3, and FeO	1·42	0·64	0·92	1·48	1·24	2·45	1·16	4·22	0·88	0·86	1·14
SiO_2	1·86	0·90	0·54	1·22	1·96	9·22	0·74	3·48	0·96	0·62	1·18

In inspecting these figures, it should be remembered that samples 1A, 1B, and 1C were taken from different depths in one pit; similarly samples 2A, 2B, and 2C were taken from different depths in another pit. Of these eleven analyses only numbers 2C and 4 indicate any marked divergence in composition.

Sample 2C, as already stated, was taken from the lower part of the deposit as exposed in a pit and was faintly discoloured and otherwise sharply marked off from the overlying white material of which 2A and 2B represent samples. Sample number 4 was taken at a distance of 25 feet from the edge of one of the bodies; as far as physical appearances indicated there was nothing to lead one to believe that this sample would differ in composition from any of the other samples. In working the deposits it would be easy to leave untouched material of lower grade such as that represented by sample 2C, but the inclusion of material such as that represented by sample number 4 could be avoided only by careful sampling prior to mining since there did not appear to be any physical characters that could be used as a guide.

To the writer it appears that if the deposits are to be worked so as to produce a relatively high and uniform grade of material, it will be necessary in the case of each deposit to carefully sample the material both horizontally and vertically. The information gained from the analyses of such samples should indicate the lateral and vertical limits to which various "blocks" could be worked with the expectation of obtaining a product carrying between 41 per cent and 42 per cent MgO with about 3 per cent of CaO, Fe_2O_3, Al_2O_3, and SiO_2. Of such material it is thought that at least 150,000 tons are present, but no truly satisfactory estimate of the amount of the relatively high grade material can be made except with the aid of many more analyses.

ORIGIN.

The analyses quoted in the foregoing section, indicate that the material of the deposits is now very largely a hydrous magnesium carbonate, presumably hydromagnesite; but the material represented by analysis number 7 was in a fairly compact form traversed by films of a glassy mineral, probably a basic hydrous magnesium carbonate. It is possible that the large amount (19·42 per cent) of hygroscopic water reported by the analyst may be mostly loosely combined water, and the consolidated material might, therefore, be quite largely composed of basic carbonate. Similar consolidated material was obtained at several localities and indications of its existence seen elsewhere. Whether the consolidated phase is secondary to the loosely coherent phase, or the reverse, is unknown. No evidence was secured that would indicate whether the materials of the deposit are still essentially similar in physical and chemical composition to their original conditions, or have been radically metamorphosed.

In the north outskirts of Atlin, a low, ill-drained depression slopes down to the lake shore. At this place, occurs a patch of hydromagnesite mixed with soil and vegetable matter. The material lies on a slope and possibly has been transported or reworked by surface waters. At this locality occurs a spring which ...."is surrounded by a deposit of hydromagnesite, with some iron oxide cementing this material...... It is more than probable that it is to the water of this and similar springs......that the deposits of hydromagnesite, occurring near Atlin town site, owe their origin...... These are quite dry during the summer season, but in spring, it is said, springs issue all along this course."[1]

Hoffmann[2] furnishes an analysis of this spring water which is reported as having a temperature of 33 degrees F. at its point of issue. Hoffmann states that ......"conformably with the results of an analysis by Mr. F. G. Wait, 1,000 parts, by weight, of this water, at 15·5° C. contained:

[1] Gwillim, J. C.: G.S.C., Report on Atlin mining district, pp. 45-46, 1901.
[2] Hoffmann, G. C.,: G.S.C. Report of the section of chemistry and mineralogy; Ann. Report, Vol. XIII, part R, pp. 47-51, 1903.

Potassa	0·0145
Soda	0·0796
Lime	0·1635
Magnesia	1·9204
Alumina	0·0065
Ferrous oxide	0·0087
Sulphuric anhydride	0·0501
Phosphoric anhydride	trace
Boric anhydride	trace
Carbonic anhydride	5·9360
Chlorine	0·0015
Silica	0·0825
Organic matter	trace
	8·2633
Less oxygen, equivalent to chlorine	0·0003
	8·2630

Hoffmann states that the collector of the sample of the spring water, Mr. Pender, made a cutting about 6 feet deep in the deposit close to where the spring issues, and forwarded to him samples of the various materials found. From this information, Hoffmann determined that the uppermost layer, 18 to 24 inches thick, consisted of greyish-white hydromagnesite; below this lay a thin stratum of greyish, somewhat magnesian, calcareous tufa; below this, about 3 inches of brown, ferruginous, calcareous tufa; below this, a thin layer of yellowish, slightly magnesian, calcareous tufa; below this 3 or 4 feet of brownish-red, ferruginous somewhat magnesian, calcareous tufa extending as deep as the cutting was made.

Hoffmann writes in conclusion..... "There can, I think, be little doubt but that all these deposits of hydromagnesite occurring at the back of Atlin town site, owe their origin to the water of springs of very similar, if not precisely the same composition, as that of which the analysis is given above".......

Robertson examined the hydromagnesite deposits in 1904, and the following is based on his account.[1] To the east of Atlin town site there....."is a depression..... in places showing 'hummocks' of white magnesite which seem to be 'growing up' from the swampy level, for certainly these deposits are constantly rising higher and higher and now form mounds 5 to 8 feet above the swampy level.... This deposit was at first considered to be simply an accumulation of magnesite formed from the decomposition of the surrounding rocks and deposited by surface waters in the swamps. If such was its origin it seems incredible that the deposit should be so free from clay and other materials equally portable, by water, and that it should be deposited in mounds above the water level" ..... Robertson concluded that the hydromagnesite is forming from magnesia-rich rocks immediately underlying the hydromagnesite beds and that in the change to hydromagnesite there is an increase in bulk, thus giving rise to the appearance of "growing upwards" presented by the materials.

There seem to be valid objections to the two modes of origin suggested respectively by Robertson, and by Gwillim and Hoffmann. As Hoffmann describes it, the spring deposit in the north part of Atlin is tufa-like and composed of alternating layers of markedly varying compositions, some of them being only slightly magnesian. On the other hand, the hydromagnesite beds are practically of uniform composition and structureless. They present none of the phenomena usually found to be characteristic of deposits from springs. If the hydromagnesite beds were formed by springs it would appear that the present hydromagnesite beds are a very highly modified form or residuum of the original deposits and have lost all their original structure.

[1] Robertson, W. F.: Report of the Minister of Mines (B.C.) for 1904, pp. 82-83, 1905.

Gwillim states that it was reported to him that in the spring of the year, springs issued along the line of the hydromagnesite beds. So far as the present writer could learn it would seem quite probable that after a wet interval these fissured and semi-porous deposits would be heavily charged with water which might, in part, escape after the manner of springs. To a superficial observer it might appear at such times as though deep-seated springs were affording the water draining from the beds and, perhaps, it was on such appearance that Gwillim's informants based their statements.

Robertson's conception that the deposits have formed from immediately underlying bodies of magnesite or magnesia-rich rocks, seems based very largely on the fact that the deposits now stand out in relief and that, as he also mentions, excavations in the beds are quickly filled up again. But there are no exposures of solid rock in the immediate vicinity, and the results obtained from over fifty-five bore-holes uniformly indicate that the deposits rest on soil. Neither was any satisfactory evidence secured of present growth of the beds. It was noted that comparatively recent excavations were largely filled in again, but it seemed very evident that this filling in process was due to a gradual infalling of the walls and of material from the surface of the surrounding bed. The fact that the deposits now stand out in relief clearly seems due to differential erosion, for the hydromagnesite is sticky when wet and less easily eroded than the bordering soils and unconsolidated materials. The deposits seem to be decreasing, not growing in size.

Robertson argues that the hydromagnesite beds cannot represent stream-borne materials laid down in swampy ponds, since the deposits are free from interbedded clays, sands, etc., such as would be also transported by streams. This conclusion seems well established, but nevertheless it appears to the present writer that the deposits may have originated in ponds lying in swampy areas. Of interest in this connexion are the following statements made by Hoffmann[1] regarding a deposit of hydromagnesite........"met with .....in the immediate vicinity of the 108-mile House on the Cariboo road, ninety-three miles north of Ashcroft, Lillooet district, in the province of British Columbia, where it forms three or four deposits of from fifty to one hundred feet across, standing a foot or more above the level of the surrounding surface......A shaft......passed through first, close upon five feet of the pure white material; then, a layer of about six inches of the same of a somewhat yellowish colour; then, another layer of some three feet of the pure white material; then, another layer of about eighteen inches of the yellowish coloured material; then, another, apparently thin, layer of the pure white material; finally reaching, what evidently constitutes the bed of the deposit, a dark coloured mud containing a few more or less well preserved shells......"

The point of immediate interest in the above description of the Lillooet deposit is the presence of shells in the mud forming the floor of the deposit; their existence strongly suggests that the deposit was laid down in a pond. At Atlin no shells were anywhere observed in the basement material, but the soil bordering and underlying the beds was not unlike what might be expected to occur about the edges and over the bottoms of ponds. The outlines of the deposits, their saucer-shaped cross sections, their topographical situation in depressions even now holding ponds, and the lack of any of the structures commonly associated with spring deposits, all seem indicative of an origin in ponds. Presumably then as now the ponds in the swamps received their waters by underground ways, except perhaps in the spring of the year or at other times of excessive

[1] Hoffmann, G. C.: G.S.C., Report of the section of chemistry and mineralogy; Ann. Rept. part R, vol. XI, pp. 10-11, 1900.

precipitation. Under conditions such as these, little or no stream-borne detrital matter would find its way to the ponds.

The hydromagnesite beds lie in depressions excavated in unconsolidated materials and are situated on the north side of the wide valley of Pine creek extending easterly from Lake Atlin. Much of Pine Creek valley is occupied by unconsolidated materials: gravels, sands, clays, and boulder clays. In places these deposits are 200 feet or more deep and effectually conceal bedrock. Terraces are frequent up to heights of about 600 feet above Lake Atlin.[1]

The hydromagnesite deposits occur on the north side of the valley, near its mouth and not far from the north-bounding ridge which here is comparatively low. Along the foot of the north ridge in this general neighbourhood there is a narrow stretch of imperfectly drained, in part swampy land. A short distance away from this swampy area, the valley bottom extends as a broad flat a mile or so wide dropping in several terraced steps to where Pine creek flows through it along a deep-cut channel. Towards the lake front, in the immediate vicinity of the chief bodies of hydromagnesite, the features of the terraces are largely destroyed and the land slopes irregularly downwards to the lake level. Over a very considerable area of 5 or 6 square miles in the general vicinity, there are no permanent streams. A few comparatively well-defined stream courses are present, but they are quite dry in summer and the normal drainage appears to be altogether effected underground.

The hydromagnesite deposits lie on the surfaces of the unconsolidated materials described as flooring so much of Pine Creek valley. The main deposit of the group described first on the preceding pages, lies about one-half mile east of Atlin lake. About 100 yards southeast of this bed, there is an abrupt rise of about 40 feet to a broad level area, presumably part of a terrace, and having an elevation of about 160 feet above Lake Atlin. About one-third mile eastward, there is a very small body of hydromagnesite lying in a very faintly marked depression in the terrace floor. Northeastward from here, along a general course leading up to Lake Como, a couple of miles distant and about 700 feet above Atlin lake, are several small patches of white, powdery material, presumably hydromagnesite, occurring in swampy depressions between low hills.

The north end of the main body of the first described group of hydromagnesite deposits, lies on the edge of the swampy area previously mentioned as occurring along the foot of the ridge bounding Pine valley on its north side. Within this swampy area and less than 200 feet away from the large hydromagnesite bed, there is a circular area about 140 feet in diameter, of a white powdery mineral here about 1¾ feet thick. Considerably decayed vegetable matter lies on and near the surface and it is evident that normally this patch is covered with water, the past season of 1915 having been a very dry one. Several hundred yards distant from this place, well within the swampy area, there is a pond about 100 yards long. This pond when seen in August, 1915, had shrunk sufficiently to lay bare a wide margin of its bed and this is floored with what at the time of examination was thought to be hydromagnesite mixed with vegetable matter and shells. The depth of the material could not be ascertained, but was at least one foot. On the bottom of the part of the pond still occupied by water, could be observed a white substance, in large flake-like masses. The following are the results of an analysis made by Mr. N. L. Turner, of a sample of the material from the borders of the bed of the pond.

[1] Gwillim, J. C.: Idem, pp. 11, 14, 32, 38.

Analyses Made on Material Dried at 105° C.

SiO_2	0·98
Al_2O_3	0·04
Fe_2O_3	0·03
FeO	0·07
CaO	48·84
MgO	2·52
CO_2	41·15
H_2O (combined)	6·01
	99·64
Hygroscopic water; loss at 105°C.	2·52

The material as collected, save for a few large shell fragments, is exceedingly finely granular and under the microscope yielded no indication of an organic origin. Presumably, however, it should be classed as a marl.

Assuming that the hydromagnesite deposits did originate in ponds in swampy areas there remains for consideration the question as to how the mineral came to be deposited there. It would appear that there is little or no published, pertinent information regarding the chemical and physical conditions governing the formation of normal and basic magnesium carbonates. Lacking such data, it may be supposed that waters bearing magnesium carbonate in solution and in excess over any other accompanying dissolved salts, found their way, chiefly by underground means, into ponds in swampy areas. During annually recurring dry seasons, the loss of water by evaporation would exceed the amount inflowing, and the pond water becoming supersaturated, hydrated magnesium carbonate might be precipitated. Possibly the precipitation was due to other changes in the solution rather than that of concentration, perhaps due to loss of carbon dioxide. Each year during wet seasons the ponds would fill up, the whole swampy area would be flooded, and the solution in each pond would be reduced to practically the same original concentration and chemical condition as before. Under such conditions and if magnesium carbonate greatly exceeded in amount the other compounds in solution, it would appear probable that deposits consisting essentially of basic magnesium carbonate would continue to grow so long as conditions remained stable. There would be also a tendency to precipitate any other compounds held in solution, such as calcium carbonate, silicic acid, etc., but if these materials are present in only relatively minor amounts, the results of such a tendency would be variable and would probably be governed by many variable factors.

Mr. R. A. A. Johnston has suggested to the writer that possibly the magnesium was not originally deposited in the form of hydromagnesite; that, for instance, the compacted material with its films and vugs of what appears to be a basic hydrous magnesium carbonate, as found here and there towards the base of the beds, may represent one stage in the transformation of the material from its original to its present condition. Mr. Johnston believes he can detect faint indications of a fibrous structure while the glassy mineral occurs partly in semi-circular or semi-spherical films or veinlets. If these phenomena are to be interpreted as marking stages in the transformation from some unknown condition to the present one, then the whole question of the mode of origin of the deposits is placed in doubt; it might be that the deposits were the products of springs, but now completely changed as regards structure and perhaps much modified as regards their bulk composition. To the writer, however, it seems just as logical to consider the compacted material as secondary to the powdery hydromagnesite as it is to hold the reverse to be the truth. It has also been suggested that the hydromagnesite might be conceived as having had a marl-like origin, and as being due to the action of life as is assumed to have been the origin of the marl in the at present existing nearby pond to which reference has already been made. The fact that in this pond calcium carbonate, not magnesium carbonate, appears now to be forming under conditions such as those postulated under the hypothesis that the magnesium carbonate formed in ponds, at first thought almost seems to quite destroy the arguments in favour of this hypothesis and to justify the acceptance of what seems to be the only possible alternative: that the deposits have formed from springs even though the beds in form, structure, and composition now seem to lack all evidence of such an origin. But, since the essential difference between forming from springs and in ponds is only that in the case of springs the mineral-laden, underground waters issue directly at the surface, whereas in the alternative case they discharge into standing bodies of water, therefore to the writer there seems to be no evidence at present available conclusively demonstrating the fallacy of the "pond" hypothesis.

The ultimate source of the hydromagnesite is, doubtless, the magnesia-rich rocks of the neighbourhood. Pine Creek valley and its bounding ridges are underlain by what Gwillim termed the "Gold series"; these rocks are bounded on the north by a very extensive area of intrusive granite, the boundary line in a general way following the summits of the ridges on the north side of Pine Creek valley, but in places the granite body extends southwards down the north slopes of the valley. The "Gold series," according to Gwillim,[1] consists of dunite, serpentine, impure magnesite derived from the dunite and serpentine, and various schists, shales, and eruptives. The material may have been taken into solution through the action of suitably charged waters on the solid rocks, or on the unconsolidated materials spread so thickly over the vicinity, or on both the solid and unconsolidated material. The swamp waters with their presumably high content of organic acids suggest themselves as active agents in the processes of solution.

The presence of the large and small blocks of stone resting on the surface of the hydromagnesite along the southern margin of the largest bed seems difficult to account for. Apparently they must have been placed there after the hydromagnesite formed. (1) They may represent residual elements from a cover of unconsolidated materials that once overlay the bed and which, save for these rock fragments, has since been wholly removed. There appears, however, to be no direct evidence to support this hypothesis; the occurrence of an analogous bed of the mineral on the surface of the terrace level a short distance east, indicates that the hydromagnesite beds are of later date than the time of deposition and terracing of the unconsolidated materials. Nearby, in a road cutting, a thin filmy layer of hydromagnesite was seen lying several feet below the present surface. A cursory inspection of this occurrence indicated that the material either had been mechanically transported or had been deposited from solution by circulating waters. (2) The boulders, etc., resting on the hydromagnesite bed, may have been brought into place by a vigorous stream which since has been entirely diverted or destroyed. This hypothesis seems unsatisfactory, for a stream powerful enough to transport blocks of stone 3 feet in diameter would surely have quite removed the hydromagnesite from its stream bed. Any hypothesis invoking the aid of glaciers or floating ice seems equally untenable. (3) The rock fragments may represent talus material derived from once bordering slopes of unconsolidated materials. This, to the writer, seems to be the least unsatisfactory hypothesis applicable to the case in point.

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[1] Gwillim, J. C.: G.S.C., Report on Atlin mining district, pp. 18-23, 1901.

TELKWA VALLEY AND VICINITY, BRITISH COLUMBIA.

(*J. D. MacKenzie.*)

INTRODUCTORY.

The completion of the Grand Trunk Pacific railway in 1914 gave a renewed impetus to the development of northern British Columbia in general, and it has aroused hopes that the increased transportation facilities which the railway affords will result in the transformation of some of the many mineral prospects along its route into shipping mines. Probably the most important mineral-bearing district served by the new road is the country drained by the Bulkley river and its tributaries and in this section deposits of copper, silver, lead, and zinc have occasioned a large amount of prospecting in the last fifteen years.

In order to furnish information about these deposits, their geological relations, and their prospective value, as well as to determine the general geological features of the district as a whole, an examination of this area was begun by R. G. McConnell in 1914. After a few weeks' work, however, Mr. McConnell was obliged to leave the field to take up the duties of the Deputy Minister of the Department and the examination of the area was recommenced by the writer during the field season of 1915.

The principal field work done was the areal geological mapping of the basin of the Telkwa river and its tributaries, on a scale of 1 inch to 2 miles, together with the examination of the mineral deposits within the district. In addition, a brief examination was made of the limonite deposit situated on Limonite creek, a tributary of the Zymoetz river; the Zymoetz River coal area was visited but not examined in detail, and assistance was furnished Mr. W. H. Boyd of the Survey in making a 1 inch to 1 mile contoured map of the area; the recently discovered Copper Crown group of mineral claims was mapped and the ore deposits studied, and several other prospects in various parts of the Bulkley valley and vicinity were visited, though time did not permit of the detailed investigation of any but those above mentioned.

The writer wishes to express his thanks to the many residents of the district whose never-failing interest and frequent co-operation and assistance furnished material aid in the work. In particular he is indebted to Mr. W. J. Carr, road superintendent, of Smithers, for assistance in clearing trails, and he also wishes to thank J. C. Cochran and B. T. Lea, members of the field party, and V. Dolmage, field assistant, whose incessant efforts to further the season's work were much appreciated.

GENERAL GEOLOGY.

Provisional Table of Formations.

Bulkley formation		Post Lower Cretaceous
	Intrusive contact	
Skeena formation		Lower Cretaceous
	Unconformity (?)	
Coast Range batholithic rocks		Upper Jurassic (?)
	Intrusive contact	
Hazelton formation		Jurassic

Hazelton Formation.

The oldest rocks exposed in the region are members of a great mass of pyroclastic, effusive, and probably intrusive volcanic rocks, termed by Leach[1] the Hazelton group, and to which the name Hazelton formation is here applied. These rocks are strikingly red in colour; brick reds, indian reds, claret, and purple shades predominating. They are largely fine-grained, evenly laminated well bedded tuffs, though flow rocks or sills are represented. The Hazelton formation is flexed into undulating open folds, is greatly jointed, and is in places broken by faults. Fossils were not found in these rocks in the Telkwa valley; but a few, as yet undetermined, were discovered east of the Bulkley river, on Grouse mountain. The age of the formation has not yet been definitely established, but fossils collected by others[2] indicate a range in age from Jurassic to Lower Cretaceous. It is hoped that careful attention in the future to stratigraphy and structure will fix the age of these important rocks more precisely. The economic importance of the Hazelton formation lies in the fact that it forms the country rocks of the mineral deposits of the district.

Coast Range Batholithic Rocks.

The formations termed here the Coast Range batholithic rocks consist of massive, medium granular plutonic rocks of the nature of quartz diorites, diorites, etc., with associated dyke rocks of related types. These rocks are well exposed in the extremely rugged eastern ridges of the Coast range, situated in the western part of the district examined. In these ridges the Telkwa and Morice rivers head. The batholithic rocks are intrusive into the Hazelton formation, which they have metamorphosed along the contact. In the contact zones adjacent to the batholithic intrusives are a number of prospects on veins formed by the mineralizing influence of the intrusive rocks.

Skeena Formation.

The rocks of the Skeena formation occupy several small basins in scattered localities, notably on Goldstream, on Goat and Tenas creeks, and on the Telkwa river about 6 miles from Telkwa. They consist of quartzose sandstones and argillaceous and sandy shales containing coal seams.

The age of these rocks is given as Lower Cretaceous (equivalent to the Kootenay of the Rocky Mountain province) by W. W. Leach[3] on the evidence of fossil plants. Leach further states that the Skeena formation is apparently conformable on the Hazelton formation.[4] The rocks are poorly exposed and the writer could not determine with certainty the relation between the two formations, but, in general, they appear to be structurally concordant. On account of the striking dissimilarity in the lithological nature of the Skeena and the Hazelton formations, the writer believes that an appreciable period of erosion took place previous to the deposition of the Skeena beds, and that they rest unconformably, or at any rate disconformably, on the Hazelton formation.

Bulkley Formation.

Cutting both the Hazelton and the Skeena formations are a number of dykes and sills of various lithologic characteristics to which the term Bulkley formation is applied. In addition, large irregular intrusive masses of quartz porphyry

[1] Leach, W. W., Geol. Surv., Can., Sum. Rept., 1910, p. 93.
[2] Geol. Surv., Can., Sum. Rept., 1912, p. 58.
[3] Leach, W. W., Geol. Surv., Can., Sum. Rept., 1910, p. 94.
[4] Idem, p. 94.

and associated rocks, which cut the Hazelton formation at various places in the district, are also provisionally assigned to this formation.

The Bulkley intrusives are important economically because with them are associated a number of mineral deposits, some of which, in this and adjacent districts, seem to be of considerable importance.

ECONOMIC GEOLOGY.

Metallic Deposits.

A large number of mineral claims have been taken up and prospected in the district examined, and with very few and unimportant exceptions these were visited and examined by the writer or by Mr. Dolmage, his assistant.

The King, Jackpot, and Colorado claims in Hunter basin were not visited by the writer, and the report given is based on the examination made by Mr. Dolmage.

Various types of deposits are represented—veins of both the fissure and replacement type; replacements in sheared, sheeted, or crushed zones; mineralized zones associated with dykes, etc. Most, if not all of the deposits, so far as could be determined in the field, are of a type formed under conditions of intermediate to high temperatures and pressures[1] and are in close association with the intrusive bodies of igneous rocks.

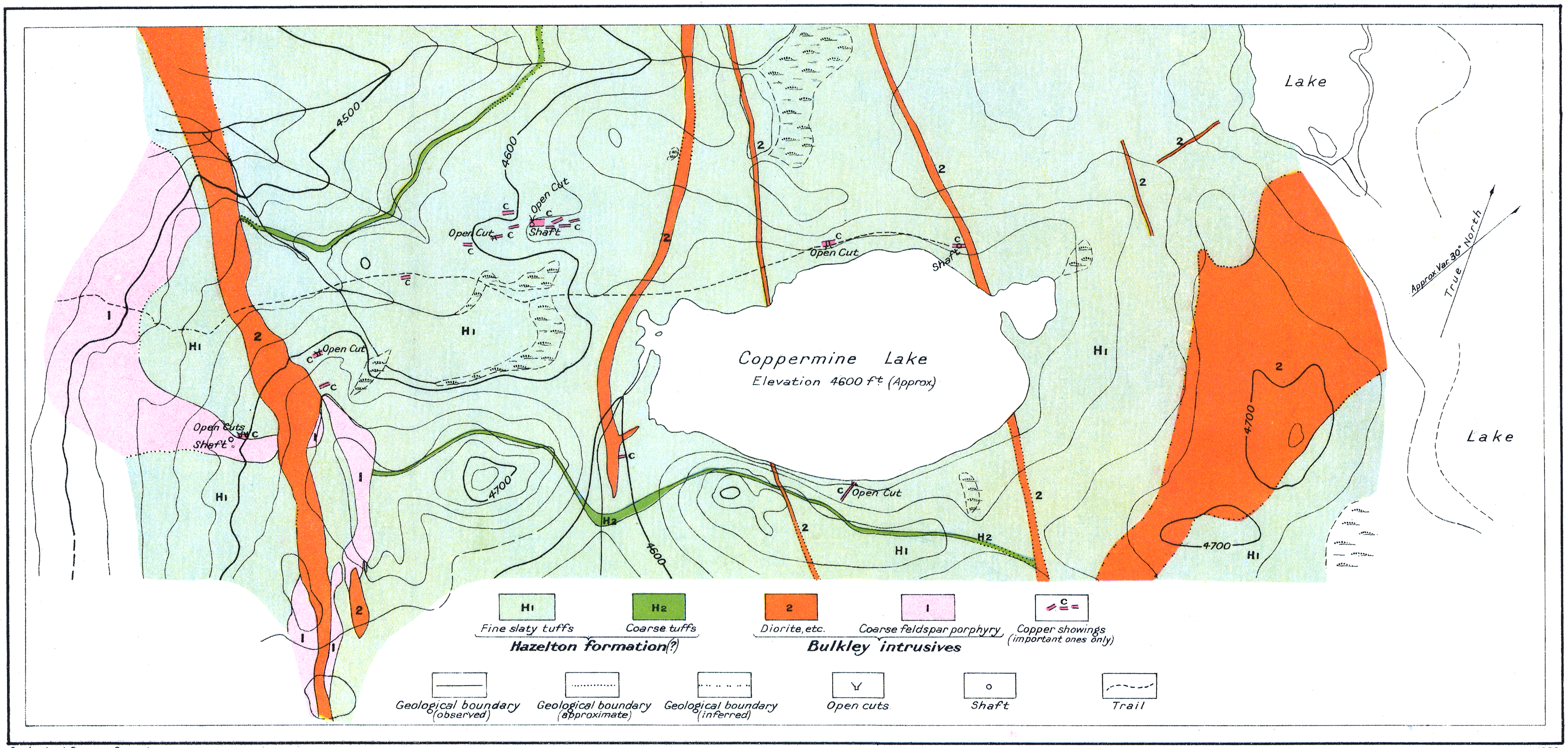
A number of the claims have had only slight amounts of development work done on them, while some others have been fully prospected. In many instances the size of the deposit, the quality of ore, or the situation renders the claims of highly improbable present or future value. Some of the deposits are well enough exposed at the surface, or have been sufficiently prospected to make an opinion as to their worth justifiable, and these will be described below.

King and Jackpot Claims. The King and Jackpot claims, owned by William Hunter, on the southeast side of Hunter basin at an elevation of about 6,250 feet, are located on a strongly marked fissure vein, which can be traced discontinuously for about 1,800 feet, in altered Hazelton tuffs and flows. The vein varies in character: in places it is filled with quartz and ore minerals between sharp walls, in other places it is represented by jointed and mineralized country rock. In thickness the vein runs from a few inches to 4 feet, averaging about one foot. The ore minerals are bornite and chalcopyrite, occurring mainly in fairly well defined shoots up to a foot thick. The other dimensions of the shoots are not yet ascertained, but the length is probably in some cases up to 30 feet or more. The principal gangue mineral is quartz. Much of the ore extracted is rich in appearance and a shipment of 15 to 20 tons has been made from this claim, but the smelter returns could not be ascertained. The following assays were made from samples taken by Mr. J. D. Galloway.[2]

	1	2	3	4
Gold (oz.)	0·03	0·14	0·20	0·08
Silver (oz.)	4·8	26·9	25·8	87·2
Copper (per cent)	2·0	14·6	29·0	32·8

1. Sample of whole vein, 4 feet wide, 400 feet east of shaft.
2. Sample of 18 inches at "West showing" near western end of vein.
3. Bornite mixed with magnetite from same place as No. 2.
4. Chalcopyrite from same place as No. 2.

[1] Lindgren, W., Mineral Deposits, 1913, p. 513.
[2] Idem, p. 53.



Geological Survey, Canada. 1608

Diagram of **Copper Crown Group**, Grouse Mountain, B. C.

Miles

5 4 3 2 1 0 5 10

To accompany Summary Report by J. D. MacKenzie, 1915.

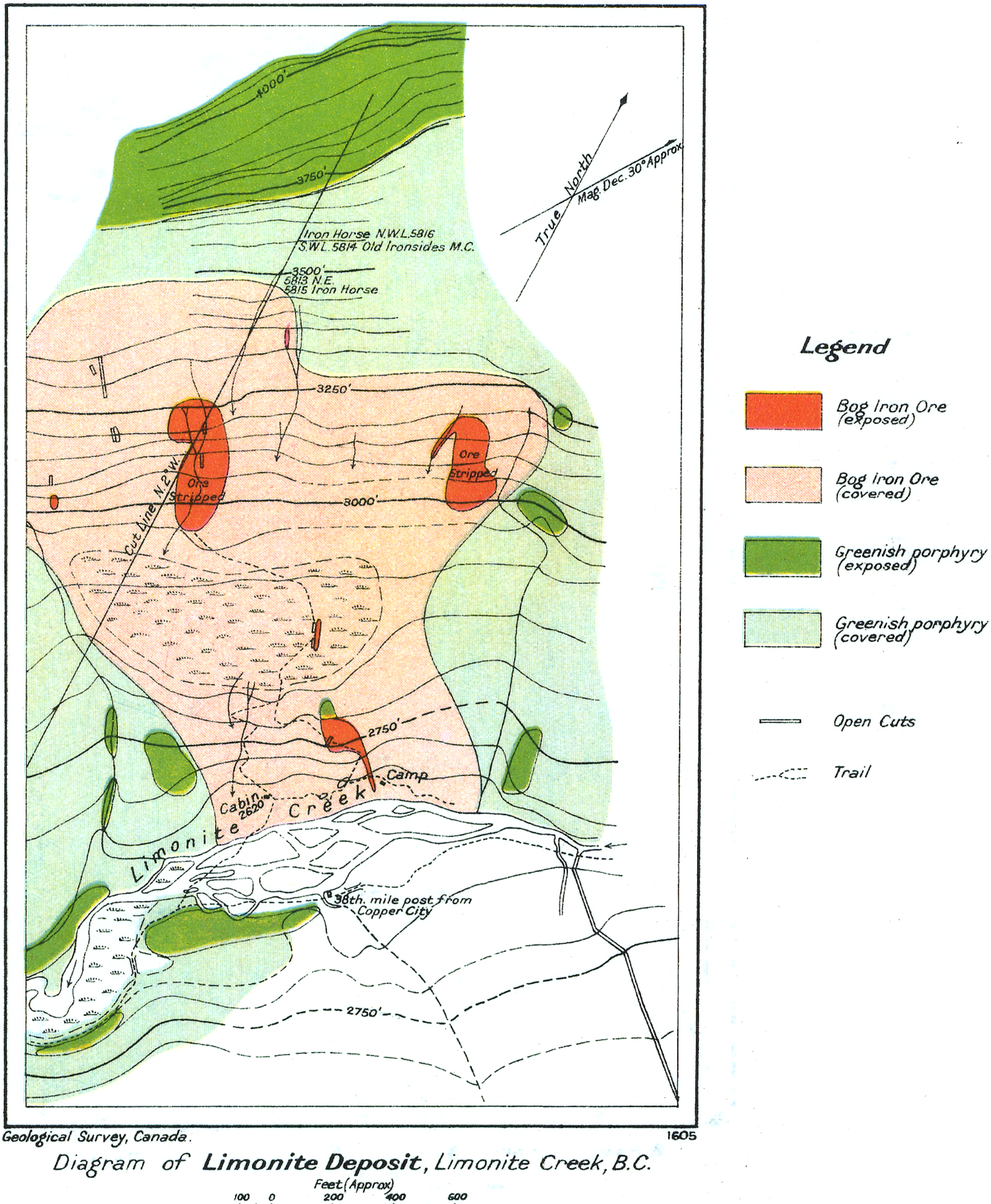


Diagram of **Limonite Deposit**, Limonite Creek, B.C.

To accompany Summary Report by J.D. MacKenzie, 1915.

Colorado Claim. On the Colorado claim, said to be owned by J. C. Cochran and C. Thoman, and situated on the northwest rim of Hunter basin at an elevation of 5,700 feet, the workings were in an unsafe condition and partly filled with ice, so a thorough examination was impracticable. The following notes are largely based on Mr. Galloway's report[1] and on an examination of the dump.

The deposit is a calcite and quartz filled fissure vein from 12 to 24 inches thick, in tufaceous rocks of the Hazelton formation. The vein is prospected by two tunnels, one above the other, with connecting stopes, the upper tunnel extending in 50 feet and the lower over 150 feet. The metallic minerals visible are mainly tetrahedrite, with a little bornite and chalcopyrite. Assays from Mr. Galloway's report are given below.

	1	2
Gold (oz.)	0·02	0·02
Silver (oz.)	69·2	298·0
Copper (per cent)	6·5	25·5

1. Sample of dump said to represent the run of the veins.
2. Picked high grade ore.

Hunter Claim. This claim is located on the northeastern rim of Hunter basin, at an elevation of 5,500 feet, and is owned by William Hunter.

The deposit consists of an irregular crushed zone, which in places is largely replaced by calcite, here and there localized into more or less definite leads. The zone in which crushing has taken place is about 50 feet wide and is visible for over 100 feet in a northerly direction. The metallic minerals are chalcopyrite, bornite, tetrahedrite, and galena, together with specularite in a calcite gangue with some quartz. The ore occurs in irregular shoots of varying size located along the foot-wall of the crushed zone. One of the shoots has been taken out, and averaged 2 feet thick by 20 feet in its longest dimension. Other shoots will probably be found, but the irregularity of the deposit renders any prediction most uncertain. The following assays were obtained by Mr. Galloway from samples taken of the 25 tons of ore extracted during the summer of 1914, and shipped previous to the writer's examination.

Gold (oz.)	0·02
Silver (oz.)	73·6
Copper (per cent)	1·2

Although none of the three properties mentioned in Hunter basin give promise of developing into large mines, it is probable that, with the increased facilities for transportation that will be afforded by the wagon road now building toward the basin, and with careful mining, they may be worked on a small scale at a profit.

Copper Crown Group. The Copper Crown group of five claims is located on Grouse mountain, an abrupt ridge forming the steep eastern wall of the Bulkley valley, about 18 miles southeast of Telkwa. The claims are at an elevation of about 4,800 feet, and are on the western edge of the ridge, overlooking the valley. They were discovered in the summer of 1914, are owned by L. Schorn and Samuel Bush of Telkwa, and are under bond to Messrs. Trimble and Anderson of Portland, Oregon.

[1] Idem, p. 54.

The accompanying map illustrates the geological conditions in this portion of the district.

The deposits are found in well bedded, dark green, and greenish-grey, water-lain, fossiliferous, feldspathic, and tufaceous sediments of the Hazelton formation; the latter are intruded by a series of roughly parallel dioritic and complementary dykes, which are assigned to the Bulkley formation. The sediments dip south-eastward at low angles, and are much jointed, and also rendered schistose in certain zones which are approximately parallel to the dykes.

The ore deposits are mostly located on a low ridge running along the north side of a little lake. They have been prospected at various places for a distance of about 3,200 feet in length, the width of the ore-bearing zone varying up to 100 feet, though this width is not all ore. The prospect openings consist of shallow open-cuts, trenches, and shafts, none extending completely across the possible ore zone, and none over 10 feet deep.

The metallic minerals, which are chalcopyrite and zinc blende, are localized in a sheeted zone, which is in general parallel to the strike of the sediments, and nearly vertical. The joints (sheets) of the zone show little or no slickensiding, and are spaced from a fraction of an inch to several inches apart. The ore minerals are found in narrow fissure veins, representing filling of the openings in the sheeted zone, and also as irregular replacement veins and masses throughout the zone. There is a little quartz gangue associated with the sulphides. Well defined walls were not observed for the deposit as a whole, though they are present locally. This ore-bearing, sheeted zone has been broken by post-mineral faults, usually of only a few feet displacement and nearly vertical. Those observed are roughly parallel to the strike of the dykes and the direction of the schistosity in the sediments. Proceeding east along the zone, it can be seen to be offset to the north along the faults, and from the areal distribution of the ore minerals it is thought that the western portion of the zone may be affected by faults of greater displacement than those observed elsewhere.

With respect to the tenor of the ore but little definite information is available, as no systematic exploration nor assaying has been done. The following descriptions of some of the prospect openings will serve to give an idea of the character of the more highly mineralized portions of the deposit.

At the initial post of the Copper Crown claim a sheeted zone 12 feet wide is made of closely spaced joints from ½ to 4 inches apart, most of which can be traced on the surface for 10 feet, and in some cases two or three times that far. Chalcopyrite occurs in the fissures in this zone, forming lenticular and irregular veinlets of the solid mineral, the largest seen being 3 inches thick, by 16 inches long. A shoot in the zone, 3 feet thick and 10 feet long, contained about 20 per cent chalcopyrite, and other, less rich shoots also occurred. Twenty-two feet east of the place just described, a 2-foot pit shows a shoot 4 feet thick, visible for 10 feet, which contains about 25 per cent chalcopyrite, and a 10-inch vein in the middle of the shoot, exposed for 5 feet, is nearly pure chalcopyrite. At a distance of 190 feet from the initial post mentioned, the continuation of the same zone is 35 feet wide, prospected by a shaft on the south side of the zone and a trench on the north side. The shaft is 5 by 6 by 8 feet deep, and exposes a 5-foot shoot that may run 20 per cent chalcopyrite. The rest of the 35 feet is lower grade ore, except for one or two small shoots, up to 18 inches thick.

Eastward from here for a distance of about 100 feet are many short veinlets of chalcopyrite from ½ inch to 4 inches thick.

At the east end of Coppermine lake, on the Eureka claim, a shaft 6 by 5 by 8 feet deep and some trenching expose a 10-foot mineralized zone in greenish tuffs, which is probably the continuation of the one just described. The zone strikes north 80 degrees east and dips about 75 degrees north. Following is a section of the zone, from the hanging-wall to the foot-wall:

Chalcopyrite, pyrite, and quartz	6 in.
Rock, slightly and irregularly mineralized	6 "
Ore shoot, about 25 per cent chalcopyrite	2 feet
Rock, slightly and irregularly mineralized	2 "
Ore shoot, about 25 per cent chalcopyrite	5 "

The stated amounts of chalcopyrite were in all cases estimated by eye, the mean of two independent estimates by different observers being taken.

This deposit, so far as it has been prospected, is of a promising appearance, and is also favourably located with regard to transportation, as it lies on the very edge of the Bulkley valley, with the railway across the river only 4½ miles distant in an air line.

Claims Owned by the North Pacific Iron Mines, Limited. The bog iron ore property owned by the North Pacific Iron Mines Limited, of Prince Rupert, is situated on Limonite (Summit) creek, a tributary of the Zymoetz (Copper) river, 38 miles east of Copper city on the Skeena. It is 6 miles west of the summit of the Zymoetz River-Telkwa River trail, and about 40 miles from Telkwa. The property consists of nine claims on the north side of the creek, covering approximately 375 acres.

The largest of the deposits on the property, shown in the accompanying sketch map, was examined by the writer and is described below. He was later informed on good authority, however, that other, smaller, similar deposits occur at higher elevations on the mountain side, farther back from the creek, but these were not visited by him.

The deposit examined, which consists of a sheet of bog iron ore of unknown thickness, extending from the "moss roots" to bedrock, lies on the steep north side of Limonite Creek valley. It extends from the stream itself for a distance of 1,800 feet in a straight line up the mountain side, which rises steeply from an elevation of 2,600 feet at the stream to 3,500 feet at the upper edge of the bog iron ore. The irregular area underlain by the limonite measures about 2,250,000 square feet (50 acres), and its greatest width is about 1,800 feet.

Everywhere in this area, yellow or brown earthy limonite may be uncovered merely by removing the moss from the surface; there is no overburden except the trees and moss growing on the limonite beneath, and this vegetation has been removed by burning in two places, leaving large areas of the ore exposed.

The deposit consists of bedded bog iron ore, occurring in platy layers from 1 to 3 inches thick, lying parallel to the hill-side, which here has an average slope of nearly 30 degrees. In addition to the stripping of the ore by burning, prospecting has been done by trenching and sinking numerous pits. The greatest thickness of limonite anywhere exposed is 15 feet; in two or three places 10 feet are exposed, and several cuts show 3 to 4 feet. In no place has the bottom of the sheet of ore been reached, and as no systematic attempt has been made to determine the quantity of ore present it is difficult to form any estimate of the amount available.

The ore consists of yellow and brown earthy limonite, free from sandstone or other impurities, rather soft and of a loose consistency so that it may readily be dug with a pick or cut with an axe. The ore extracted from the large open-cuts has disintegrated on weathering to a crumbly, in part pulverulent mass, ranging in size of grain from a powder to fragments an inch or two across. It is thoroughly saturated with water as it lies in the bed, but when dried might run about 20 cubic feet to the ton, at a guess.

If the surface area be taken at 2,250,000 square feet this figure would give 112,500 tons per foot of depth. An average depth of 5 feet for the deposit is almost certain; 10 feet is probable and perhaps the depth is greater. In other terms 562,500 tons may be considered as almost certainly proven; twice that as probable, and perhaps the amount is considerably larger. Analyses of the ore are given below:

Analyses of Ore from North Pacific Iron Mines, Ltd.

	1	2	3	4	5	6	7	8	9
Iron (metallic)	54·20	56·01	54·32	52·19	51	50·6	53·2	53·2	54·0
Silica (SiO_2)	1·02	0·83	1·99	1·56	2	1·7	1·31	1·62	1·04
Manganese (Mn)	0·85	0·51	0·39	0·70					
Phosphorus (P)	0·407	0·016	0·065	0·616	none	none	0·0016	0·014	0·002
Sulphur (S)	1·16	1·52	1·14	1·47	1·7	0·8	2·65	1·89	1·15
Water, combined	18·54	16·02	20·47	19·61					

Analyses 1 to 4 were made by H. A. Leverin, Mines Branch, from samples collected by J. D. MacKenzie.

1. Sample of a trench wall, from 2 feet to 10 feet below the surface. Taken by cutting a groove 1 foot wide, 6 inches deep, 8 feet long, and quartering to 8 pounds.
2. A picked specimen representing a 12-inch, harder, more compact band about 2 feet below the surface at the locality of No. 1, and also found in several other places in the deposit.
3. Sample of dump thrown out of a cut made in the deposit on a steep hill-side; the cut is 2 to 3 feet wide, with a level bottom 40 feet long and a 20-foot face, exposing 15 feet of platy bedded ore lying on the hill-side.
4. Sample of the dump from a trench 2 feet wide, 3 feet deep, and 50 feet long.

(These four analyses were made on material finely ground and dried at 104°C. until all hygroscopic moisture had been expelled.)

5. Sample taken at a depth of 15 feet from the surface (doubtless from the cut represented by analysis 3). Collector, W. M. Brewer.
6. Sample sent to British Columbia Bureau of Mines by the owner. (Analyses 5 and 6 by the analyst of the British Columbia Bureau of Mines.)

7, 8, and 9. Analyses by Falkenburg and Laucks, of Seattle.

These analyses, on samples taken in different ways and by different men, and made by at least three different analysts, agree very well, and emphasize the homogeneity and purity of the bog iron ore.

The country rock on which the ore lies is an altered, greenish porphyry, containing in many places impregnations of pyrite. Across the valley of Limonite creek to the south this porphyry is in contact with quartz diorites of the Coast Range rocks, which are probably intrusive into it. The writer is informed that on the mountain side above and to the north of the iron deposit are many quartz veins carrying pyrite.

The deposit lies on the western slope of the high eastern ridges of the Coast range and the rainfall in this district, to judge by the vegetation, is very much in excess of that only a few miles to the east. At any rate moisture is abundant throughout most of the year, and water is constantly flowing down the hill-side under the moss. The water flowing over the iron deposit has a strong taste of iron salts, and plainly has been derived from the decomposition of iron sulphides farther up the mountain side. This strong solution of iron sulphates trickling down under the moss has built up the deposit as it now stands by the progressive transformation to limonite of successive layers of moss and other vegetation, from beneath. That the efficacy of this process is undoubted is borne witness to by the limonitized twigs, roots, chips, fir needles, and cones, that have been transformed partly or wholly to limonite in the few years since the burned areas were cleared. In several places beautiful stalactitic terraced accumulations of limonite have been built up, which are even now in rapid process of growth.

The iron ore is excellently situated for mining, provided transportation could be obtained. There is ample hemlock and balsam fir timber in the vicinity, and Limonite creek, with its fall of 400 feet in the first mile of its course from the lakes at its head, would furnish sufficient power for a considerable plant, at all seasons, as the water could be readily impounded in storage reservoirs. The necessary railway transportation is not available, but W. M. Brewer[1] writing for the British Columbia Bureau of Mines states that: "he was informed by C. C. van Arsdol, Chief Engineer of the Grand Trunk Pacific Railway Company, that it was perfectly feasible to construct a railroad through this portion of the country viz., the Zymoetz River route . . . ."

Coal.

Coal occurs at several localities within the area mapped, the seams being found in the shales and sandstones of the Skeena formation.

The coal areas on Cabin and Goat creeks and on the Telkwa river have been described by W. W. Leach,[2] and no work of importance has been done in prospecting these basins since his examinations were made.

On two of the headwaters of Goldstream, a tributary of the Morice river, small coal basins occur. These areas were outlined by the writer and both found to be very small, the larger not over 2 or 3 square miles in area. Details of structure could not be ascertained owing to the lack of exposures, but the remote location and the small possible area of coal renders these coal basins economically unimportant.

On Chettleburg creek, a tributary of the Zymoetz river, a number of promising coal seams have been discovered and to some extent prospected. An excellent description of the seams and workings in this field may be found in Bulletin No. 4 of the British Columbia Bureau of Mines, 1915, by J. D. Galloway, pages 39-47.

A topographical map, on a scale of 1 inch to 1 mile, of the district in which the coal occurs, has been partly completed, and a careful geologic examination of this district is proposed to be made in the near future.

[1] Brewer, W. M., British Columbia Bureau of Mines, Bull. No. 3, 1915, p. 26.
[2] Leach, W. W., Geol. Surv., Can., Sum. Rept., 1910, p. 98; 1908, p. 41; 1907, p. 22.

EXPLORATION IN THE NORTHERN INTERIOR OF BRITISH COLUMBIA.

(*Charles Camsell.*)

INTRODUCTION.

Four weeks during the month of September, 1915, were spent in a rapid reconnaissance of a part of the northern interior of British Columbia lying north of the Grand Trunk Pacific railway between the 124th and 126th meridians. This region includes the basins of Stuart, Trembleur, and Takla lakes of the Fraser River drainage system, and the headwaters of Omineca, Manson, and Nation rivers of the Peace River system.

The route through this region was by wagon from Vanderhoof on the Grand Trunk Pacific to Fort St. James on Stuart lake, and from that point by canoe up Stuart, Trembleur, and Takla lakes, and the connecting rivers, to the north end of Takla lake, a distance of about 140 miles. The Hazelton-Omineca pack trail was then followed from Takla landing east to Manson and thence south to Fort St. James.

The reconnaissance was undertaken for the purpose of obtaining general geological information on a region about which we had previously very little knowledge, though part of it had once been a very productive gold placer district and now gives promise of containing lode deposits of importance.

The short time available for the trip prevented anything more than the most cursory examination of the geological conditions. Sufficient information was obtained, however, to warrant the statement that parts of the region show evidence of important mineralization and are worthy of more serious attention by both placer and lode prospectors. Not a great deal of development can be expected, however, until transportation is improved and the cost of freight reduced.

Economically, the most important part of the region is that known as the Omineca placer mining district, centring about Manson, where placer mining operations have been carried on more or less continuously since the discovery of gold there in 1868. The total production of gold from this district cannot be given with any degree of accuracy because of blanks in the annual records; but, judging from the published statistics, it must be at least $750,000.[1] At present the production is very small, the amount given in the statistical tables of the British Columbia Bureau of Mines being $6,000 for the year 1914. In this class of mining, however, it is difficult to obtain reliable figures, because most of the work is done by groups of men or individuals who, for various reasons, persistently understate the amount they recover, so that it is certain the amount mined must be considerably greater than the above figure.

At the time of my visit at the end of September, about twenty miners altogether were working in various part of the Omineca district. Some of these were placer mining on Tom, Germansen, Slate, and Lost creeks, and Omineca and Manson rivers. Others were prospecting either for placer deposits in the upper waters of Nation river or for lode deposits in other parts of the district.

The district is reached by trail either from Hazelton, 180 miles distant, or from Fort St. James, 110 miles to the south, but the trails are in such a bad condition that heavy packs cannot be carried over them. The freight rate from

[1] Annual Report of the Minister of Mines, B.C., 1914, p. 178.

either point is about 10 cents per pound. Fort St. James is connected with Vanderhoof on the Grand Trunk Pacific railway by a good wagon road 40 miles in length.

The greater part of the route between Vanderhoof and Manson by way of Takla lake had not previously been examined by any geologist nor had that between Manson and Fort St. James, though these routes are both old and have been used by miners and the Hudson's Bay Company for a great many years.

The first reference to any part of the region traversed, in the reports of the Geological Survey, is found in the Report of Progress for 1875-76, when Stuart lake was visited by A. R. C. Selwyn and John Macoun. G. M. Dawson was at the same point in 1876[1] and in 1879 he followed the shore of Stuart lake from the northwest end to Fort St. James and thence east to Parsnip river.[2]

In 1894, R. G. McConnell[3] examined the northern part of the region, making a traverse up the Omineca river and across to Takla lake; and in 1908 W. F. Robertson,[4] of the British Columbia Bureau of Mines, traversed Takla lake from Takla landing to Driftwood river on a trip to the Ingenika gold fields.

Topographically the region traversed lies partly in the great Interior Plateau region of British Columbia, but mainly in a mountainous country which borders the plateau region on the north. South of Stuart lake is a belt of almost flat country having an average elevation of about 2,400 feet above the sea. This belt forms part of the Nechako valley which in turn comprises one of the largest areas of level agricultural land in the whole province of British Columbia.

North of this belt the surface of the country becomes more irregular, and is broken by short isolated ranges of mountains rising 1,000 to 2,000 feet above the level of the valleys. This portion when viewed broadly is neither a true plateau nor a typical mountain region, but marks a transition from one to the other. It covers the region about Stuart lake and extends from there in a north-northeasterly direction towards the Nation lakes, where it gradually merges with the more mountainous region of the Omineca.

North and west of the last mentioned belt is an unbroken mountainous region, very rugged and high on the west towards Babine lake, but more subdued and rounded in its outlines towards the headwaters of Nation and Omineca rivers. In this portion the highest peaks reach an elevation of about 7,000 feet above the sea, and since Takla lake stands about 1,300 feet, the maximum vertical relief is about 5,000 feet.

The region examined lies on either side of the Pacific-Arctic divide, the drainage on the northeast being by way of Nation and Omineca rivers into the Peace and thence northward to the Arctic. On the southwest the waters flowing into Takla, Trembleur, and Stuart lakes find their way to the Pacific by the Stuart, Nechako, and Fraser rivers. For a mountain region the gradients of the streams are not steep, particularly on the Pacific slope where the great master valley occupied by Stuart, Trembleur, and Takla lakes has a very gentle slope to the southwest, permitting navigation throughout by canoe without any serious obstruction. On the Arctic slope the grades are steeper, but the streams flow in broadly flaring valleys filled with a thick layer of glacial or river wash which conceals the underlying bedrock in all but a few isolated places.

The predominant physiographic feature is the great master valley which extends in a northwesterly direction from Stuart river to Bear lake for at least 160 miles and possibly for about 80 miles farther to the headwaters of the Skeena river. It has a width ranging from 2 to 6 miles and a depth which increases northward until it reaches a maximum of about 5,000 feet. It is occupied

[1] Geol. Surv., Can., Report of Progress 1876-77, p. 54.
[2] Geol. Surv., Can., Report of Progress 1879-80, Part B.
[3] Geol. Surv., Can., Annual Report, Vol. VII, 1894, Part C.
[4] British Columbia Bureau of Mines, 1908.

successively by Stuart lake, Tachi river, Trembleur lake, Middle river, Takla lake, Driftwood river, Bear lake and river, and the headwaters of Skeena river, the last three draining out of the valley westward. It is an ancient structural valley coinciding in direction with the general trend of the rocks and lying parallel to the other great longitudinal valleys of the Cordillera.

The region east of this great valley exhibits physiographic features of much greater maturity than those which characterize the region to the west. The summits are all well rounded and the valleys broad and flaring. There is no evidence of recent general elevation of the region of such strength as to permit the trenching of the valleys deeper than the mantle of surface material. Glacial drift is very deep and widespread and this adds to the appearance of maturity of relief. Lakes are very numerous and, in most cases, they have resulted from the disorganization of the drainage by the damming of the valleys by glacially transported drift.

A very large proportion of the whole region has been burnt by fires which are said to have swept over it, from Cariboo to Omineca, about 48 years ago. The original forests of spruce and fir were then destroyed and a small, scrubby, second growth of pine has now replaced them. The timber-line in this region reaches to an elevation of about 5,500 feet, but only in the northern and western parts do the mountains rise much above this level.

The land suitable for agricultural purposes lies mainly in the southern portion of the region and the best of it is found in the valley of Nechako river, where the soil is a fine grey silt originally deposited as a sediment in the bed of an ancient glacial lake. Other glacial lakes of smaller extent existed south and east of Fort St. James and on Nation river and deposited sediments which make an excellent soil. Some good land is also found in the great valley occupied by Stuart and Takla lakes. Much of the remaining country, however, is more or less stony or sandy on the surface, and considerable of it in the Omineca region is so rocky as to be useless for agricultural purposes.

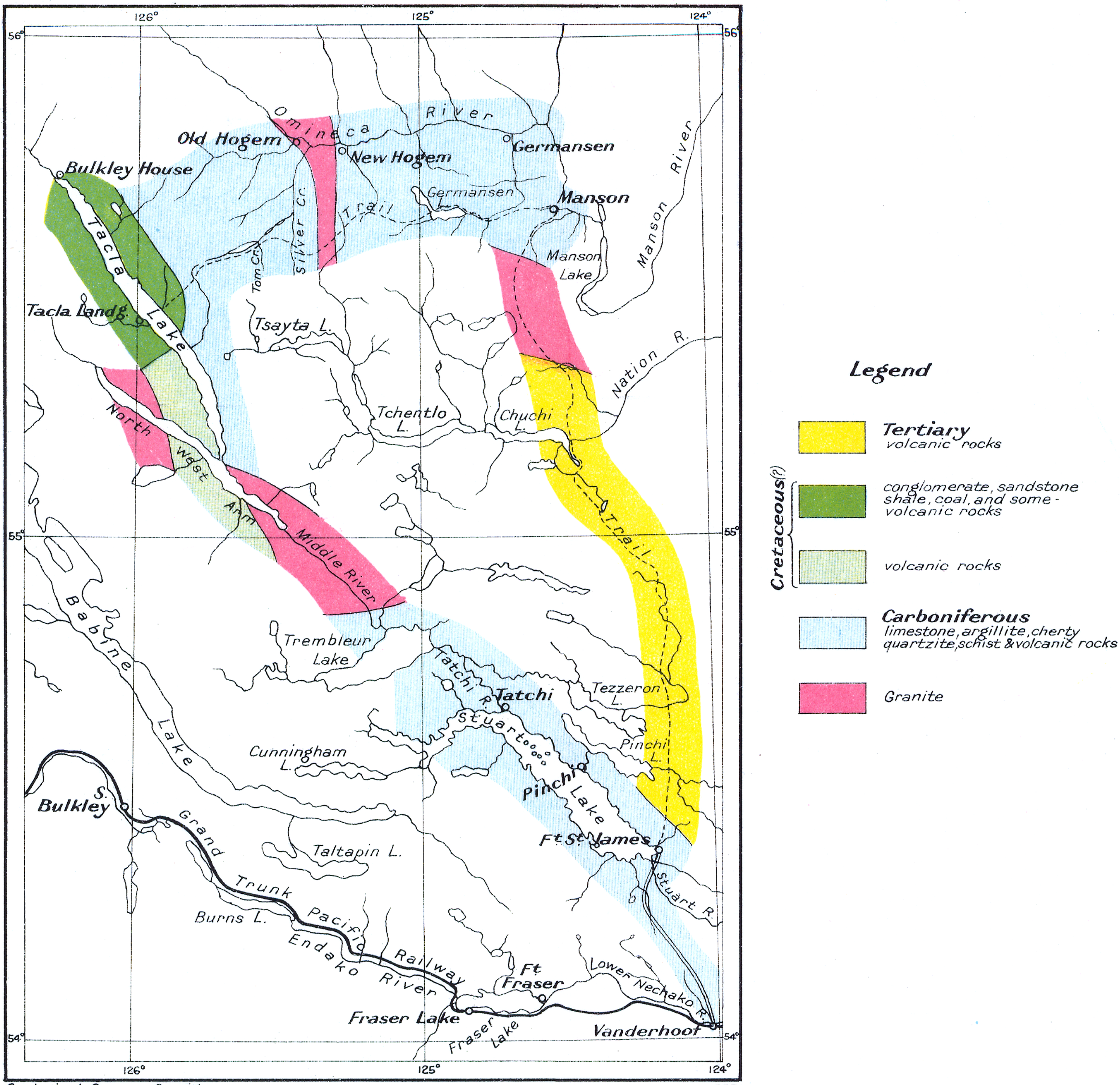
GEOLOGY.

The geology of the region is summarized in the following table of formations:

Pleistocene and Recent	River gravels and glacial deposits (boulder-clay, silt, moraines).
Tertiary	Volcanic rocks.
Cretaceous	Conglomerate, sandstone, shale, coal.
	Volcanic rocks.
Triassic or Jurassic	Granite.
Carboniferous	Limestones, argillites, cherty quartzites, slates, schists, and volcanic rocks.

Pleistocene and Recent. The mantle of unconsolidated materials of Glacial or post-Glacial age is particularly thick and widespread over the whole region, so much so that outcrops of the solid rocks are very rare in all the lower levels except west of the great Stuart-Takla valley. Clays and silts, the deposits of glacial lakes, occur in Nechako valley, south and east of Stuart lake, on Nation river, and in some of the valleys of the Omineca. Thick deposits of boulder clay and other unassorted glacial material cover the country south of Stuart lake and the basins of Nation, Manson, and Omineca rivers. Most of the boulders in these beds are of local origin and show a movement of the main ice-sheet in a general direction, north to south.

During the later stage of glaciation, when the valley glaciers flowed down the principal valleys irrespective of their direction, projecting spurs were truncated, parts of the valleys deepened, and terminal moraines built up at several



Geological Survey, Canada 1607

Diagram of Part of **Northern Interior** of **British Columbia**

Miles
10 5 0 10 20 30 40 50

To accompany Summary Report by C. Camsell, 1915.

points. Many of the lakes that still persist are the result of the unequal distribution of morainal material and there are many instances of stream diversion due to the same causes. The recent gravel deposits have been formed by the rearrangement of the glacial deposits by the streams, but nowhere are they abundant except on the Omineca watershed.

The great ice-sheet appears to have been thick enough to cover the summits throughout this region except a few on the western side of the Stuart-Takla valley. Striæ, however, were observed only in some of the valleys where they show a movement of what were no doubt valley glaciers parallel to the valley.

Tertiary. Fresh looking and unaltered rocks of presumably Tertiary age occupy the country bordering the trail between Nation river and Pinchi lake. On account of the thick covering of drift, however, few outcrops were observed. These are andesites, diabases, porphyries, or breccias, which form as a rule low hills with irregular and broken outlines trending in a northwesterly direction. Lookout mountain, at the west end of Tezzeron lake, is a flat-topped isolated hill with steep cliff faces, and composed of a fine-grained black diabase.

Cretaceous. Rocks which have been classed by McConnell[1] as Cretaceous occupy part of the western side and the whole of the northern end of Takla lake. They embrace a volcanic as well as a sedimentary series, which are conformable and to a certain extent interbedded with each other.

The volcanic portion of this series occupies the west shore of Takla lake on either side of the narrows and extends several miles up the northwest arm. It consists of soft green andesites, mottled tuffs and breccias, and some rhyolites and porphyries, all showing more or less evidence of metamorphism. The series rests unconformably on granite or the Carboniferous rocks with a conglomerate member at the base.

A prominent red bluff, situated 4 miles north of Takla landing on the east side of the lake, is made up of rhyolite belonging to this series of rocks. Whether the rhyolite is intrusive into the adjacent conglomerates or interbedded with them is not quite clear.

The sedimentary portion rests conformably on the volcanic and consists of conglomerate, sandstone, shale, and some coal. The beds dip at high angles and strike diagonally across the lake in a north and south direction, apparently occupying an ancient depression with which the outlines of Takla lake do not now strictly conform. The conglomerate contains pebbles of quartz, cherty quartzite, slate, and granite embedded in a siliceous matrix. The shales contain a number of plant remains. Determinations have not yet been made of the fossil plants, but the correlation of these beds with the coal-bearing Cretaceous rocks of the Groundhog field to the north, seems probable.

Granite. Bodies of granite are exposed on Middle river, the northwest arm of Takla lake, Silver creek, and in the country between Manson and Nation rivers. It is a massive, coarse-grained, grey variety easily identified even at a distance by the colour of its outcrops and the character of its topographic forms. It is intrusive into the Carboniferous rocks, but overlaid by the volcanics of Takla lake.

Carboniferous. Rocks of this age extend along the shores of Stuart lake and northward beyond Trembleur lake. Another area occupies part of the west shore of Takla lake and extends eastward to the Omineca placer mining region.

On Stuart lake the rocks consist of massive, blue limestone underlaid by cherty quartzites, argillites, and green schists, the last being probably altered volcanic rocks. The beds have been very much disturbed and metamorphosed and now dip at high angles with a general northwesterly strike. The age of these

[1] Geol. Surv., Can., Annual Report, Vol. VII, 1894, pp. 26C and 35C.

rocks has been determined as Carboniferous by G. M. Dawson from the presence in them of Fusilina and other fossils.[1]

On Takla lake black and grey sandy slates predominate with only small bands of dark blue limestone. Here, as on Manson river, the series contains a great many quartz veins which, in the latter locality, are probably the original source of the gold of the placer beds.

On Germansen creek, volcanic flows, tuffs, and breccias form a large proportion of the series, and on Manson river and its tributaries these are replaced by green chlorite schists, slates, and narrow bands of ferruginous dolomites. No fossils were found in the northern area, and its rocks have been correlated with the Stuart Lake rocks purely on structural and lithological grounds.

The Carboniferous rocks are cut by the granite and at Silver creek are also intruded by a small body of pyroxenite.

MINERAL DEPOSITS.

The Cretaceous sedimentary rocks at the north end of Takla lake contain small streaks of coal at certain points, but the only seam observed that approaches workable dimensions occurs on Firepan creek, about 3 miles inland, on the west side of the lake. The seam is exposed in the stream bed, overlaid by shale and sandstone. It is about 40 inches wide, but contains some small streaks of clay. It dips 20 degrees to the northwest and strikes southwest. The coal shows some crushing and fracturing and is traversed by many small veinlets of quartz.

The following is an analysis of a picked sample made by the Mines Branch:

Laboratory sample number	651
Moisture condition of sample	as received.
Proximate analysis:	
Moisture	8·7
Ash	10·3
Volatile matter	36·7
Fixed carbon (by difference)	44·3
Ultimate analysis:	
Sulphur	2·0
Fuel ratio: fixed carbon to volatile matter	1·20
Coking properties	non-coking.

This is the only known outcrop of a coal seam in that locality, but as no attempts have been made to prospect the field other seams may yet be found in it that will increase its importance. At the same time, if these rocks prove to be of the same age as those farther north in the Groundhog coal field, it will add to its importance and make this field one that should be well worth thorough prospecting.

The placer gold deposits of the Omineca have been worked continuously by a few men since their discovery about 1868, but the yield of gold has never been very great. During the season of 1915 only about twenty miners were at work and these were employed on Manson, Slate, Lost, Germansen, and Tom creeks. The yield per man is said to range from $3 to $10 per day, and the gold runs about $17.50 per ounce.

The gold is fairly coarse and judging from the shape of the nuggets, has not travelled far. Quartz is frequently found attached to the nuggets suggesting that they have been derived from veins of quartz in the schists and slates that form the country rock of the region. Other metallic minerals observed in these placers are the silver amalgam arquerite, native copper, and some platinum.

[1] Geol. Surv., Can., Report of Progress, 1876-77, p. 55.

Though there are some fairly high grade gold and silver-bearing quartz veins in the district no lode mining has yet been attempted owing to the high cost of transportation. The veins occur in the schists and slates, and contain galena, pyrite, chalcopyrite, and tetrahedrite in a gangue of quartz and in some cases, calcite. They run as a rule with the formation, and while the majority are small, some are as much as 6 or 8 feet in width.

Of the whole region traversed the portion occupied by the slates, schists, and associated rocks of the Omineca district presents the most favourable conditions for the occurrence of metallic mineral deposits. These rocks are intruded by bodies of igneous rocks; they contain many mineralized veins of quartz which appear to have been the source of the gold of the placers, and there are other evidences which suggest the presence of a zone of metallization which it would be well worth the time and effort of the prospector to explore. The first effort for the development of this district, however, should be devoted to the improvement of the means of entry and the reduction of the cost of transportation, for after this is done it will no doubt be possible to work many of the placer deposits that are too low grade to work under the present conditions, and at the same time prospecting for lode minerals will be greatly stimulated.

BRIDGE RIVER MAP-AREA, LILLOOET MINING DIVISION.—HIGHLAND VALLEY COPPER CAMP, ASHCROFT MINING DIVISION.—HUMAN SKELETON FROM SILT BED NEAR SAVONA. BRITISH COLUMBIA.

(*C. W. Drysdale.*)

Bridge River Map-Area, Lillooet Mining Division.

INTRODUCTION.

The Bridge River map-area lies west of the Fraser river, about 100 miles inland from the Pacific coast and 130 miles north of the International Boundary line and includes the most important mines of the Lillooet mining division. It includes approximately 600 square miles of mountainous Coast Range country between latitudes 50° 40′ north and 51° 02′ north, and longitudes 122° 25′ west and 123° west.

The main part of the field season of 1915 was spent by the writer in geologically mapping the Bridge River area, in which work he was most ably assisted by W. J. Gray. An excellent topographic base map was furnished by the Topographic Division. This map, which was made by W. E. Lawson and E. E. Freeland, during the field seasons of 1912 and 1913, is plotted on the scale of 1:96,000 (1 inch = 8,000 feet), for publication at about 2 miles to 1 inch, with topography shown by contours at an interval of 200 feet. The topographic sheet proved to be of the greatest assistance and only through its use was it possible to complete in a single season the geological mapping of such a large area.

Preliminary work by the Geological Survey was done in the Bridge River district in 1911 when Charles Camsell[1] made a brief reconnaissance trip there,

[1] Summary Report, Geol. Surv., Can., 1911, pp. 111-115.

and again in 1912 when A. M. Bateman[1] made a more detailed examination of the region. In the autumn of 1910, W. F. Robertson,[2] Provincial Mineralogist, visited the district and in the summer of 1913, W. M. Brewer, M.E.,[3] examined and reported on it in more detail for the Provincial Bureau of Mines. G. M. Dawson[4] in his 'Report on the area of the Kamloops map sheet' describes the geology in the vicinity of Lillooet, including the mouth of Bridge river, but does not deal with the country farther west.

The writer wishes to thank the mine managers, prospectors, and residents of the district for their kind hospitality and assistance during the field season, which aided considerably in the progress of the work.

MEANS OF ACCESS.

The Bridge River map-area is accessible by pack-trails and in part by wagon road from Lillooet, one of the oldest towns and distributing points in the interior of British Columbia. Lillooet is about 25 miles southeast of the map-area and is situated on a high river terrace overlooking the Fraser river. Railway connexion with Vancouver is now afforded by the recently constructed Pacific Great Eastern railway. Good roads connect Lillooet with Lytton (45 miles down the Fraser valley) and with Ashcroft (60 miles distant) both towns on the Canadian Pacific railway, as well as with Clinton and other points up the Cariboo road.

GENERAL CHARACTER OF THE DISTRICT.

The Bridge River map-area lies on the eastern flank of the Coast Range mountains, its northeastern corner forming a part of the transition belt of more subdued mountains separating the Coast range proper from the Interior plateau of British Columbia. Within this area are three main mountain-units, all trending in a northwest-southeast direction and known from north to south as the Shulops, Bendor, and Cadwallader mountains respectively.[5] The mountains are of the erosion type and of more than one cycle development. They are characterized by having broad upland stretches much sculptured by present and past mountain glaciers and streams. The uplands are surmounted, here and there, by rugged snow clad peaks and ridges whose northern slopes are precipitous and difficult of ascent. The mountain peaks range in elevation from 8,000 feet to 9,600 feet above sea-level and the main valleys entrenched beneath the uplands vary from 1,900 feet to 3,000 feet. Timber-line averages about 6,500 feet and as a rule the southern mountain slopes support open and park-like stretches of timber in contrast to the more heavily timbered and brushy northern slopes. Through the kindness of Mr. Percy Le Mare, District Forester, the following list of forest trees in the Lillooet district is given:

Douglas fir..........................	*Pseudotsuga taxifolia* (Poir.) Brit.
Western red cedar..................	*Thuya plicata* Don.
Yellow pine........................	*Pinus ponderosa* Laws.
Lodgepole pine.....................	*Pinus contorta* London Sudio.
Western white pine................	*Pinus monticola* Dougl.
White bark white pine............	*Pinus albicaulis* Englmn.
Hemlock............................	*Tsuga heterophylla* (Raf.) Sarg.
Spruce..............................	*Picea Englemanni* Englmn.
Balsam fir..........................	*Abies lasiocarpa* (Hook.) Nutt.
Poplar, aspen......................	*Populus tremuloides* Michx.

[1] Summary Report, Geol. Surv., Can., 1912, pp. 188-210.
[2] Report of the Minister of Mines, British Columbia, 1911, pp. 134-148.
[3] Report of the Minister of Mines, British Columbia, 1913, pp. 246-273.
[4] Annual Report, Geol. Surv., Can., New Series, Vol. VII, 1894, pp. 96-101B.
[5] Geographic Board of Canada. Decisions Jan.-Feb., 1915. Canada Gazette, March 13, 1915.

Black cottonwood	*Populus trichocarpa* Torr. and Gr.
Balm-of-gilead	*Populus balsamifera* Linn.
Broadleaf maple	*Acer macrophyllum* Pursh.
Dwarf maple	*Acer glabrum* Torr.
Dwarf juniper	*Juniperus communis* Linn.
Rocky mountain red cedar	*Juniperus scopulorum* Sarg.
Western birch	*Betula occidentalis* Hook.
Mountain birch	*Betula fontinalis* Sarg.
Alder, white	*Alnus rhombifolia* Nutt.
Alder, mountain	*Alnus tenufolia* Nutt.
White willow	*Salix lasiolepis* Benth.
Western yew	*Taxus brevifolia* Nutt. (scarce).
Western dogwood	*Cornus Nuttalli* Andb. (scarce).
Western service-berry	*Amelanchier alnifolia* Nutt.

A small collection of wild flowers was made in the field and turned over to the biological division. Mr. J. M. Macoun reports on the collection as follows: "List of Plants collected in Bridge River district, Lillooet, B.C., by C. W. Drysdale and W. J. Gray, July, 1915.

Equisetum laevigatum R. Br.	Smooth scouring rush.
Carex invisa R. Br.	
Salix nivalis Hook.	
Oxyria digyna (L.) Hill.	Mountain sorrel.
Erigonum subalpinum Greene	
Silene acaulis L.	Moss campion.
" *Macounii*, S. Wats.	Macoun's catchfly.
Arenaria capillaris Poir. var *nardifolia* (Ledeb.) Regel.	
Delphinium Menziesii DC.	Larkspur.
Potentilla flabellifolia Hook.	Cinquefoil.
" *nivea* L.	Snowy cinquefoil.
Epilobium anagallidifolium Lam.	Pimpernel willow-herb.
Phyllodoce glandulifera (Hook.) Coville	White mountain heather.
" *empetriformis* (Smith) D. Don	Red mountain heather.
Polemonium humile Roem and Schult.	
Phacelia sericea (Graham) A. Gray	
Myosotis sylvatica Hoffm. var. *alpestris* Koch.	Forget-me-not.
Penstemon Menziesii Hook.	Beard-tongue.
Veronica alpina L.	Alpine speedwell.
Mimulus Lewisii Pursh.	Pink monkey flower.
Pedicularis Langsdorfii Fisch.	
var. *lanata* Gray	Lousewort.
Solidago ciliosa Greene	Goldenrod.
Erigeron compositus Pursh	
Erigeron salsuginosus Gray	Daisy.
Arnica undescribed species	Arnica.
Senecio triangularis Hook.	Groundsel.

"Two of these plants, *Myosotis sylvatica* var. *alpestris* and *Pedicularis Langsdorfii* var. *lanata*, have not before been recorded west of the Rocky mountains south of the Yukon river, and their occurrence in the Lillooet region several hundred miles from where they had before been collected, is very remarkable.

"The *Arnica* is not represented in the herbarium of the Geological Survey and Dr. P. A. Rydberg is of the opinion that it represents an undescribed species.

"In addition to the above the following species were common but not collected. Lupine (probably *L. arcticus*), yellow monkey-flower (*Mimulus Langsdorfii*), phlox (*Phlox Douglasii*), indian paintbrush (probably *Castilleja miniata*), oregon grape (*berberis aquifolium*), wild gooseberry, wild strawberry (*Fragaria bracteata*), wild raspberry (*Rubus strigosus*), saskatoon or service berry (*Amelanchier florida*) wild onion (*Allium cernuum*)."

Vegetables and the hardier fruits are successfully grown at elevations not exceeding 2,500 feet, the district possessing climatic conditions very similar to those of the western interior of British Columbia.

The Bridge River region is one of the most popular districts in Canada for big game hunting, the hills abounding in bighorn sheep (*Ovis canadensis*), goats (*Oreamnus montana*), mule deer (*Odocoileus hemionus*), and in certain localities black, brown, and grizzly bears. Cougars, coyotes, wolverines, beavers, groundhogs, and porcupines are not uncommon, and blue grouse, willow grouse, and ptarmigan are plentiful. Nearly all the streams and lakes are well stocked with fish.

GENERAL GEOLOGY.

A brief outline of the geology of the district will be given here and many of the names used and correlations made must be considered only tentative, pending further study and laboratory work.

The geological age, name, and character of the various rock formations outcropping within the limits of the map-area are presented for the sake of conciseness in the following tabular form:

Table of Formations.

Era.	Period.	Formation name.	Form and lithological character.	Thickness in feet.
Quaternary	Recent	Volcanic ash.	White andesitic pumice (siliceous earth).	2±
		Stream deposits.	Gravel, sand, silt, and clay.	
	Pleistocene	Stream deposits.	Gravel, sand, silt, and clay.	250±
		Glacial deposits.	Boulder clay or till.	
		Unconformity.		
Tertiary	Eocene (?)	Rexmount volcanics.	Light coloured volcanic breccia, tuff, and andesitic lava.	1,000±
			This rests in places upon conglomerate, sandstone, and shale with a few thin seams of lignite coal.	300±
		Rexmount porphyry.	Intrusive stock and sills of andesitic porphyry.	
		Unconformity.		
		Big Sheep volcanics(?)	Reddish weathering carbonate rocks containing chalcedony veinlets, fluidal and breccia structures, and associated with magnesite and cinnabar(?) closely related to Shulops volcanics and probably derived from them.	

Era.	Period.	Formation name.	Form and lithological character.	Thickness in feet.
		Eldorado granodiorite.	Intrusive stocks and sills of granodioritic porphyry.	
	Lower Cretaceous	Eldorado series.	Interbanded green sandstone and grey to black argillite with grey feldspathic sandstone and coarse to fine conglomerate. Also thin beds of crystalline limestone and flows of andesite.	15,000±
Mesozoic	Upper Jurassic	Bendor granodiorite.	Intrusive cupola stocks (Coast Range batholith) of granodiorite and diorite.	
		Cadwallader diorite.	Intrusive sheets and stocks of augite diorite varying from quartz monzonite and augite porphyrite to gabbro and pyroxenite. Country rock of gold-quartz veins.	
	Jura-Triassic(?)	Cadwallader series.	Conglomerate, sandstone, limey conglomerate and sandstone, crystalline limestone, dolomite, heavily bedded cherty quartzite with thin argillite interbeds (mud cracks and ripple-marks); greenstone (andesitic) interflows agglomeratic in places. Red weathering peridotites (dunite and wehrlite) (Shulops volcanics) altered to serpentine in many places and associated with chromite. Possibly Lower Cretaceous in age.	12,000±
		Unconformity.		
		Cache Creek Group: Whitecap schist series.	Quartz mica schist, andalusite schist, squeezed conglomerate and sandstone, phyllite, talcosic, sericitic, and chloritic schists.	8,000±
Palæozoic	Devono-Carboniferous	Cache Creek Group: Bridge River series.	Mainly contorted chert and cherty quartzite ("Crowfoot quartzite") red arenaceous schist, metargillite, and crystalline limestone lens. Flows of black metabasalt chiefly near top of series and which in many places display pillow structure.	9,500±
			Total thickness	46,052±

STRUCTURE.

The regional structure of the above formations may be described as that of a broad anticlinal dome elongated in a northwest-southeast direction and pitching at a low angle to the northwest. Bridge river and its tributaries, Tyaughton and Marshall creeks, have incised themselves deep within the Palæozoic core of this dome and exposed the basal, much contorted and faulted chert and meta-basalt of the Bridge River series. The faulting has been chiefly of the normal or gravity type, the fault blocks having been stepped down in the direction of the pitch of the anticlinal dome. Marshall and Pearson ridges, which trend with the axis of the anticline, are composed of these older formations; the northern portion of the core being bounded by Marshall creek on the east and Tyaughton creek on the west.

Unconformably overlapping the Palæozoic core, and forming the limbs of the northwestward plunging anticline, are two great series of Mesozoic formations, first the Jura-Triassic, Cadwallader series, then farther out on the dome, the Lower Cretaceous, Eldorado series. The western limb of the anticline, next the Coast Range batholith, is composed of closely compressed formations belonging to the Cadwallader series which are intruded and deformed by large stocks of the Bendor granodiorite. On approaching the stocks the formations nearly always swing and parallel the granodiorite contacts. In a few cases, however, the stocks appear to crosscut the formations. The eastern limb of the anticline, on the other hand, borders the Interior plateau and is composed dominantly of the Shulops serpentine and peridotite members of the Cadwallader series intruded by flatly dipping sills of andesitic porphyry. Conformably overlying and interfolded with the Cadwallader series is the Eldorado series of Lower Cretaceous age. Considerable faulting and mashing marks the contact between these two formations. Although the Eldorado series next the Coast range is compressed and overturned, on passing eastward toward the Interior plateau close folds and faults give place to open folds and simpler structures. The open folds and simple structures of the Lower Cretaceous sandstone member may be well seen in the valley of the Yalakom river (north fork of Bridge river) near its source.

The topography of the map-area was found to conform closely to bedrock structures; the trend lines of the mountains and valleys in many cases following the formational strikes. The close relations of erosion to anticlinal structures and igneous intrusion are well expressed in the landscape of the district.

ECONOMIC GEOLOGY.

Special attention was paid in the field to the working mines of the Bridge River map-area and the examination of mineral occurrences of prospective value.

The main mineralized belt was found to occupy the western flank of the Bendor mountains, forming an arc concave toward the centre of the mass. This arc corresponds to a part of the western limb of the Bridge River anticlinal dome which is compressed against the Coast Range batholith and intruded by steeply dipping cupola stocks and tongues of granodioritic rocks. The ore deposits appear to be genetically related to these younger intrusives and are found in the cover rocks of the underlying batholith. The gold-quartz deposits are confined mainly to the Cadwallader diorite which has proved because of its hard, compact, homogeneous nature to be physically a good formation to preserve regular and persistent fault fissures. The fissures have served as channels for the heated alkaline carbonate solutions containing gold, which were given off during the later stages of batholithic invasion and consolidation. At certain localities in the fault fissures where temperature, pressure, and other physico-chemical conditions were favourable, free gold was deposited from solution to form ore-shoots.

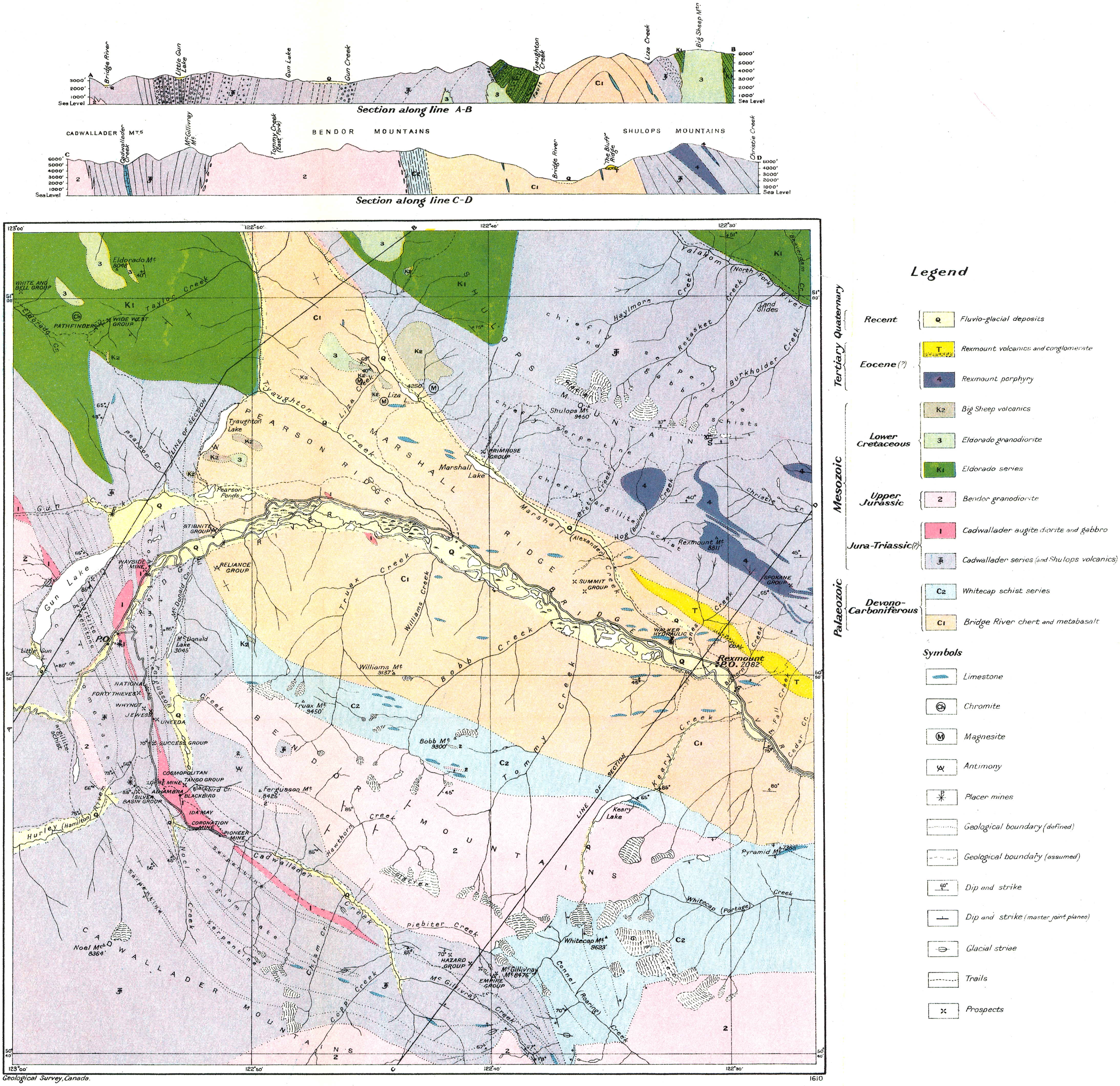


Diagram of **Bridge River** Area, Lillooet Mining Division, B.C.

Miles 5 4 3 2 1 0 5

To accompany Summary Report by C.W. Drysdale, 1915.

The main problem in the economic geology of this belt was to try to determine the factors which controlled such localizations of values. In addition to the underground work, plane-table traverses were run in an endeavour to correlate the numerous veins and vein systems as well as to delimit the boundaries of ore-bearing augite diorite. The main areas of Cadwallader diorite are indicated on the accompanying map. "Float" of this formation was also found on the north-west end of the Bendor mountains above timber-line and on the eastern limb of the anticlinal dome in the Cadwallader series of Yalakom valley (north fork of Bridge River valley) so that with more detailed work other areas of Cadwallader diorite may be added to those already mapped.

A small staff of men, under the management of J. G. Perry, were working at the Coronation mine. Most of the work was being done on the Countless claim on the outcrop of the two main veins where fair values were being obtained. Some development work was done on the recently discovered upper vein of the Little Joe claim. About 20 tons of gold-quartz ore were milled during the summer of 1915, 5 tons of which was a trial lot from the Countless vein. During 1914 the Coronation milled 120 tons and recovered over 230 ounces in gold and about 400 ounces in silver. The 10-stamp mill[1] on the property has a rated capacity of 30 tons per day and to date has treated about 7,600 tons of ore. Four blanket tables were constructed in 1915 to save the concentrates, the first lot of concentrates running $105 per ton and the second lot $40 per ton. It is estimated that there are 5,000 or 6,000 tons of tailings on the mill dump which will run about $10 in gold per ton, the lowest assay reported being $5 per ton.

The Pioneer mine[2] resumed operations late in the summer of 1915. The owner, Mr. A. F. Ferguson, put in a 1,700-foot flume line and a bunk house and extended the wagon road preparatory to installing a sawmill, compressor, and a 25-ton Bryan mill to treat the gold-quartz ore of this property. The Wayside mine was being developed by D. C. Paxton. A lot of some 20 tons of ore was treated in a test stamp mill and yielded about $16.50 to the ton. The Lorne mine[3] was expected to shortly resume mining operations. In addition to gold-quartz deposits, which with the gold placers have proved to date to be the most important, there are partly developed silver-copper and antimony veins, as well as undeveloped occurrences of copper, chromite, magnesite, talc,[4] pumice[5] (siliceous earth) and lignite coal. Although the market conditions at present are excellent for the sale of antimony,[6] copper, chromite,[7] and magnesite[8] the high cost of wagon-haulage and horse-packing of such ores from this inaccessible district to the railway prohibits profitable mining.

During the course of the field work the following properties(arranged in tabular form) were examined and will be described in a memoir now in course of preparation.

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[1] For description of mill see Sum. Rept. Geol. Surv., Can., 1912, p. 198.
[2] Sum. Rept., Geol. Surv., Can., 1912, p. 200.
[3] Sum. Report, Geol. Surv., Can., 1912, p. 198.
[4] Talc is used extensively in the manufacture of paper, for talcum powder, and as a filler in the cheaper grades of toilet soap, in paints, and has many other uses. It is found in considerable quantities in the Cadwallader series of the Shulops and Bendor mountains.
[5] Pumice is used as a polishing material, in the manufacture of scouring soaps, metal polisher, etc. It occurs in great quantity throughout the district as the most recent formation. A chemical analysis of this material is being made by the Mines Branch.
[6] Since the outbreak of the war, many new uses of antimony have been discovered and with the cutting off of the Austrian supply, the price has gone up. Besides its common use in making such alloys as type-metal, Britannia-metal, and Babbitt metal, and for medicinal purposes, it is used extensively for hardening certain kinds of rubber, and in the manufacture of shrapnel shells; the latter, it is said, calls for 20 per cent of the supply.
[7] Chromite is used in the manufacture of chrome steel in which case the iron content is also utilized; in the chemical industry for making chromic acid and the various salts of chromium, which in turn are used for making paint and ink pigments and for other purposes.
[8] Magnesite is used extensively for refractory linings in basic open-hearth furnaces; for artificial stone and mineral floor making; for wall board; in the manufacture of paint; for medicinal purposes; and, to a limited extent now, is used in the calcined form in the manufacture of carbon dioxide (CO_2) used for aerating beverages. Probably 90 per cent of the supply before the war came from Hungary and the remainder from islands in the Aegean sea.

Gold-Quartz Deposits.[1]

Name.	Veins.	Claims and fractions.	Owner.
Pioneer mine	3	10	A. F. and S. Ferguson, Vancouver.
Coronation mine	5	5	Coronation Mining Co., Victoria (F. H. Forbes, Sec.).
Ida May	2	4	Alpha Bell Gold Quartz Mining Co., Vancouver.
Blackbird	2	1	Blackbird Syndicate of Victoria (F. H. Forbes, Sec.).
Tango	1	2	Chas. Noel and M. Keeley.
Lucky Boy fract. (Argyle)	1	1	Mark R. Eagleson.
Alhambra	2	2	New York Syndicate, Estate of Milton Rathburn, *et al.*
Lorne	8	6	Lorne Amalgamated Mining Company.
Cosmopolitan	2	1	Paul Santini.
Cosmopolitan fraction	1	1	Mark R. Eagleson.
Maud S. fraction	1	1	Dr. H. A. Christie, S. Gibbs, and T. P. Reed.
Success	1	3	A. Williams.
Uneeda	1	2	W. H. Haywood.
Jewess-National	1	2	F. H. Kinder.
Silver Basin	2	6	Carl Wihksne and Mrs. C. P. Dam.
Why-Not	2	2	Burnside Syndicate, Victoria.
Forty Thieves	1	3	John Marshall estate and R. B. Skinner estate.
Wayside	3	10	Bridge River Gold Mining Co., Cincinnati, Ohio.
Marconi	1	7	O. Fergusson and Walker.
Total	40	69	

Silver-Copper Veins.

Name.	Veins.	Claims and fractions.	Owner.
Empire	1	3	McGillivray Mountain Mines, Ltd.
Hazard	1	1	J. M. Williams.
Hazard No. 1	1	1	S. D. Cooper.
Hazard No. 2	1	1	G. H. Kirkpatrick.
Bluebird	1	1	Dr. H. A. Christie.

Antimony Veins.

Name.	Veins.	Claims and fractions.	Owner.
Stibnite	1	16	C. H. Allan, Geo. Ronen, C. C. Dixon, J. B. Tiffin, W. A. McPhelan.
Reliance	1	4	Geo. Salmon, F. A. Brewer, *et al.*, Vancouver.
Empire	1	1	McGillivray Mountain Mines, Ltd.
Pathfinder (Victoria)	1	1	E. J. Taylor and Grant White.

[1] For description see Summary Report, Geol. Surv., Can., 1912, pp. 195, 196.

Placer Gold Deposits.

The following are the main placer properties within the limits of the map-area: the Golden Dream Mining Company's property near the mouth of McDonald creek in Bridge River valley; the Walker Hydraulic property[1] on Marshall creek, owned in Cincinnati; the Silver Basin property, near the mouth of Cadwallader creek and Hurley river (south fork Bridge river) owned by Carl Wihksne *et àl;* and the Eldorado Creek property, owned by the Eldorado Mining Company.[2]

Other Properties.

Besides the above, the following properties, many of which are outside the limits of the map-area, were examined; the Broken Hill property on Sehbring creek, owned by the Broken Hill Mining and Milling Company, Limited, of Vancouver; the Spokane group on Christie creek, owned by Dr. H. A. Christie; the McGillivray Creek mine (old Brett mine) on Anderson lake, owned by the Anderson Lake Mining and Milling Company; the White and Bell group in Eldorado basin; the Wide West group in Taylor basin, owned by E. J. Taylor and the J. Shuster estate; the Summit group on Marshall ridge, owned by W. W. Jones, H. M. Babb, and others; the Primrose group near Marshall lake, owned by J. Ross and W. W. Jones. The Golden Câche and Ample properties on Cayuse creek were also visited.

Chromite.

A small deposit of massive chromite or chrome iron ore of good quality was noted on the northern slope of Taylor basin associated with serpentine and a reddish weathering peridotite.

The chemical analysis of this ore made by the Mines Branch is as follows:

SiO_2	Al_2O_3	CaO	Cr_2O_3	MgO	FeO	Ni	H_2O	
4·82	19·94	0·05	48·72	12·79	12·80	Undet.	Undet.	=99·12

The chromite from Taylor basin has been examined by Mr. R. A. A. Johnston, mineralogist of the Survey, who has noted the presence of very small diamonds in it. The diamonds, after extraction from the chromite, rapidly break up into smaller fragments. The occurrence here of diamonds is similar to that reported by the Survey from Tulameen[3] and Scottie creek[4] near Ashcroft, B.C. in which the diamonds are found also in chromite in a country rock of serpentinized peridotite.

The streams flowing through the Shulops volcanic member of the Cadwallader series are worth prospecting because of the possible presence of diamonds of commercial size as well as platinum. The widest belt of serpentinized peridotite (Shulops volcanics) occurs in the northeastern corner of the map-area along the Shulops mountains and northward to No Axe and Mud lakes. "Float" of aragonite ($CaCO_3$) in radiating globules was noted in the latter localities, either the product of mineral springs or produced by chemical processes of concentration in surface water by reactions between solutions. A narrower belt of serpentinized peridotite follows the western limb of the Bridge River anticlinal dome right to the southeastern corner of the map-area where it is cut off by granodiorite.

Magnesite.

Considerable masses of magnesite of good quality occur associated with the same serpentinized peridotite near Liza lake and in the Shulops mountains.

[1] For description see Summary Report, Geol. Surv., Can., 1912, p. 209.
[2] For description see Summary Report, Geol. Surv., Can., 1912, p. 209.
[3] Camsell, Charles, Geology and Mineral Deposits, Tulameen district, B.C.: Geol. Surv., Can., Memoir 26, pp. 146-153.
[4] Summary Report, Geol. Surv., Can., 1911, pp. 123-124.

The occurrences noted are indicated on the accompanying map. The fusibility of this magnesite was tested by Mr. J. Keele[1] who found it to remain intact at 1,700 degrees Centigrade. A chemical analysis of the magnesium carbonate made by the Mines Branch resulted as follows:

MgO	CaO	FeO	Fe_2O_3	Al_2O_3	CO_2	SiO_2	H_2O (above 105°C)	H_2O (below 105°C)	
43·42	0·46	0·56	0·25	0·23	47·28	7·46	0·58	0·10	=100·34

The magnesite ($MgCO_3$) was probably formed near the surface as a result of the decomposition of serpentine and peridotite by atmospheric waters containing CO_2. It is harder than calcite, with a greater specific gravity. Mr. R. A. A. Johnston found some of the magnesite to be admixed with silica and varying quantities of iron, calcite, and a green chromiferous silicate (possibly mariposite). The formation of magnesite is indicated by the following equation:

$$H_4 Mg_3 Si_2O_9 + 3CO_2 = 3 MgCO_3 + 2H_2O + 2SiO_2.$$

The silica is found deposited as chalcedony in veinlets and vugs. The presence of both chromite and magnesite in this district so far as the writer is aware, has never been reported before.

Antimony.

The ore of antimony in the Bridge River area is the sulphide, stibnite (Sb_2S_3, antimony 71·4 per cent) which occurs in the massive form in a gangue of quartz averaging from 40 to 60 per cent antimony and free from arsenic, zinc, and lead. The ore carries gold values varying from a trace up to $12 per ton. The stibnite is present in small lenses or "pockets," and "nests" varying in width from a fraction of an inch to a foot. The lenses follow fissures and shear zones in a belt extending along the western limb of the Bridge River anticline from McGillivray mountain to Tyaughton lake and northward. The chief country rock of the working properties is the black metabasalt of the Bridge River series which has been intruded in this locality by irregularly shaped masses of a light coloured porphyry highly kaolinized and calcified near the ore.

The Reliance group of 4 claims situated on the southern side of the Bridge River valley opposite Gun creek, and about 1,100 feet above the level of the river, was first located in August, 1910, by F. A. Brewer, who relocated the property in July, 1915. In September, 1915, this property had 4 tons of ore of good grade bagged and ready for shipment. All this ore came from an open-cut, 10 feet deep and 60 feet long, on a fissure vein in metabasalt of the Bridge River series. The vein strikes north 51 degrees east (magnetic) and dips to the northwest from 70 degrees to vertical. A narrow tongue of porphyry resembling Cadwallader diorite, follows the hanging-wall for a short distance and it was at this locality that the ore richest in antimony and highest in gold values ($10.40 per ton in gold, was recovered. Southward, the vein is cut off by a fault striking north 85 degrees east (magnetic). The metabasalt beyond the fault displays pronounced pillow structure. The striations in the fault plane dip to the west at an angle of 32 degrees. The amount and direction of displacement has not yet been determined.

The Stibnite group of claims lies directly opposite the Reliance on the north side of Bridge River valley at an elevation of about 2,445 feet A.T. or 345 feet above the level of the wagon road. The original locators were E. J. Taylor, and the late J. Shuster. The claims were relocated in May, 1915, by C. H. Allan and associates who have been actively carrying on development work on the property during the summer of 1915. A tunnel bearing north 6 degrees west (magnetic) was driven for over 85 feet and several small lenses of ore of good quality encountered. The vein dips to the northwest at an angle varying from 30 to 40 degrees and has been traced for over 200 feet on the surface by means of open-cuts. The uppermost of the three cuts (about 75 feet above the tunnel

[1] Chief of ceramics division, Mines Branch.

level)has exposed 8 inches of massive stibnite in a lens striking north 35 degrees west (magnetic). The ore appears to be scattered in lenses throughout the sheared porphyry mass, several such lenses having been opened up by the tunnel. Near the portal of the tunnel, the vein and porphyry is faulted to the hanging-wall for a distance of about 20 feet. The highest gold values ($12 per ton) are reported from the hanging-wall where the wall is composed of the Bridge River metabasalt. In September, 1915, the stibnite property had several tons of high grade ore bagged and ready for shipment.

The stibnite is considered to have been deposited from hot ascending waters charged with igneous emanations connected with a Tertiary volcanic cycle. The decomposition and concentration of ore in "nests" and "pockets" probably took place at slight depth under moderate pressure. The solutions spread widely through the brecciated and fractured country rocks. It is quite probable that cinnabar (HgS) the sulphide of mercury, which has been reported from several localities associated with the so-called Big Sheep volcanics and which deserves further diligent search, was deposited during the same solfataric stage of volcanism as the stibnite and associated gold.

The occurrences of stibnite so far developed in this region are of such small dimensions and necessitate so much dead work in mining that under present conditions it is very doubtful whether they can be profitably worked. The only chance for the future lies in detailed systematic prospecting and development, in the amalgamation of interests, and, after sufficient ore has been blocked out, the installation of a small smelting plant in the district to produce crude antimony or antimony metal.

Highland Valley Copper Camp, Ashcroft Mining Division.

INTRODUCTION.

The Highland Valley copper camp is situated about 27 miles, by wagon road, southeast of Ashcroft, on the watershed halfway between Ashcroft and Nicola. The occurrence of copper ore at this locality has been known of for more than fifteen years; but, since discovery, the properties have been only sporadically worked, owing, largely, to the long wagon-haul which discouraged active mining operations, other than the regular annual assessment work on the various properties. The early work was done mainly in the capping basaltic lava which is not so favourable an ore-bearing formation as the underlying granitic rocks. Furthermore, a thick mantle of drift and soil covering most of the district and the lack of an abundant water supply render prospecting a difficult task.

Recently, with the increasing demand for ores of copper, more attention has been given to the Highland Valley camp. Bonds have been taken up on certain properties and others have resumed operations. During 1915 the Snowstorm mine, owned by Messrs. G. Couvrette, Geo. Ward, and Stuart Henderson, shipped three cars of high grade ore to the Tacoma smelter. The first car load of 44 tons netted $78 per ton, the second of 32 tons $101 per ton, and the third of 32 tons $77 per ton. The Chataway and Sanson group of claims were bonded in 1914 to Messrs. Frederic Keffer and Henry Johns of Spokane, who have organized the Highland Valley Mining and Development Company and are carrying on systematic development work and accumulating ore on the dumps. On September 8, 1915, the Glossy mine, owned by Mr. J. W. Burr and others, was bonded to Messrs. L. Carlson, O. B. Gerle, and S. P. Dunlevy. A shaft is being sunk and at 30 feet shows 5 feet of ore assaying $28 per ton, the values being mainly in copper. About 20 tons of high grade ore were sacked and ready for shipment at the beginning of October. The cost of wagon-haulage from the Glossy mine to Ashcroft is $6 per ton, while that from the Snowstorm to Ashcroft is $10 per ton. Freight rates to Tacoma from Ashcroft are about $6 per ton.

The approximate positions of the various properties are indicated on the accompanying outline map, compiled in large part from Dawson's Kamloops map-sheet. The district, it will be seen by the map, is within a short distance of the Canadian Pacific railway at Spatzum.

At the close of the field season of 1915 the writer made a short reconnaissance trip to a few of the main properties in Highland valley. Among those visited were the Glossy and Snowstorm, on the northeast side of the valley, and the Tamarac (Sanson), Shamrock, and Chataway group of claims, on the southwest side.

ORE OCCURRENCE.

The copper ore occurs in fault fissure veins traversing a grey granitic rock[1] varying from a granite to a quartz diorite and of upper Jurassic age. The veins so far discovered, are from a few inches to several feet in width and can be traced on the surface for distances varying from 100 to 2,000 feet. They are bent and faulted in places. At least two systems of fissuring are present, one trending in a general north-south direction (magnetic) and with steep dips to the east, the other in a general east-west direction and either vertical, or dipping steeply to the north or south. The Snowstorm fissure belongs to the north-south system and the Chataway, Tamarac, and Glossy belong to the east-west system. The fissures are warped fracture planes and vary a great deal in trend from place to place. The two systems of fissuring correspond closely in direction and dip to the master joint planes in the granitic mass and probably bear genetic relationships to them.

The ore minerals include bornite, chalcocite, chalcopyrite, tetrahedrite, chrysocolla, azurite, malachite, and melanterite with occasionally molybdenite and molybdite; the gangue is made up of quartz, sericite mica, chlorite, and altered granite. The Snowstorm ore, shipped in July 1915, ran 30·78 per cent in copper, 6·44 ounces in silver, and $1.40 in gold per ton.

GENERAL GEOLOGY.

For a description of the general and structural geology and physiography of this region reference may be made to Dawson's "Report on the Area of the Kamloops map-sheet,"[2] and to more recent work by the writer during the field season of 1912.[3]

The following table of formations, taken from the Summary Report, 1912, gives the geological sequence, age, and approximate thickness of the different formations present.

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[1] Microscopic examination of a specimen from the Tamarac property proved to be a quartz diorite.
[2] Geol. Surv., Can., Ann. Report, Vol. VII, 1894, pp. 1-427B.
[3] Summary Report, Geol. Surv., Can., 1912, pp. 115-150.

Table of Formations.

Era.	Period.	Formation name.	Approx. thickness in feet.
Quaternary....	Recent............	Soil and subsoil........................	....
	Pleistocene.........	Fluvioglacial deposits.....................	....
Tertiary.......	Lower Miocene.....	Kamloops Volcanic group.................. Basalt, andesite, agglomerate, breccia, and tuff (Tranquille beds).	3,000 ∓
	Oligocene (?).......	Ashcroft rhyolite porphyry.............. Coldwater group.......................... Conglomerate, sandstone, and shale.	1,000 ∓ 5,000 ∓
Mesozoic......	Lower Cretaceous...	Queen Charlotte Islands formation (?)........ Chiefly shale, conglomerate, and sandstone.	5,000 ±
	Jura-Cretaceous....	Spence Bridge Volcanic group............. Liparitic and andesitic lava, tuff, arkose, and conglomerate.	5,000 ±
	Upper Jurassic.....	Granitic intrusives. Batholith and cupola stocks. Country rock of copper veins.	
	Jura-Triassic.......	Nicola group.............................. Greenstone (porphyrites), impure quartzite, argillite, limestone, agglomerate, and tuff.	10,000 ∓
Palæozoic......	Carboniferous.......	Câche Creek group........................ Cherty quartzite, argillite, greenstone, and limestone (Marble Canyon limestone).	9,500 ∓

DESCRIPTION OF PROPERTIES.

Snowstorm Group. The Snowstorm group of four crown granted claims, and other claims, is situated on Kirkpatrick mountain on the northeast side of Highland valley, 30 miles distant from Ashcroft. The elevation of the main workings is about 5,075 feet above sea-level. The property was located in 1905 by Gilbert Couvrette and is owned by Couvrette, G. Ward, and S. Henderson.

The main vein on the property is opened up by means of a 100-foot shaft with a 62-foot drift at the 50-foot level. The level is connected with the surface by a 70-foot crosscut tunnel. The vein varies in strike from north-northeast to north (magnetic) and dips to the east at an angle of 75 degrees. The ore-shoot from which the shipping ore was mined, has a pitch length of about 125 feet, a stope length, at a point 65 feet below the shaft-collar, of 75 feet, and a stope length in the shaft bottom said to be from 15 to 20 feet. The shoot has a tendency to pitch steeply to the southwest. The average width of the ore-shoot is 2 feet, with a maximum width of 4 feet. Above the tunnel level, the vein makes a sharp bend of 20 degrees and it was in that part of the vein that the highest grade of ore was obtained. The best ore was found to follow the hanging-wall which is well defined and marked at the southwestern end of the ore-shoot by a gouge 1½ feet wide. When the shaft was visited October 1915 it was full of water and inaccessible below the tunnel level. The walls of the vein are an altered granite with, in places, a porphyritic phase on the foot-wall. To date, Mr. Henderson has shipped 108 tons of first grade ore from the above described ore-shoot. Some second grade ore in which the bornite occurs disseminated through the altered granite, lies on the dump awaiting better transportation facilities. Practically no development work has been done in search of additional ore-shoots on the main vein or to locate parallel shoots. Surface prospecting farther up the hill is restricted by the occurrence of capping flows of basaltic lava belonging to the Kamloops Volcanic group (lower Miocene).

Glossy Group. The Glossy group of seven mineral claims is located on the western end of Mount Glossy, 26 miles distant by wagon road from Ashcroft and 9 miles from Spatzum, a siding on the Canadian Pacific railway. The elevation of the main workings is about 5,500 feet above sea-level.

The Glossy, Forge, and Cinder claims were located by the late Isaac Decker, May 31, 1904, and are owned by J. W. Burr and John Wood. The property was bonded to O. B. Gerle, S. P. Dunlevy, and L. Carlson, September 8, 1915, and energetic development work was being pushed with a view to proving sufficient ore to warrant the construction of a railway spur from Spatzum. A wagon road was built to connect the property with the main Ashcroft road; and mine buildings were erected.

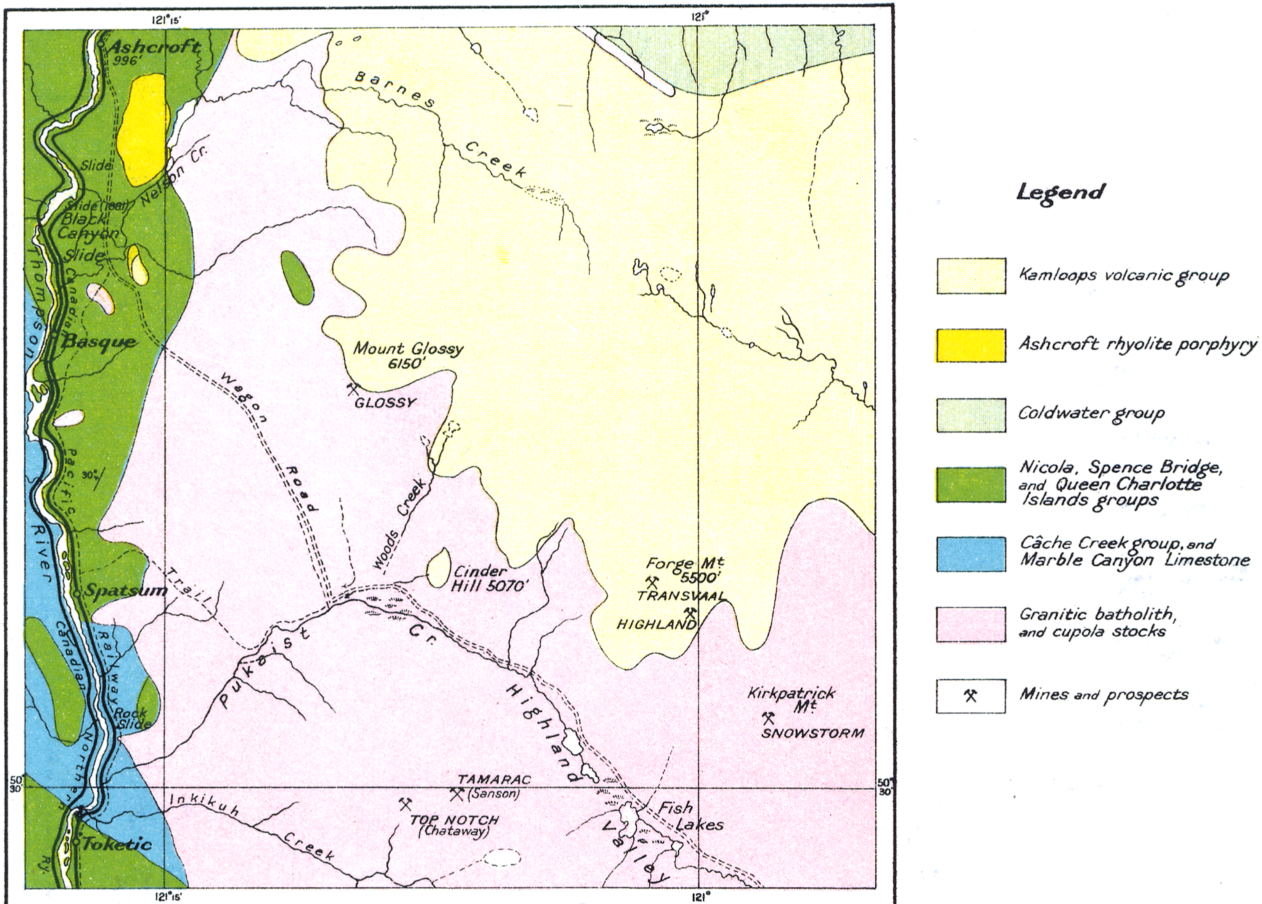
The main vein on the Glossy property is developed by means of a shaft (30 feet deep October 1915) and numerous open-cuts. It has been traced in this manner for a distance of about 2,000 feet along its apex. The strike of the vein at the shaft is north 77 degrees west with a steep northerly dip. It varies in width from a few inches to 9 feet as exposed in a surface trench. The country rock is grey granite and the best values are found on the hanging-wall side of the vein. Owing to the recency of the removal of the protective capping of basaltic lava[1] (Kamloops Volcanic group of lower Miocene age) the upper oxidized zone of the vein is present to a considerable depth. At other properties more remote from the lava remnants, erosion and glaciation removed the oxidized zone and laid bare the sulphides at the surface.

The brightly coloured decomposed ore of the Glossy mine contains malachite, azurite, chrysocolla, melanterite, tetrahedrite, bornite, and probably some undetermined oxides in a gangue of quartz and altered granite. Tetrahedrite or grey copper is more plentiful in depth and the shaft has exposed two streaks, near the centre of the vein, one 4 inches in width and the other 8 inches. About 20 tons of ore were sacked and ready for early shipment at the beginning of October, 1915. Specimens of this ore assay 31·8 per cent of copper ($111.30), 0·10 ounces of gold ($2), and 6·24 ounces of silver ($3) with a total value of $116.30 per ton. A sample of the decomposed ore weighing 1 pound 8 ounces assayed by the Mines Branch was found to contain 0·04 ounce of gold, a trace of silver, and 20·68 per cent of copper to the ton of 2,000 pounds.

Adjoining the Glossy group are five other claims also bonded to the same syndicate. These include the Top Nitch and Spokane located by P. Sawyer and P. Gilbeau. Prospect pits and trenches expose parallel mineralized joint planes in the granite.

Top Notch or Chataway Group. The Top Notch group of four full-sized claims, three of which are surveyed, is located on the southwest side of Highland valley, the Chataway ranch being 25 miles distant from Ashcroft. The mine workings are about 3½ miles from the ranch and wagon road and at an elevation of approximately 5,400 feet above sea-level. The Top Notch claim was located by Geo. Chataway, July 3, 1907. Most of the tunnelling and development work has been done by Chataway and John Cowan. The property was bonded in 1914 by F. Keffer and H. Johns of Spokane, Washington. The main vein is

[1] The lava capping and cliffs are present about 1,000 feet north of the workings and the soil and subsoil at this end of the mountain contain much amygdaloidal basalt derived from the receding lava cliffs.



Geological Survey, Canada. 1611

Diagram of **Highland Valley Copper Camp**

Ashcroft Mining Division, B.C.

Miles

1 0 2 4 6 8

To accompany Summary Report by C.W. Drysdale, 1915.

opened up by means of about 218 feet of adit tunnelling or drifting and 55 feet of crosscutting, the latter to determine the width of the vein at regular intervals. The 50-foot winze near the portal of the tunnel and the shaft beyond the ore dump were inaccessible October 1915. The ore is chalcopyrite, with decomposition products in a soft easily broken gangue of quartz, sericite, and altered wall rock, the sericite being the most abundant gangue mineral. The country rock is the normal coarse-grained granodiorite, intruded by a spotted porphyritic phase containing large phenocrysts of quartz along with chlorite and biotite in a feldspar base. The spotted porphyry was noted at several of the properties and should in future mine work be carefully differentiated from the normal granodiorite.

The ore occurs in a warped fissure vein with a general east-west strike and a vertical to steeply southerly dip. About 120 feet in from the mouth of the tunnel, the vein is cut by a fault which horizontally displaces or heaves the portion of the vein east of the fault, northward or to the foot-wall side. The nature of this faulting is indicated on both sides of the fault plane by drag structures and by a general swinging of the vein in the direction of the faulting. The hanging-wall of the vein is well defined and marked by gouge material and the foot-wall is indefinite and might be defined as a commercial rather than structural wall. The width of the vein matter containing ore has been determined by crosscuts into the foot-wall to be, on an average, about 10 feet. Average assays of the ore are stated to give 5 per cent copper, and gold and silver together 60 cents to the ton.

Tamarac Group. The Tamarac or Sanson group, consisting of seven claims, six of which are surveyed, adjoins to the northeast the Top Notch group. The surveyed claims are the Tamarac, Shamrock, I.X.L. Fraction, Major Fraction, Star, and Duke. The main workings are at an elevation of 5,200 feet above sea-level. The property is owned by Dr. Geo. Sanson and Geo. Ward and was located in July, 1902, by A. M. Leitch and Henry Cargile. The Sanson group is under bond to the Highland Valley Mining and Development Company of Spokane, Washington.

Several parallel quartz veins with general east-west (magnetic) trend and steep northward dip have been disclosed by means of three prospect shafts (inaccessible October 1915), one tunnel, and a number of open-cuts. The veins correspond in strike and dip to the master joint planes in the grey, coarse-grained biotite granite and quartz diorite. The ore is chalcopyrite, bornite, pyrite, and copper carbonates in a quartz-sericite-chlorite gangue of hydrothermally altered granite. Molybdenite and molybdite, the yellow oxide, also occur in small quantities at the Tamarac property[1] and indicate pneumatolitic conditions of deposition. The average metal contents of the surface ore are given as 2·80 per cent copper and about $1 a ton in gold and silver.

Transvaal Group. The Transvaal group of six crown granted claims viz., the Transvaal, Imperial, Chamberlain, Ladysmith, Pretoria, and Mafeking is situated on the northeast side of Highland valley about 19 miles distant from Ashcroft. The property was located in September, 1899, and is owned by Jas. Hosking, Wm. Knight, and Geo. Novak. This property was extensively developed while under bond to the Consolidated Mining and Smelting Company of Canada. Time did not permit its examination, but the following description is taken from the Annual Report of the Minister of Mines, British Columbia, for 1907: "The shaft has two compartments, and is reported to have been sunk 200 feet, with, at the 100-foot level, a drift to the west of 160 feet in length, and another to the east, of 180 feet, and from the latter a 40-foot

[1] Report on the Molybdenite Ores of Canada by T. L. Walker, Mines Branch, Dept. of Mines. No. 93 (1911) pp. 52-53.

cross-cut was driven. At the 200-foot level a drift was made to the east for about 75 feet. The shaft is surmounted by a shaft-house, in which a hoisting engine had been installed, which has since been removed. A few feet to the northeast from the shaft are some large open pits, in which were to be seen a certain amount of blue carbonate of copper, occurring as irregular patches in a black amygdaloidal trap dyke. The mineral, as shown in these cuts, is not present in sufficient quantity to constitute an ore, although appearing greater than it really is, owing to the contrast of the blue carbonate against the black enclosing rock. The underground workings mentioned had been undertaken to prove this surface-showing at a depth, and, judging from the character of the dump and the fact that no ore had been shipped, no ore-body of importance was encountered in the workings.

"Some 1,500 feet from the shaft to the northeast there is a tunnel about 200 feet long, evidently driven to prove up a surface-showing of copper in a similar trap-rock, but, as far as could be seen, no sufficient amount of ore was met with in the tunnel."

Other Highland Valley properties not visited, are:

Highland Group. The Highland group includes seven claims, the Highland, Standard, Glenora, Glenora Fraction, Nickel Plate, and Virginia, all owned by Geo. Novak and J. S. C. Fraser. This group adjoins the Transvaal group on the south, at a slightly lower elevation.

Yellow Jacket Claim and Victor Group. These claims are situated on the southwest side of Highland valley directly opposite the Snowstorm mine. L. Cameron, J. McGillivray, and G. W. Mortimer located the Yellow Jacket, January 4, 1910, and the Victor group in 1914.

Turkey Trot and Tango Claims. The Turkey Trot and Tango claims are situated 2 miles west of Fish lake and were located by R. J. McKay and F. Duttweiler, December 31, 1914.

CONCLUSION.

The copper veins of Highland valley may be classified according to form as lode fissure veins and sulphide disseminations, in a sheared coarse-grained grey granitic rock varying from quartz diorite to granite and associated with spotted porphyry intrusions. One or other of the walls of the veins, most commonly the hanging-wall, is well defined and the other is indistinct and of a commercial rather than structural nature.

The fissuring systems appear to have been controlled in their development by the master joint planes in the granitic mass. Along these joint planes the accumulated crustal stresses found relief by shearing and faulting. The presence in the ores of such high temperature and pressure minerals as sericite, bornite, and molybdenite indicates that the ore-bearing solutions were primary and probably ascended from some deep seated metallic hearth depositing the metals at an intermediate depth below the surface. The magmatic solutions in this case were given off probably following the lower Miocene volcanism, for the capping basalts of the Kamloops Volcanic group are reported to be mineralized and to contain copper ores in places. The sheared and intimately faulted master joint planes served as channels for the solutions and at certain localities the physico-chemical conditions were favourable for the formation of ore-shoots. With more underground development work it may be possible to gather enough geological data to determine the factors which have controlled such localization of values. At present the limited extent of the mine workings and the concealment of so much of the territory by drift and deep overburden prevent the gathering of the necessary information.

The work that has already been done in Highland valley demonstrates the presence of copper veins within comparatively easy reach of the main line of the Canadian Pacific railway. The veins occur in an area covering at least 20 square miles, are of high grade although narrow, and are of deep-seated origin. With further careful prospecting and systematic development, it may be expected that a sufficient quantity of copper ore will be blocked out to warrant the construction of a spur line to connect the Highland Valley camp with the Canadian Pacific railway at Spatzum. Until such transportation facilities are afforded, it will be practically impossible to operate the mines successfully.

Human Skeleton from Silt Bed near Savona, B.C.

A few days were spent at the beginning and end of the field season, in an examination of a locality near Savona, British Columbia, where a human skeleton was discovered in 1911, in beds that were alleged to belong to the Pleistocene white silts of Dawson and, therefore, to be of Glacial age. This claim of great antiquity for the beds was made in a paper presented before the Royal Society of Canada in May 1915, and since, if it were established, it would give evidence of the presence of man in North America at an earlier date than has yet been recorded, it was deemed worthy of investigation. The conclusion was reached that the discovery in no way differs from many others made during the construction of the Canadian Northern railway through the valley in which the skeletons were evidently of modern, burial origin.

After considerable difficulty the writer was fortunate enough to find the original discoverer of the skeleton, a local rancher who was able to direct him to within a few feet of the exact spot where he had unearthed the bones while cutting a trail up to a bench on the Smith Curtis ranch.

The bones were excavated from the east side of a small shallow gully incised in a comparatively narrow, low, alluvial bench. This bench fringes the edge of the rocky north shore of Kamloops lake close to its western end and outlet to the main Thompson river. The Thompson river is at present slowly cutting its channel down to grade and thus lowering the level of the lake. The skeleton locality is about 50 yards east of the Smith Curtis ranch house and about 25 feet above the present level of the lake. The Canadian Northern railway has been built since the discovery and cuts through the silt and gravel bank a few feet below where the bones were found. The railway grade has removed the lower part of the trail but has exposed in a cut a good section of the silt, gravel, and sand in the immediate vicinity. In the gully itself on the eastern side of which the bones were found there is evidence, in the presence of large boulders and wash, of considerable redistribution of materials and it is quite possible that the remains have been disturbed since burial. No trenching into the bench had been done to ascertain whether the surface silt at this locality was not a recent veneer skirting older silts and gravels nor had records been kept to prove that the materials containing the remains had not been redistributed.

No glacial section is exposed on the north-side of the lake at this immediate portion of the valley bottom and the silt, gravel, and sand so well exposed in the railway cut belongs to a series of Recent age. Similar sections are found in many places throughout the Thompson valley, dominantly in the lower portions of valley-fill material and overlying (in most places unconformably) a heavier and more evenly bedded compact clay silt. This clay silt, of glacial origin, is Dawson's 'White Silt' formation of Pleistocene age. Erosion remnants of this massive clay silt and accompanying boulder clay form prominent cliffs several hundred feet above the valley bottom with outstanding 'hoodoos' at many places throughout the valley. This clay silt which presents such a striking feature in the landscape can readily be distinguished from the overlying sandy silts and river gravels of Recent age which are still being deposited at certain aggrading sections of the valley bottom. The shifting of such zones of aggradation and degradation, dependent in large part upon climatic oscillations and in part recent post-Glacial uplift,[1] has taken place in the Thompson valley from the time of the retreat of the valley ice up to the present. Such river and lake deposits of Recent age must be carefully distinguished from the much older glacial outwash materials which were laid down contemporaneously with the retreat of the valley ice. The silt bed in which the remains were found became thinner and pinched out a short distance eastward giving place to gravels and sand. The silt is the normal sandy variety with evidence, in the presence of pronounced cross bedding and stray pebbles up to several inches in diameter, of being laid down by shifting currents in a lake bottom. The silt interfingers and is overlaid by coarse gravel and sand, but no boulder clay nor evenly bedded clay silt (Dawson's 'White Silt') was observed in the vicinity.

Even assuming that the Indian remains were laid down contemporaneously with sedimentation and were not buried by human hands nor animals, nor caught in one of the frequent landslides of this semi-arid youthful[2] valley, there is no physiographic evidence of great antiquity. The alluvial series at this section is clearly of Recent and not Glacial (Pleistocene) age. The Indian woman may have been drowned in Kamloops lake and her body buried along with the normal accumulation of silts and gravels on the lake bottom during one of the many physiographically recent high water stages in the history of the Thompson valley. The lake level is being gradually lowered as the Thompson river continues to cut its course down to grade. This river cutting was probably hastened and the level of the lake rapidly lowered by recent post-Glacial uplift.[3] In this way good sections of Recent gravel, sand, and silt, possibly with entombed remains, have been exposed to view in the valley bottom.

It is natural that in such youthful valleys as that of the Thompson river, where wasting of land goes on rapidly and the corrasive power of streams is great, that landslides and redistribution of unconsolidated valley-fill material should be of common occurrence. The semi-arid nature of the climate further favours such a redistribution of materials as the precipitation in the district is of a semi-torrential type as shown by the character of the valley hill-sides which are carved into innumerable gullies and ravines terminating below at the terrace flats in alluvial fans or aprons.

The skeletal remains have been examined by F. H. S. Knowles, physical anthropologist of this Department, whose report is published in the anthropological section.

It seems evident that the burden of proof for the antiquity of the Savona skeleton rests with the advocates of a Pleistocene age for the Indian remains.

IRON INDUSTRY.—SLOCAN AREA AND GRENVILLE MOUNTAIN, BRITISH COLUMBIA.

(*O. E. LeRoy.*)

From May 22 to August 3, I was engaged as chairman of the committee inquiring into the iron industry of Canada. The interval between August 4 and September 8 was spent in visiting the Slocan silver-lead mines, in gathering

[1] Camsell, Chas., Summary Report, Geol. Surv., Can., 1911, p. 109.
[2] Summary Report, Geol. Surv., Can., 1912, pp. 126-127. Describes the great landslides of 1881 and 1905 and discusses their origin.
[3] Summary Report, Geol. Surv., Can., 1911, p. 109.

information on molybdenite occurrences in southern British Columbia, and in making an examination of the mineralized belt on Grenville mountain near Paulson. Two days were spent with S. J. Schofield in field work west of Kootenay lake correlating the geology of the Slocan area with that of Ainsworth and East Kootenay.

SLOCAN MAP-AREA.

About thirty mines and prospects were being worked at the time of my visit and general conditions were better than they had been for several years. The following working mines were inspected: Hope, Slocan Star, Noonday, and Surprise at Sandon; the Standard and Hewitt at Silverton; the Rambler-Cariboo, Lucky Jim, Whitewater, and Cork-Province. The principal development work was being done on the Payne, Noble Five, and Galena Farm. On the former an upraise was being driven to connect the main tunnel with No. 8 level, a vertical distance of 600 feet. A tunnel was being driven on the Galena Farm to tap the old workings off the shaft. On the Noble Five a deep tunnel was being driven to cut the main vein at over 600 feet vertically below the old workings. Minor development was being done on about fifteen of the smaller properties and several are working under lease.

On the Black Grouse claim, Kane creek (north fork of Carpenter), a small shoot of ore was struck containing native silver and argentite.

The Alturas antimony mine, Kane creek, 18 miles from Three Forks, was shipping ore to Liverpool.

GRENVILLE MOUNTAIN.

Three days were spent in an examination of the Inland Mining Company's claims on Grenville mountain as well as the other claims in the immediate vicinity. The veins are quartz and carry values in gold and silver.

KOOTENAY DISTRICT, BRITISH COLUMBIA.

(*Stuart J. Schofield.*)

The high price of metals caused renewed activity in mining in the Ainsworth mining camp which had been at a standstill since August, 1914. During the field season of 1915, the detailed investigation of the Ainsworth camp was completed after the sphere of operations had been extended to include the Bluebell mine on the east shore of Kootenay lake opposite Ainsworth. In addition to the study of the above camp, investigations were carried on in several districts of British Columbia with a view to correlating the formations of these widely separated regions. In company with O. E. LeRoy typical stratigraphical sections and ore deposits of the Slocan region were examined. The Cambrian section at Canal Flats, which was visited in 1914 by C. W. Drysdale and myself, was revisited with L. D. Burling and further collections of fossils were made. From Canal Flats the Pre-Cambrian rocks of the Purcell series were studied as far south as Wasa, where they were joined with the corresponding sections of the Cranbrook map-area. The great interest taken in the origin of the Purcell trench in the vicinity of Creston warranted the study given to this locality during the past field season. I wish to acknowledge my indebtedness to Mr. S. Fowler of Riondel for the results of his scientific studies of the Bluebell mine, which have extended over several years.

M. F. Bancroft, under my supervision studied and correlated the rocks exposed on the eastern shore of Kootenay lake and as far east as the western boundary of the Cranbrook-map-area. Mr. Bancroft submits a separate report.

O. D. Boggs acted ably as geological assistant.

Ainsworth Mining Camp.

In this report only a brief mention will be made of the results accomplished, since a final report on this area is now in preparation. The rocks and the chief ore deposits were described in the Summary Report of 1914. During the season of 1915 the surface mapping as well as the examination of the principal prospects of the area were completed.

Highland Mine. In the Highland mine, ore has been found on the fifth level which was driven during the winter months. The ore occurs at the contact of the quartzite and the overlying green hornblende schists.

This occurrence substantiates the results of the investigation of last year, published in the Summary Report of 1914. The tunnel will open up the ore-body between the fifth and the third levels and as soon as the level can be placed in working condition, a large output may be expected.

No. 1 Mine. No. 1 mine was reopened in February of this year. At present the inclined shaft is being extended below the third level to cut the vein where it apparently will resume its normal or westerly dip.

Bluebell Mine. The Bluebell mine, situated on the eastern shore of Kootenay lake opposite Ainsworth, is supposed to be the earliest known lead deposit in British Columbia. The ore deposit is a replacement of crystalline limestone at its contact with an overlying mica schist; and since these enclosing rocks strike almost north and south with a dip of 45 degrees to the west, the ore-bodies have a concordant position. The ore consists mainly of pyrrhotite and galena with small quantities of pyrite, zinc blende, and native copper, in a gangue of calcite, silicified limestone, and pyroxene. As noticed by previous investigators, the ore shoots are apparently associated with east and west fissures.

District East of Kootenay Lake.

(*M. F. Bancroft.*)

A reconnaissance by S. J. Schofield[1] in the Kootenay district of British Columbia during the field season of 1913 embraced a distinctly promising field for unravelling still further the geology of the Purcell range.

The Purcell range, as defined by Dr. R. A. Daly, constitutes a mountain system trending slightly west of north. The boundaries of this group are marked by structural depressions and valleys in which flow the master streams of the region. The structural depressions are the Rocky Mountain trench on the east and the Purcell trench on the west. Kootenay lake occupies the southern third of the Purcell trench. The southern boundary is in the United States where the Kootenay River valley leaves the Rocky Mountain trench and connects the two trenches east to west. The Purcell range, as defined, lies between the

[1] S. J. Schofield, Summary Report, Geol. Surv., Can., 1913, page 130. G. S. C., Memoir 76, 1915.

[2] R. A. Daly, Geol. Surv., Can., Memoir 38, 1912, page 30, and Memoir 68, 1915, chapter I.

Rocky Mountain system and the Selkirk system of British Columbia. Within these boundaries it covers an area of about 250 miles in latitude by about 60 miles in longitude.

From a geological standpoint our knowledge of the area under consideration has been greatly increased since 1912 through the reports to the Geological Survey by Dr. Daly and S. J. Schofield.

With this recent accumulation of an immense number of facts there is inevitably introduced in their classification a certain number of new names still quite unfamiliar to workers outside this particular field.

On structural evidence[1] it is stated that the Purcell range belongs to one mountain assemblage or orogenic unit consisting of northerly-striking anticlines and synclines. Hence the geology of any one selected area will require a more or less general presentation since it forms an integral part of the geology of the whole range.

For the above reason this preliminary report can only outline the general geological features and economic geology of the area in question.

During the field seasons of 1913 and 1914 the writer became acquainted with the sedimentary rock types and formations which make up the geological structure of the region. Continuing under the general supervision of Mr. Schofield the writer in 1915 made structure sections to determine the stratigraphy, east of Kootenay lake on the western boundary across the watershed of the range. John Whitebread of Nelson, B.C., was employed as assistant.

The area chosen by the Survey for investigation comprises approximately 18 miles in longitude by 27 miles in latitude, the limits being 116°30′ to 116°39′ west and from 49°24′ to 49°45′ north.

The eastern shore of Kootenay lake from a point 4 miles north of Kuskonook to about opposite Ainsworth furnished the base line for the telemeter survey and points of entry to the field.

THE GENERAL CHARACTER OF THE DISTRICT SURVEYED.

The topography is rugged and consists of irregular mountain groups.

The relief in the area varies from Kootenay lake, with an elevation of 1,760 feet above sea-level to the highest mountain locally known as Snow Crest, with an elevation well over 9,000 feet. The summit country has a number of peaks approaching 9,000 feet and the elevations along the divide in few places fall below 6,500 feet.

The character of the relief is well illustrated in the Purcell trench. Taking an average profile in that region, it is found that in a distance of 2½ miles from the shore of Kootenay lake there is a rise of 4,000 feet. From this point the summit country is approached by a much gentler grade.

Drainage.

The south fork of St. Mary river is the principal stream draining the part of the area which lies east of the divide. From the western slope of the divide six separate streams averaging 10 miles in length flow down into Kootenay lake.

Kootenay lake is the general base-level for the drainage of the area. The water flowing east from the divide pursues a very much longer course via St. Mary and Kootenay rivers to the lake than the water flowing down the western watershed.

[1] S. J. Schofield, Summary Report, Geol. Surv., Can., 1913, p. 135.

Glaciation.

At present small glaciers are found in many rock basins in the neighbourhood of the divide. That glaciers formerly mantled the whole region is shown in the erosion forms of the country. Vertically walled valleys, waterfalls from tributary streams, and empty rock bound amphitheatres are everywhere conspicuous. The soil covering and erratic boulders are further evidence of widespread glaciation of the region.

GENERAL GEOLOGY.

The area embraces a large region of sedimentary, non-fossiliferous, metamorphosed rocks. It was hoped that the investigation of this field might furnish further chronological data, since the Pre-Cambrian age of these rocks has not been definitely proved. However, nothing determinative has been found to effect this classification.

This enormous thickness of conformable sedimentary rocks has been subdivided into three series as they occur in the area studied: the Purcell series, the Selkirk series, and the Shuswap series of Kootenay lake.

The Purcell series, as defined by Daly and Schofield, along the International Boundary and in East Kootenay, crosses the eastern edge of the area and occupies most of the region east of the divide. The series consists of a great thickness of argillaceous quartzites, argillites, and limestones.

The Selkirk series, as here identified by[1] R. G. McConnell, is to be found on the western slope of the Purcell range, and on the basis of field evidence is to be considered as in part the equivalent of the Purcell series. The eastern geological boundary of the Selkirk series is along the[2] Creston formation, a member of the lower part of the Purcell series. The Creston formation appears to be the conformable base of the Selkirk series. The Selkirk series consists of alternating bands of coloured schists, heavily bedded quartzites, hard conglomerates, dolomites, dolomite conglomerates, or pseudo-conglomerates and thin sheets of dyke rock.

The Shuswap series of Kootenay lake is represented on the northwest side of the area investigated and appears to pass in this region conformably over the Selkirk series. The Shuswap series consists of grey gneisses, mica schists, crystalline limestones, garnetiferous schists, and quartzites, invaded by numerous unaltered pegmatite dykes.

The structural geology in this conformable accumulation of sediments appears to be dominated by open folding consisting of northerly striking anticlines and synclines.

The igneous geology is recorded throughout the sedimentary belt by the injection of thin acidic and basic dykes.

A large body of granite crosses the southern edge of the area and cuts off the southern extension of the Selkirk and Purcell series. From its wide extent and manner of invasion this igneous body may be considered as a batholith with the Selkirk series and Purcell strata covering portions still concealed. In addition to the great batholith a small stock of granite invades the Shuswap and Selkirk series in common. There are no other areas of igneous rock in the region surveyed.

Through the Selkirk series there are distinctly recorded at least two separate invasions of igneous material. These are highly altered thin sheets fully as schistose as the invaded rock with which they are interbedded and a fresh, unmetamorphosed, and, therefore, younger intrusive.

[1] McConnell, R. G., Geol. Surv., Can., Annual Report, Vol. X, 1897, page 31A.
[2] S. J. Schofield, Summary Report, Geol. Surv., Can., 1913, page 136.

The problems of contact and regional metamorphism and the description of the voluminous stratigraphic column are beyond the scope of this preliminary report.

ECONOMIC GEOLOGY.

There are no mines at present in operation in the region, but several groups of claims were staked near the divide in the early nineties of the last century. At that time the Kootenay district, owing to the discovery of rich silver lead properties in British Columbia, Idaho, and Montana, was over-run by prospectors.

The discovery of the Silver Hill mine, located at the head of Canyon creek, and the White Grouse claims to the southeast of the area, led prospectors to a very considerable outlay of money and labour in the region.

The ore deposits may be classified as follows:

Bedrock deposits—primary.
- Syngenetic (contemporaneous).
  - Sedimentary represented by thin bed of hematite.
- Epigenetic (subsequent).
  - Fissure veins.
    - Parallel to the bedding planes.
    - Cutting across the country rock.
  - Replacements in limestone.

The ore from the fissure veins consists mainly of coarse-grained galena and zinc blende, with smaller amounts of pyrite and chalcopyrite.

The groups of claims in the Selkirk series are: the Humboldt mine, the Canyon Creek claims, Johnson's claims, Proctor Basin claims, the Five Metals claim, the Grey's Creek iron claim, the La France Mining Company property, and the Dark Canyon claim. Besides these the German Mountain group of claims of Messrs. Kuhn and Holland and the Valparaiso and Imperial mines are found in the large granite area on the south of the area. This list sums up the properties in which any interest has been taken in recent years by prospectors.

Although none of these properties appear to be of striking economic importance under the present facilities for transportation, yet a study of the ore-bodies is of some scientific value and will afford some knowledge of the character of the deposits that may be expected to be found in the region.

Numerous specimens were collected for study, and these will enable the writer to prepare a detailed description of the properties examined, at a later date.

NOTES ON THE STRATIGRAPHY OF THE ROCKY MOUNTAINS, ALBERTA AND BRITISH COLUMBIA.

(*Lancaster D. Burling.*)

The work of the 1915 field season consisted in the examination of two sections, one along the Canadian Pacific railway between Banff, Alberta, and Golden, British Columbia; the other in the vicinity of Mount Robson on the Grand Trunk Pacific railway. In this work the writer had the effective assistance of E. C. Annes. The objective was the detailed study of the lower Palæozoic rocks and fossils for use in a general report on the lower Palæozoic stratigraphy of the Cordilleras. The publication of this larger report will naturally be somewhat delayed, but some of the stratigraphic data secured are of sufficient general interest to warrant their brief description at the present time For convenience these data will be presented in stratigraphic order, the youngest first:

Jurassic. The small triangular outcrop of shales occurring just west and north of Massive, Alberta,[1] and described[2] as a "downfaulted block of dark brown Fernie shales containing ammonites, which indicate that they are Jurassic in age," was visited for the purpose of securing some of the ammonites for the collections of the Survey. Several species were secured, the most striking of the number being a nearly complete specimen of a fossil fish. This appears to be from the same horizon as the fish described from an unknown horizon and locality, under the name of *Platysomus canadensis.*[3] No associated species were available to assist in determining the stratigraphic position of the latter specimen and it was tentatively placed in the Permian. The fossils seeured, together with other collections made by E. M. Kindle and H. W. Shimer in the same region, indicate the general correctness of the tentative correlation of the rocks at this point with the Upper Banff shale. There appears, therefore, to be no known Jurassic along the railway section west of Banff; and the outcrop west and north of Massive, instead of being faulted down into contact with the Carboniferous Rocky Mountain quartzite to the east, is a representative of the Upper Banff shale and occupies its normal position above the Carboniferous. The collections secured appear to afford new data as to the systemic relations of the Upper Banff shale, but these have not yet been determined.

Devonian. The Devonian was found to lie without observable unconformity upon the Cambrian in the Sawback range west of Banff, Alberta, and S. J. Schofield and C. W. Drysdale (personal communication, 1914), report similar conditions in the mountain north of the head of Upper Columbia lake, 60 miles to the south. The fossils which were secured from the Devonian have been referred by Kindle to the middle and upper portions of that system and the underlying strata are referred to the Upper Cambrian. Dr. F. D. Adams[4] has recently described a similar condition of affairs in North Kootenay pass, 80 miles to the southeast of Upper Columbia lake, and only a short distance east of Elko where Mr. Schofield[5] found the Cambrian and the Devonian to be separated only by a formation, the Elko, whose age relations were not known. Mr. Schofield and the writer visited the Upper Columbia Lake locality during the 1915 field season and in addition to the collections which they secured near the Cambro-Devonian contact, they were able to prove that the Elko limestone is to be referred to the Cambrian. Consequently the juxtaposition of the Devonian and Cambrian is proven to be true over an area some 125 miles long in a north and south direction and 50 miles in lateral extent. Thirty miles west of the most northern of these four localities, however, the Cambrian is overlain by 10,000 feet or more of Ordovician and Silurian strata.

Ordovician. The Goodsir shale[6] has been described[7] as forming the base of the Ordovician in the Canadian Pacific Railway section. The evidence for this determination was the presence in the lower portion of this 6,000-foot formation of a small fauna from which Mr. Walcott has identified and described a new species of "*Ceratopyge.*" Several faunal horizons have now been discovered in this formation and an additional collection secured from the "*Ceratopyge*" horizon which indicates that the lower part of the Goodsir shales should be

[1] "Route Map, between Banff and Golden," Twelfth International Geological Congress, 1913, Guide Book No. 8, Part II, opposite p. 188.
[2] Idem. p. 191.
[3] Lambe, Trans. Roy. Soc. Canada, 3d ser., vol. VIII, section 4, 1914, pp. 17-23.
[4] Paper before the Geological Society of America, Washington Meeting 1915.
[5] Summary Rept. Geol. Survey, Canada, for 1913, pp. 131-132, 1914.
[6] Allan, Sum. Rept. Geol. Survey, Canada, 1911, 1912, p. 180.
[7] Walcott, Smithsonian Misc. Coll., vol. 57, No. 7, 1912, p. 229.

correlated with the Upper Cambrian Orr formation of the House Range section, Utah.[1]

Cambrian. The Sawback formation is a term proposed by J. A. Allan[2] for the series of rocks lying below the Intermediate limestone in the Sawback range west of Banff, Alberta. In 1887, R. G. McConnell[3] mapped and described these rocks as Cambrian, referring them to the Castle Mountain group, but the collections which he made at that time, and which are preserved in the collections of the Survey, were not mentioned in his report and have escaped notice. Because of lithological differences between the rocks of the Sawback formation and the Cambrian to the west, Mr. Allan removed that formation from the Cambrian and placed it more or less tentatively in the Devonian,[4] a reference which he confirmed in 1915.[5] During the field season of 1915 this formation was first studied by Mr. Kindle who secured Cambrian fossils from the upper part of the section. Subsequently the writer examined the formation in detail and secured fossils from a dozen or more faunal horizons in the section. These are all of Cambrian age, and confirm Mr. McConnell's early reference of this group of rocks to that system.

Further collections were secured from the Upper Cambrian Ottertail limestone[6] which will not only enable us to determine the age relationships of that formation still more closely, but will serve to delimit the underlying Chancellor formation from whose 4,500 feet of strata no fossils have yet been secured.

The line between the Middle and Upper Cambrian was found over wide areas to be the locus of a pronounced emergence of the sea bottom. Limestones with Middle Cambrian faunas grade upward into a series of thin-bedded limestones whose upper layers exhibit the peculiar type of down-warping along joint planes exhibited by the Lockport dolomite near Niagara Falls.[7] This horizon, which in itself bears evidence of prolonged exposure to the air, is overlain by a series of red and yellow shales with ripple-marks, mud-cracks, and casts of salt crystals, and these in turn give way to limestones with faunas of Upper Cambrian age. These continental features first appear in the basal beds of the Bosworth formation on the Canadian Pacific railway and at the base of the Lynx formation on the Grand Trunk Pacific railway and serve to correlate at least part of these formations with each other and to indicate the correctness of their reference to the Upper Cambrian.

The "Lower Cambrian" Albertella fauna was assigned by the writer in 1914[8] to the Middle Cambrian, a reference which was of necessity based solely on a comparative study of the fauna, since it was only known from drift blocks or from sections in which its stratigraphic position was ill defined. During the past summer the writer was fortunate in finding the Albertella fauna in place in the Middle Cambrian strata of Mount Bosworth, British Columbia; in Castle mountain, Alberta; and near Mount Robson on the Grand Trunk Pacific railway. At the latter locality it is in the limestones of the Chetang formation; in the two former it is in a shale interbedded several hundred feet up in the Cathedral limestone. Its true position is thus approximately 700 feet above the horizon to which it has been assigned.[9] It is, of course, possible that earlier horizons may

[1] Walcott, Smithsonian Misc. Coll., vol. 53, No. 5, 1908, pp. 175-177.
[2] Sum. Rept., Geol. Survey, Canada, for 1912, 1913, p. 172.
[3] Ann. Rept. Geol. and Nat. Hist. Survey, Canada, 1886, p. 28D.
[4] Sum. Rept. Geol. Survey, Canada, for 1912, issued 1914, p. 172. Twelfth Inter. Geol. Congress, Guide Book No. 8, Part II, 1913, p. 182.
[5] Idem. for 1914, issued 1915, p. 43.
[6] Allan, Sum. Rept. Geol. Surv., Canada, for 1911, 1912, p. 180.
[7] Kindle and Taylor, Geol. Atlas, U.S., Niagara Folio No. 190, 1913, Illustrations III, Plate XXIV.
[8] Early Cambrian stratigraphy in the North American Cordillera, with discussion of the Albertella and related faunas. Geol. Survey, Canada, Museum Bull. No. 2, 1914, pp. 93-129.
[9] Walcott, Smithsonian Misc. Coll., Vol. 55, No. 2, 1908, pp. 21-22; No. 5, 1908, pp. 203, 212. Vol. 57, No. 8, 1912, pp. 242, 244, etc.

yield and may have yielded representatives of this characteristic fauna, but there is no question regarding the reference of the large drift block on the slopes of Mount Bosworth to the horizon just described instead of to the lower portion of the Mount Whyte.

The Albertella fauna is of special interest because it is the oldest Cambrian fauna yet found in contact with the Pre-Cambrian rocks of Montana and the region adjacent to the International Boundary. However complete the diastrophic evidence regarding the Pre-Cambrian age of the Siyeh limestone and its associated rocks may be considered to be, these Beltian rocks are only proven by the faunal evidence to be pre-Albertella or pre-early Middle Cambrian in age. Among the early collections of Dr. George M. Dawson in the vicinity of the Upper Columbia lakes, however, there is a well defined species of *Olenellus* and it is possible that this region may be the key to the difficulty. In a reconnaissance of the region by Mr.Schofield and the writer in the past summer the Cambrian section was extended for a considerable thickness downward, but the Lower Cambrian was not found nor were the relations of the Cambrian to the Galton series observed.

At the line separating the Middle from the Lower Cambrian, evidence was secured indicating the presence of a diastrophic break of considerable magnitude. No specimens of undoubted *Olenellus* were found above this line and isolated examples would seem to be too easily explained as recurrences[1] to necessitate the placing of the boundary between the Lower and Middle Cambrian at the top of the Mount Whyte formation.[2] As suggested in 1914[3], the upper portion of this formation seems to be correctly referred to the Middle Cambrian, leaving the lower massive limestones containing *Olenellus* in the Lower Cambrian with the underlying St. Piran. Incidentally this restores McConnell's Bow River group as a term confined to rocks of pre-Middle Cambrian age.

Collections of the "New Lower Cambrian subfauna," described by Mr. Walcott[4] from the Mahto formation, were secured from the drift at the type locality upon the surface of the Mural glacier and include a new species of the Mesonacidae somewhat closely resembling *Paedumias*[5] in general outline and the telsonlike spine on the fifteenth segment, but differing from that genus in having at least twenty-nine (the end is broken away) rudimentary segments posterior to the fifteenth. The species appears to occupy a position preceding *Paedumias* and succeeding *Mesonacis* on the line of development between *Nevadia* and *Olenellus*.[6]

SIMPSON PASS TO KANANASKIS, ROCKY MOUNTAINS PARK, ALBERTA.

(*John A. Allan.*)

The writer spent fifteen days (Sept. 1 to 14,) in the field this season collecting data to complete the field work on a geological section across the Rocky mountains in the vicinity of the main line of the Canadian Pacific railway.

A trip was made up Healy creek, across Simpson pass, and down Redearth creek, to ascertain the structural relations existing between the older, western part

[1] Burling, Geol. Surv., Canada, Museum Bull. No. 2, 1914, p. 106.
[2] Walcott, Smithsonian Misc. Coll., vol. 53, No. 5, 1908, pp. 212-215.
[3] Burling, Geol. Surv., Canada, Museum Bull. No. 2, 1914, p. 106.
[4] Smithsonian Misc. Coll., vol. 6, No. 11, 1913, pp. 309-316.
[5] Walcott, Idem, vol. 53, No. 6, 1910, p. 304.
[6] Idem, pl. 44.

of the Rocky mountains, made up essentially of Pre-Cambrian and Cambrian strata, and the younger, eastern part of this mountain system consisting largely of later Palæozoic sediments. A few days were spent east of Banff in the Fairholme range examining the relations existing between the later Palæozoic and the lower Mesozoic sediments. Two days were spent in the Sawback range making a further examination of the Sawback formation which has been previously stated to be lying conformably below the Intermediate formation, which is Devonian in age.

The stratigraphic section west of Bankhead has been tabulated by the writer in Guide Book No. 8, Part II, pages 168-171 of the International Geological Congress, 1913. A structure section of the formations west of Minnewanka lake accompanies the same report.

Simpson Pass.

At the head of Healy creek, in the vicinity of Simpson pass, the beds consist of white and ferruginous quartzites, siliceous slates, and thick-bedded conglomerates of Lower Cambrian age. To the northeast of the pass a fault has displaced these beds against a series of limestones and interbedded shales which are older than the Intermediate formation exposed in the base of Bourgeau mountain. The conglomerate series is several hundred feet thick and does not everywhere lie at the base of the Cambrian. An excellent exposure was observed at the head of the south fork of Redearth creek, at the foot of Monarch mountain, which showed the flat-lying Pre-Cambrian slates overlain conformably by massive-bedded white quartzites.

The Lower Cambrian beds form a prominent escarpment on the eastern side of Mount Ball range from Simpson pass to Vermilion pass. The base of these cliffs defines approximately the contact between the Cambrian and the Pre-Cambrian.

Fairholme Range.

The structure in the southwestern slope of this range, from the west end of Minnewanka lake to the Gap, is quite regular, consisting of the formations from the Intermediate limestone (upper Devonian) to the Upper Banff shales (Permian ?). The northeastern slope of this range is much broken up with complex faulting.

It has been found very difficult in the field to draw any sharp line between the Lower Banff and the Intermediate limestones from their lithological appearance. Several good fossil horizons were found in this range which will make it possible to subdivide the formations more accurately.

During the season of 1914 the writer found a series of Cambrian strata in the Ghost River valley northeast of Devils gap, near the point where the valley opens out into the plains. No such series is exposed along the Bow valley east of Kananaskis, so that these beds are apparently cut off between Devils gap and the Bow river by the overthrust which defines the eastern limit of the Rocky Mountains system.

Sawback Range.

In the Summary Report for 1912, page 172, the writer applied the name Sawback formation to a series of beds exposed in the Sawback range which are older than the Intermediate formation (upper Devonian). Further examination of these beds was made this season to ascertain their age.

Continuing west from Mount Edith a series of grey arenaceous limestones, weathering quite irregularly, is overlain by a series of shales weathering brown, yellow, buff, and reddish. These shales are overlain by limestones and shales including oolitic beds of dolomitic limestone. In the oolite beds numerous fragments of Upper Cambrian fossils, chiefly trilobites, occur. These fragments determine the age of the beds, which can also be correlated with the Paget formation (Upper Cambrian) exposed to the west. The shales which underlie the series containing the oolitic beds are lithologically like the Bosworth formation. In this shale series the writer found a band containing numerous well-preserved salt crystals. This fact seems to indicate the continental origin of these shales. The grey arenaceous limestones at the base of this section correspond to the Eldon formation (Middle Cambrian).

At least the lower part of the Sawback formation is, therefore, Cambrian in age. Since the palæontological details of this section were worked up by Mr. Burling in the field this summer, his report will deal with the relation of the Sawback formation to the overlying Devonian beds.

Trails.

The Parks Department by rebuilding old trails and making new ones is rapidly opening up and making more accessible to the tourist several hundred square miles of the most superb scenery along the eastern slope of the range which forms the continental watershed.

A trail has been opened during this season from Simpson pass, down Redearth creek, with a branch from Shadow lakes which connects with the trail running on the south side of the Bow river from Banff to Castle. Another new trail has been made from the Bow river, up Brewster creek and over the summit to Assiniboine pass. In some parts these trails are still in a very bad condition, but it is hoped that some of these difficulties will soon be overcome.

WATER SUPPLY, SOUTHEASTERN ALBERTA.

(*D. B. Dowling.*)

Investigations relating to the economic geology of the central provinces, under the general supervision of the writer, were directed to the more exact elucidation of the geological structure of western Manitoba and southern Alberta. In Manitoba the Cretaceous plateau is formed of the measures that in Alberta contain gas in favourable locations; and this fact suggested the possibility that if these beds in Manitoba contained porous members or were slightly flexed, gas fields probably small in area might be found in them. The result of the inquiry does not seem to favour the possibility of finding gas fields; but, as certain of the shales are more or less impregnated with oil, there may possibly be an industry established for the extraction of gas or oil from them. The examination of these formations was under the direction of Alexander MacLean of Toronto university.

In Alberta the principal interest was centred in the search for oil. The results were rather discouraging for the broken foothill country, with the exception perhaps of a few wells on the Sheep River anticline. The search was continued farther south and on the wide anticline underlying the plains to the east. The field work for 1914 was principally devoted to a study of the structure of the outer foothills from Bow river south to Oldman river, by S. E. Slipper and J. S. Stewart. This work was extended in 1915 by Mr. Stewart to the International

Boundary and the collection of well records and samples was continued under the direction of Mr. Slipper. The revision of the geology of the Blairmore area, dealing principally with the coal areas to the east of the Crowsnest pass, left incomplete by the death of Mr. W. W. Leach, was undertaken by Mr. Bruce Rose.

In the prairie region south of the Oldman river, three wells were being drilled for oil. This area is a part of the so-called dry belt, and one result of the drilling was the discovery of a supply of potable water at a moderate depth. It was the opinion of the Board of Trade at Lethbridge and of many influential people resident in the district, that this pointed to a possible valuable artesian supply, and at their earnest solicitation most of my own time and that of Mr. Slipper was devoted during the summer to a study of the conditions relating to water supply for this district. In this work valuable assistance was received from Mr. Peters, engineer in charge of irrigation surveys for the Interior Department, who supplied records of levels determined under his supervision.

WATER SUPPLY.

The area covered by the accompanying map is situated just east of the belt of disturbed rocks which form the foothills, and lies at a lower level than that belt. The underlying rocks are slightly flexed, forming an arch or anticline which dips to the north and also flattens in that direction. The streams which have their origin in the mountains to the southwest flow north into the valley of Oldman river, which lies along the northern edge of the area, and a smaller drainage flows east just north of the International Boundary in the valley of Milk river, a tributary of the Missouri. These two streams diverge at an obtuse angle, so that there is left a large area which is not crossed by any outside drainage. As the rainfall is below the normal of that of the northern part of Alberta the line of saturation in the underlying rocks depends greatly on the level of these two river valleys; and as they are cut deeply below the general level of the plain the surface rocks although porous have gradually become dry. The points at which moisture from these streams is admitted to the surface rocks are few and are confined to the higher land to the west and south.

In the hills called the Milk River ridge, situated north of Milk river, the beds, which are mostly sands and clays, dip gently to the west and north and where they are crossed by the river undoubtedly receive water which is found in wells to the north of these hills. The rainfall on this elevated strip is also greater than in the low country to the east and feeds the small streams and springs situated along its margin; but this drainage is absorbed in a short distance by the porous surface rocks to the north and east and does not extend far from the hills. The elevated country to the south of the boundary line, called the Sweet Grass hills, has a fairly copious rainfall, but the streams flowing from it have only a short course in Canada before discharging into the Milk river. To the east the elevated land crowned by the Cypress hills receives also a quota of the rainfall and, as the evaporation is not excessive, small streams flow westward from it toward the basin, but are deflected north by the valley of Sevenpersons coulée or the basin of Pakowki lake. The central area cut off in this way from a supply of water from the surrounding country is dependent on the uncertain precipitation within its own confines, which in several seasons has fallen very low. During the dry periods the moisture is lost not only through evaporation but also by drainage into the deeply scored old channels and most of the wells in the area become dry.

Irrigation.

In the northwestern section artificial watering or irrigation has been applied to what may be called the Lethbridge district, the water being obtained from St. Mary river near the boundary.

Other irrigable areas have been surveyed and outlined, but the realization of these projects requires time and the expenditure of large amounts of money.

Artesian Supply.

It has been suggested that in the meantime the settlers may be able to supply their stock with water by sinking wells and the present investigation into the rock structure of the dry district has had as its ultimate object the determination of the possibility of such an artesian supply.

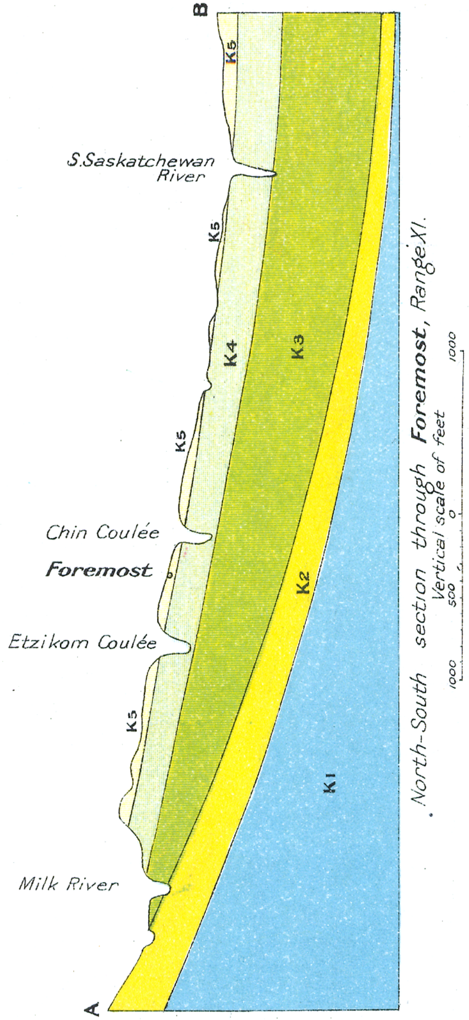
The results of this study briefly are: that the sandstones along Milk river are porous and receive and retain water; that these beds form an arch or anticline on Milk river which broadens and flattens to the north with a general downward inclination in that direction; that the saturation of these sandstones is continued down the slopes in a general north and east direction until balanced and held back by natural gas contained in the pores of the rock. As these beds are covered by fine textured shales, the contained water is under a pressure dependent on the height of the source of supply and will rise to approximately that elevation. As the country slopes to the north toward the Oldman and South Saskatchewan rivers there is a large area in which the depth from the surface to the underlying water-bearing sands is quite uniformly about 800 feet. The area in which the water may be expected to reach the surface is, however, confined to the part north of Chin coulée and to the lower land reaching the Milk river by way of the Pakowki Lake depression. In the absence of an exact determination of the line between water and gas by experiment, the northern limit of the water has been placed tentatively at the latitude of Purple Springs and Bow Island, but east and west of these points it may trend to the northward. The area that has been mapped as being low enough to warrant the expectation that wells sunk in it deep enough to reach the Milk River sandstones will be flowing wells, comprises about 1,000,000 acres. This area may be restricted on the north by the presence of gas instead of water and also may be restricted to a still lower level than that marked owing to a possible greater loss of head than that allowed; and pumping may have to be resorted to in the higher ground. The area may be increased to the east and west by sinking deeper wells; the limit of depth assumed for the area marked on the map is 800 feet.

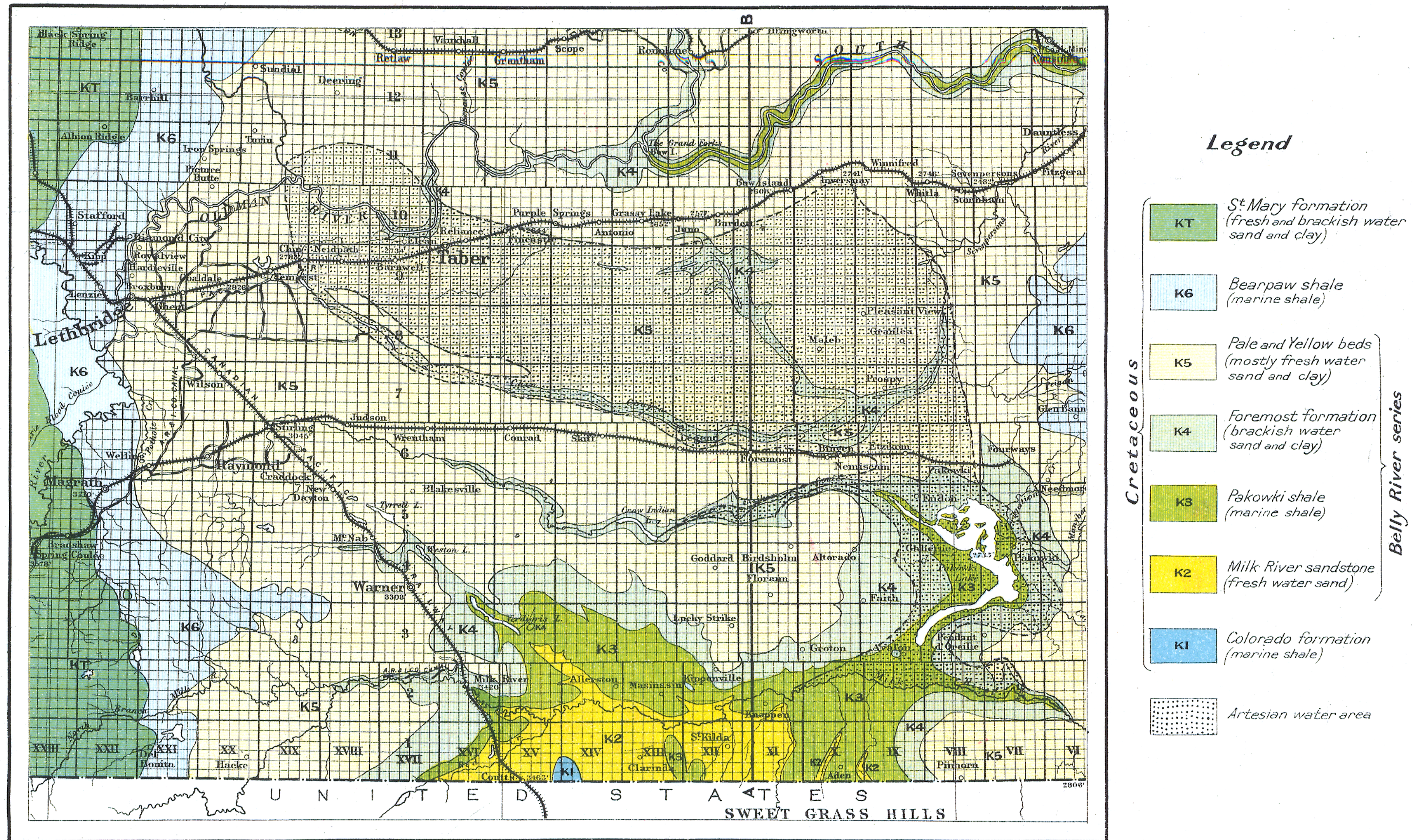
Wells in the District.

There are a few deep wells in this district that have reached the water-bearing sands and records of a number of them have been kept. In order to indicate the general dip of the beds away from the centre of the anticline the following wells located on either side of this area are cited:

Lethbridge Well. The record of a well drilled for the town by Jas. Peat and Son shows the sandy beds, which are apparently the base of the Belly River formation, to be at a depth of 1,603 feet. The lower members of this series probably correspond to the Milk River sandstones. Water came into the well in a bed of sand between 1,556 and 1,603 feet below the surface.

Medicine Hat Wells. In the records for the gas wells the most of the formations passed through are shales, but above the gas sand there is a thickness of from 200 to 300 feet of brown sandy shales that seem to represent the seaward continuation of the Milk River sandstones. The base of the formation is, however,





Geological Survey, Canada. 1604

Artesian Water Area, Southern Alberta.

Miles
10 5 0 10 20 30 40 50

To accompany Summary Report by D.B.Dowling, 1915.

nearly pure sand and from it is obtained the greater part of the gas supply, although gas is also found in the sandy shales above. The bottom of the sandy series is about 1,000 feet below the river bench on which part of the town is built, or 1,300 feet below the p. airie level.

Taber Well. In this well it is considered that the representatives of the Milk River sandstone are reached at 602 to 810 feet. At 670 feet a flow of water was struck which flowed from the top of the well.

These three wells are referred to in order to show the comparative depths of the water-bearing strata along an east and west line. Subtracting the depths at which the sands were encountered from the surface elevations we get for Lethbridge a height above sea-level for the top and bottom of these sands of 1,426 feet and 1,379 feet respectively, for Taber 1,857 feet and 2,065 feet, and for Medicine Hat 1,240 feet and 1,490 feet. These elevations, combined with the general trend of the beds as exposed at the surface, show that a broad anticline crosses the area, the axis of the fold lying about north-south.

They also demonstrate the increasing depth below the surface of the water-bearing beds, towards the east and west, and, therefore, the reason for limiting in those directions the area indicated on the map in which the sands carrying water may be utilized.

The extent of the area over which these sands carry water can be estimated only from the source of supply and there is but one possible point at which the water can enter the beds, namely, in the southern part of the area, where they come to the surface near Milk river. The distribution of the water being downward along the beds, the volume must decrease as the distance from the source increases and the water spreads through an increasingly larger superficial area of beds lying below the level of the inlet. In other words, the water is distributed over an area spreading out like a fan from the source of supply. We have no record of the amount of water in the Lethbridge well or of the height to which it rose; the probability is that it did not rise higher than to within about 200 feet of the surface. At Taber the flow is not gauged, but it is known to be several thousand gallons daily.

At Foremost, at an elevation of 2,907 feet above sea-level and about 50 feet below the lowest exposed sandstone on Milk river, the flow is 7,000 gallons daily, as reported by the railway officials, and the water rises only a few feet above the surface. The water-bearing stratum lies 625 to 725 feet below the surface. In Etzikom coulée, which is 150 feet below the elevation of Foremost, the United Oils, Limited, in boring for oil, penetrated the sands at 600 feet. The flow from this well is reported by the Irrigation Branch of the Department of the Interior to be about 16,000 gallons per day, owing to a greater diameter of bore and greater pressure at the surface.

Nearer the source of supply another oil company called Beaver Oils sank a well in the valley of Milk river a short distance to the east of the outcrop of the sandstones and experienced much trouble with the water encountered at about 165 feet in the sandstones. The flow was so great as to prevent further boring and another well was started nearby. Using necessary precautions the water was cased off in the second well. The flow from these two holes has been gauged by the Irrigation Branch of the Interior and the record shows that the first heavy rush of water has decreased and become steadier. The volume is now about half of that flowing at first and approximates 200,000 imperial gallons in 24 hours. Another well to which our attention was called is northeast of Purple Springs on sec. 16, tp. 10, range 14, W. 4th mer. According to the account of a resident, water was found in this well at a depth of 655 feet and flowed at first freely; then gas began to come with the water; and at present the well gives off gas and water alternately. The same alternation is reported in the case of wells lying north of this on the South Saskatchewan, but exact information regarding them is lacking.

The presence of gas at the top of the anticline in the water-bearing sandstones is thus indicated for the area around Bow Island, although the extent of the area over which these conditions prevail is not definitely known. The presence of water in the southern and higher part helps to seal and confine this gas and, possibly, in the areas in which the gas occurs, amounts sufficient for domestic use may be obtained without great expense in wells from 700 to 800 feet in depth.

Character of the Water.

From all these wells the water obtained has been of about the same character. There is a slight though not unpleasant taste of bicarbonate of soda with a trace of salt and the water is quite suitable for stock. Only one analysis of this water is available. The water from the well at Foremost is to be used by the Canadian Pacific railway in their locomotive boilers. A chemical test furnished by the Company follows:

Mineral Analysis of Water from Foremost.

Source of supply—well 724 feet deep. Sample taken June 8. Analysed June 10, 1914.
Colour—clear and colourless. Alkalinity to phenol phthalein—fair.
Odour—none. Acidity—none. Sediment—none.

Probable salts, parts per 100,000.		Ionic statement.					
		Ca	Mg	Na	CO_3	SO_4	Cl
Calcium carbonate........	0·32	0·13	....	....	0·19	....	....
" sulphate........	....	....	....	....	....	....	....
" chloride........	....	....	....	....	....	....	....
Magnesium carbonate........	....	....	....	....	....	....	....
" sulphate........	....	....	....	....	....	....	....
" chloride........	....	....	....	....	....	....	....
Sodium carbonate........	66·92	....	....	29·11	37·81	....	....
" sulphate........	....	....	....	....	....	....	....
" chloride........	10·64	....	....	4·19	....	....	6·45
Iron oxide and alumina silica	....	0·13	....	33·30	38·00	....	6·45
Mineral matter in solution..	77·88	Scale forming matter:					
		Parts per 100,000........			0·32		
Matter in suspension........	....	Pounds per 1,000 I.G........			½ ounce.		
Total solids by evaporation	....						

Character of the Strata to be Drilled Through.

The surface covering of drift clay with small boulders appears to be quite thin over the whole area. Accumulations of this material were found along the north side of Etzikom coulée to the south and east of Foremost and may also be looked for on the hills to the west. These accumulations are generally disposed in somewhat irregular hills giving a different topography to that of the general, evenly rounded surface.

Under this surface covering remnants of the pale and yellow beds of the Belly River formation occur over a large part of the area and are exposed along the tops of the banks of the old drainage channels which cross the district. They consist generally of yellow sandstones and clays and the bottom of the beds has been placed at a fairly persistent coal horizon represented by the seam mined at Taber and Grassy Lake. Other exposures include the seam at the Maple Leaf coal mine at the top of the bank of the Saskatchewan river north of Winifred; a coal seam on Sevenpersons coulée at the mouth of Piegan creek; coal seams near the surface at Foremost; coal seams south of Lucky Strike; and coal seams near Milk River station.

Below this coal horizon there is a mixture of sands and clays with occasional beds of sandstone and beds made up mostly of oyster shells. The mixed sand and clay member grades downward into a dark grey to brownish clay or shale with a few hard layers and an occasional streak of coal. The base of this series is marked by a coal seam that is in places of mineable thickness.

The series containing coal seams is very well exposed in Chin coulée near Foremost, though the base of the series is not seen. It may be assumed, however, that the bottom of the coulée is at or near the base of the formation. The series is exposed on the south Saskatchewan also and a comparison of these two sections shows that in the Saskatchewan section there is a general thickening of the grey clays below the upper coal seams and that probably some of the lower shales are included in it near the level of the river. This coal-bearing series is outlined on the accompanying map under the name Foremost beds. The thickness of the formation seems to vary from a minimum of 150 feet near the Milk River ridge to about 300 feet on the Saskatchewan. Eastward to Medicine Hat, the coal seams that are taken as the base of the series probably thin out and the sandy layers are probably replaced by clays; so that the divisions recognizable in the area examined could be followed down the Saskatchewan only with difficulty. The Foremost beds are generally darker in colour than the series above them and the shells found in many of the exposures denote brackish water conditions of deposition. The formation seems to have been deposited at sea-level in wide marshes that were periodically flooded from the sea, which, it can be assumed, was retreating slowly toward the east at this stage. The coal seams denote periods of stability during which luxuriant vegetation grew in the lowland swamps.

In going downward in the section below the shallow water material with its oyster beds and coal seams, dark clays containing few sandy layers and with shells considered to be purely marine are found. This series is found near the mouth of Pakowki coulée. The deposition of the beds in salt water shows that there was a marine invasion; but the exposures show that it barely reached the region represented in the southwestern corner of the accompanying map. The deposits of that time, therefore, form a wedge-shaped layer, thin and sandy where exposed on Milk river at Milk River station and thickening so that at Lethbridge they are about 200 feet thick, and at Taber of about the same thickness. In the boring south of Foremost, in Etzikom coulée, the top of the formation is sandy, showing shallow water conditions, but there is about 350 feet of dark shales. In the Medicine Hat section there is about 800 feet of shale of which the upper part may represent a part of the eastern extension of the Foremost beds changed from sandy beds to clays.

The Milk River sandstones next beneath are of shallow water and land formation. They contain remains of palms and other plants growing in a mild climate. Freshwater shells are also found in them. As these beds are of freshwater origin and the formation above is marine there must have been a change in elevation; and the approach to these sands in drilling is marked in many cases by the presence of a small coal seam, formed during the change from a land area to a submarine area. The Milk River sandstones are only slightly consolidated and several of the beds near the top of the formation in their exposures along Milk river are roughly sculptured into castellated shapes by the wind, rain, and frost and have been referred to by Dr. G. M. Dawson as "castellated sandstone." This name being applicable to other regions and beds and, therefore, not being distinctive, has not been continued as a formational name. This sandy deposit at one time covered a large area reaching northeast to Medicine Hat. Its other boundaries can only be conjectured, but it is known that it extended far to the north forming a wide sandy margin to a sea that occupied portions of the middle of the continent from Middle Cretaceous to Tertiary time. The sands from a minimum thickness of from 5 to 10 feet at Medicine Hat thicken to 200 feet at Foremost and Taber and near the mouth of Verdigris coulée are over 316 feet thick, the exposures in the coulée representing 140 feet and the sands passed through in the boring of the Stokes-Stevens well an additional 176 feet. The various sandy beds of the formation are very porous and where they are cut through along the top of the anticline by the valley of Milk river must absorb considerable water from the flowing stream.

Since the line between the clay and shale formations above this sandstone is somewhat indefinite estimates of the depth to the sands would be more easily made by assuming for an horizon marker the coal seam at the top of the Foremost beds. The distance between the seam and the top of the Milk River sandstone beneath may be given in general terms for the following places:

Milk River station about	250 feet.
Foremost about	600 feet.
Taber about	510 feet.

Using this upper coal seam—the top of the Foremost beds of the map—as an horizon marker, the distance downward to the Milk River sandstone, while only 250 feet in the region shown on the southwestern part of the map, increases rapidly to 500 feet northeastward and from that depth to about 600 feet at Foremost. The increase northward is not accurately known, but that it exists is shown in the fact that at Medicine Hat the borings show in places about 900 feet of shale or dark clay.

Within the area marked as available for artesian water it is thought that the maximum depth of the water-bearing sands will be found to be from 700 to 800 feet.

Cost of Drilling.

For all the deep wells that have been drilled in the area a standard drilling rig or rotary has been installed with a costly derrick frame for handling the pipes. The initial cost is considerable so that no estimate can be made of the actual cost that could be applied with fairness to the drilling of the first thousand feet. A portable drilling outfit that can be moved from place to place is generally used for shallow wells. There are many of these machines in the country, but few of them can drill below 600 feet. A larger type is procurable and from information gathered the cost of drilling below 700 feet can be placed at about $7 per foot. The well at Foremost was drilled by Mr. A. N. Duff of the North Star Drilling Company of Regina for the construction department of the Canadian Pacific railway. Mr. J. G. Sullivan, chief engineer, places the cost at $4,492 for a depth of 724 feet with 612 feet of 6½-inch casing. Estimates from the Northwest Drilling Company, Calgary, for a 6-inch hole from 700 to 1,000 feet with one string of 6-inch casing are placed at $7 per foot. If two strings of casing were required there would be an extra charge for the additional casing. At Medicine Hat, where the wells are close together, the standard rig has been used even for wells approximating only 1,000 feet; but the moving expense has been slight and contracts have been let at about $6.50 per foot. These costs are for bores approximating 6 inches in diameter. The cost of shallower wells is much less as is shown in the following memo furnished by Mr. I. V. Reifstack of North Lethbridge; for the first 200 feet in depth the cost is $2 per foot; for additional depths add 50 cents for each 50 feet; for cost of casing add 65 cents per foot for 6-inch casing. For cheaper wells Mr. Reifstack suggests a 3-inch hole made with a jetting machine which could go to the desired depth for prospecting for water, that is, to a depth of 1,000 feet, at very small expense, and he estimates that a 2-inch hole could be put down for 50 cents a foot. The cost of a large-bore well for depths of 700 to 800 feet would, therefore, seem to be about $5,000, an amount that would be beyond the resources of the ordinary farmer. In thickly settled communities wells of this kind might be sunk by co-operation, but the need of water for the outlying isolated farmers is most pressing in the area under consideration, and some cheaper method is required.

Cheaper Methods of Drilling. To ensure cheaper wells, as has been already suggested, bores of smaller diameter might be adopted. If the water-bearing stratum were well saturated, small wells of 2 to 3 inches diameter, which tapped it, might supply sufficient water for the needs of the farmers for stock and domestic purposes, but could not be expected to furnish water to the strata near the surface, which throughout a series of very dry years become denuded of almost all moisture.

As will be seen in the section with the map, the country as a whole slopes northward. Over a great part there is a mantle 200 to 300 feet thick, of clays with sandy layers and coal seams, lying on a series of close grained shales which are exposed in the bottom of some of the deeper coulées. This surface series if the rainfall were up to the average would absorb large quantities of moisture; surface wells of good water would be common; and the deeply etched depressions and water courses would be filled with the seepage from the surface beds. These beds are now mostly dry, deriving all their moisture from the surface rains; and the lake basins and ancient drainage channels which cut into them show few springs or other evidences of moisture. The trench known as Chin coulée formed during the retreat or melting of the glacial ice, which at one period covered the country, follows a peculiar course almost at right angles to the natural surface slope. It and Etzikom coulée to the south may be likened to very deep but unused irrigation ditches with a slight slope to the east, and with their former clean cut floors made irregular in contour by the material brought down by many slides from the sides. These coulées on a superficial examination would seem to offer many basins capable of holding large quantities of water in storage, the seepage from which, following the permeable beds, might reach some considerable distance to the north and provide water in comparatively shallow wells. To provide the water for storage the overflow from the irrigation canals east of Lethbridge is already utilized, but farther east a series of artesian wells along the valley might be sufficient.

At the present time several small lakes in the western part of Chin coulée are maintained by the overflow from the irrigation canals and no doubt help in the saturation of the porous beds beneath the surrounding country; but this seepage probably trends westwards and underlies country already supplied by surface water. The portion of Chin coulée that would by saturation be beneficial to the dry area, through underground seepage, would be the part east of range 17 and in this the artesian supply of water is thought to be available. South of the area outlined as artesian there is also the possibility of obtaining water from the Milk River sandstones beneath, but there will in places be a certain surface supply, and pumping will have to be resorted to. An elevated portion in the general vicinity of Lucky Strike post-office is dependent almost altogether on the annual rainfall; but much of this moisture does not penetrate far below the surface beds, being held by close grained rocks and some coal seams; and surface wells seem to be quite plentiful. West of this there is an area not so well supplied and as it is at a lower level deep wells sunk in it may bring water near enough to the surface to be reached by pumping.

BLAIRMORE MAP-AREA, ALBERTA.

(*Bruce Rose.*)

The field season of 1915 was spent in a detailed investigation of the geology and coal resources of the Blairmore map-area, Alberta. This work was a continuation of that done by W. W. Leach during the seasons of 1911 and 1912. Mr. Leach's report on the geology summarizes the stratigraphy and structure[1] and his preliminary geological map outlines the major features of the area.[2] Pending the publication of a fuller report, maps, and sections the reader is referred to these.

A period of five months from June 15 to November 15 was devoted to field work. Four months were spent in a study of the surface geology, the detailed mapping of the formations, and the revision of previous maps. One month was spent in mine examination and the preparation of maps and structure sections.

I wish to thank C. B. Hamil for very able and satisfactory field assistance, F. H. McLearn for aid in the interpretation of the stratigraphy, and the officials of the various mining companies for their hearty support and co-operation.

Coal mining in the area, which experienced a serious depression during the early months of 1915, is gradually recovering. A new mine has been opened by the West Canadian Collieries Limited at Greenhill on the north side of the Crowsnest river at Blairmore.

JURASSIC AND CRETACEOUS, CROWSNEST PASS, ALBERTA.

(*F. H. McLearn.*)

A stratigraphical study of the Crowsnest district is required for both scientific and economic reasons. It is a necessary preliminary to the interpretation of the structure of this productive coal region and to the interpretation of the Mesozoic history of the eastern Cordillera and western interior of Canada.

A part of the field season of 1914 was devoted to a study of the Coloradian and Montanian sections in the Blairmore and Livingstone River (east of the Livingstone range) areas. During the season of 1915 the work has been continued in the Blairmore area, particular attention being given to the part of the section ranging from Jurassic to Dakotian.

For a part of the field season, the writer was ably assisted by J. A. McLennan. Acknowledgment is also due to Bruce Rose for helpful advice during the progress of the work.

The interval from Jurassic to Dakotian witnessed important changes in the northern Rocky Mountain region. Important diastrophic events took place, and in the plant world, the angiosperms were introduced. In the Blairmore district and northward, east of the main range of the Rocky mountains, these changes are recorded in the Fernie, Kootenay, and Blairmore formations; and in the

[1] Leach, W. W., Geol. Surv., Can., Summary Report, 1911, pp. 192-200.
[2] Geol. Surv., Can., Summary Report, 1912, Map 107A, p. 234.

Fernie basin, west of the main range, in the Fernie, Kootenay, Elk conglomerates, and Flathead beds. Since the rocks of the eastern section, treated below, have already been described by Cairnes[1], Leach[2], and MacKenzie,[3] the following is designed to supplement and not to repeat the observations of these writers.

Fernie Formation.

The base of the Fernie and its relation to the underlying Turtle Mountain group has not been described. The lower contact is well exposed on the northern slope of Bluff mountain. The basal rock is a conglomerate, over one foot in thickness, which is made up of fragments of dark, cherty limestone, fossiliferous limestone, and pink to reddish, somewhat calcareous quartzite. The pebbles are angular, with irregular surfaces exhibiting corrosion hollows and knobs. They vary in size from $\frac{1}{4}$ inch to 6 inches, with an average of a little less than 2 inches. The proportion of pebbles to matrix varies from 5 per cent to about 50 per cent. The matrix is fine-grained, dark grey to black, weathering red to white. The contact rock of the Turtle Mountain group is a white quartzite and quite unlike the pebbles of the conglomerate. For several hundred feet down the Palæozoic rocks consist of quartzites, below which much limestone occurs. The reddish quartzite pebbles may have come from this upper quartzite member, but the limestone pebbles are probably the debris of the lower limestone members.

The contact is well exposed for over a quarter of a mile, and throughout this distance, the basal conglomerate follows the same horizon of the white Palæozoic quartzite. On the west slope of Turtle mountain, the contact, although not actually exposed, rests on the upper quartzitic member, and as determined with reference to a characteristic bed in this member, is at the same horizon. Thus, for a distance of 4 miles, the relation is strictly that of a disconformity. The presence, however, of fragments from lower horizons shows that somewhere, the Turtle Mountain rocks were upwarped and exposed to erosion. Overlap on lower horizons, in other localities may, therefore, be expected.

In the Grassy Mountain and Bluff Mountain sections the conglomerate is followed by dark shaly sandstone up to a 6-foot bed of shell limestone. This occurs 100 feet above the base and carries a small pelecypod fauna. Above this are dark shales with limestone lenses yielding a considerable pelecypod fauna. At the top are 185 feet of thin-bedded sandstones and shales.

In the quarry section at Blairmore and on the Castle river (south fork, Oldman) is a bed of green tuff, 50 feet wide in the latter section. Its absence at Grassy mountain may be due to faulting; or it may thin out northward. This is the earliest appearance of volcanic material in the Mesozoic sediments of the northern Rocky Mountain region. The tuff is followed by a few feet of dark shale which grades upward into the thin-bedded sandstones and shales.

The uppermost, thin-bedded, arenaceous member is very characteristic of the Fernie. It is well developed in the Blairmore and Castle River areas and has been described by Cairnes from the Moose Mountain district. It consists of alternating beds of dark shale and sandstone in 1 to 2-inch layers. The writer has collected a few fish teeth and scales from this zone. The thin bedding persists almost to the thick sandstone at the base of the Kootenay. Within a few feet of it are sandstone beds, 2 feet and more thick, interbedded with thin sandstone and shale. There is thus gradation to the basal sandstone, as noted by Cairnes and others, suggesting continuous deposition. Above the thick sandstone the bedding of the Kootenay is much thicker and more irregular. Abundant plant remains and erect stems are present, which are absent in the upper shales and

[1] Cairnes, D. D., Geol. Surv., Can., Mem. 61.
[2] Leach, W. W., Geol. Surv., Can., Sum. Report, 1911, pp. 192-200.
[3] MacKenzie, J. D., Geol. Surv., Can., Sum. Report, 1912, pp. 235-246.

sandstones of the Fernie. Thus this basal sandstone divides marine beds below from subaërial beds above, and the Fernie-Kootenay contact is marked by a change from marine to subaërial conditions and by continuous deposition.

Kootenay Formation.

A description of the lithology and structure of the Kootenay can be obtained by reference to the reports of Cairnes, Leach, and others. During the past field season plants only were collected from this formation, a special search for other material being without result.

Blairmore Formation.

The Blairmore formation is made up of green and red shales, a few grey and black shales, and sandstones and conglomerates at several horizons. Unlike the Kootenay sediments, the Blairmore rocks grew coarser westward. There is some evidence also that the red colour decreases eastward, so that it, like the variation in grain, is the result of the topographical factor, indicating steeper slopes of deposition westward and a western source of sediment.

During the past summer important evidence has been obtained concerning the flora and its distribution. Abundant angiosperms are confined to about the upper 200 feet and they are extremely rare below. No study of the plants has yet been made, but it is quite possible that the upper 200 feet is of Dakota age and the remainder, or greater part of the section, of uppermost Comanchian age.

Conclusions.

At the base of the section is a break of great importance, including all or most of Permian, Triassic, lower and middle Jurassic time. The field relations point to an upper Jurassic age for the Kootenay. The conglomerates of the Blairmore indicate the uplift of a land mass to the west, and may mark the Sierra Nevadan revolution. The hiatus between the Kootenay and Blairmore may represent all of Lower Comanchian time. The angiosperms were extremely rare in the northern interior in uppermost Comanchian time, as the floras consisted largely of ferns, cycads, and conifers.

THE DISTURBED BELT OF SOUTHWESTERN ALBERTA.

(*J. S. Stewart.*)

The area covered by the past season's work comprises part of what is known as the foothills of which a good general description is to be found in the report of G. M. Dawson[1]. The part here discussed lies, roughly speaking, between the Oldman and St. Mary rivers, with the International Boundary as the southern limit and the base of the Rockies forming the western boundary, except at the north where the Kootenay coal basin has already been outlined by W. W. Leach on the Blairmore sheet and by J. D. Mackenzie[2] on his map of the Southfork coal area.

The object of the investigation was mainly to determine the structure of the rocks, as this has a direct bearing on the location of lines along which operations should be carried on to reach horizons which may carry coal, gas, or oil.

[1] Geol. Surv., Can., Report of Progress, Part C, 1882-83-84.
[2] Sum. Rept., Geol. Surv., Can., 1912, pp. 234-246.

GENERAL CHARACTER OF THE AREA.

Although the Rocky mountains rise rather abruptly from the foothills the latter region forms a somewhat transitional province between the mountains to the west and the plains to the east. The foothill province is coincident with the disturbed belt of Cretaceous rocks and stands out sufficiently to catch the eye even of the casual observer. The structural control of the topography finds expression in a number of parallel ridges with intervening depressions which run in a general northwest-southeast direction. The region is dissected by several rivers and large creeks, including the Crowsnest, Castle (Southfork), Waterton, Belly, and St. Mary rivers. These master streams all flow in a general north-easterly direction and cut the ridges more or less at right angles.

GENERAL GEOLOGY.

Table of Formations.

Pleistocene and Recent.		Superficial deposits.
Tertiary		Willow Creek beds.
Cretaceous		St. Mary River formation.
	Montana group	Bearpaw formation. Belly River formation.
	Colorado group	Benton formation.
		Blairmore (Dakota ?) formation.

The superficial deposits consist mainly of glacial gravels and clays. In general these are thin in the northwestern part of the area and thicken in the southeast.

Willow Creek Beds. These beds are sandy shales and clays of a conspicuously reddish colour and apparently barren of fossils. They overlie the St. Mary River series with apparent conformity, and are found only at the eastern edge of the disturbed belt, where the dip is toward the northeast. Only the lower beds of the series were examined.

St. Mary River Formation. This is essentially a series of light grey to greenish-grey sandstones and sandy shales, with a few lenses of arenaceous limestone which weather an iron rust colour. At the base the shales are carbonaceous and usually contain at least one coal seam of workable thickness. Closely associated with the coal there are almost always oyster beds. A prominent limestone bed composed entirely of shells of ostrea and other types of mollusks forms one of the best horizon markers in the region; this bed occurs about 100 feet from the base of the sandy series and corresponds to the top of the beds that Dawson correlated with the Foxhills.

Besides the brackish water invertebrates found near the base of the series, other beds holding freshwater mollusks, mainly unios, are found throughout the formation. On the Crowsnest river, associated with some thin coal seams, a concretionary bed was found to be rich in plant remains, mainly leaf impressions.

The formation is apparently largely of freshwater origin becoming brackish toward the base. It has a thickness of about 3,000 feet in the vicinity of Pincher Creek but it seems to thin considerably toward the southeast and cannot be much over half this thickness on the St. Mary river. The division between this series and the Willow Creek beds is arbitrary and is based entirely on the change in colour and lithology.

The St. Mary River formation occupies the same stratigraphic position as the Edmonton formation and, in its lower part at least, is apparently the southern equivalent of the Edmonton.

Bearpaw Formation. This is the series which G. M. Dawson correlated with the Pierre shale. It consists of blue grey and black clay shales which contain numerous large calcareous concretions that weather a rust colour. The contact with the St. Mary River series above is a gradational one, the shales become carbonaceous and are interbedded with others of an olive green colour, finally passing into sandstone. The formation carries a characteristic marine fauna which can be roughly recognized in the field. Some of the best fossils are found in the concretions.

A complete section of these shales was not seen; they are very susceptible to erosion and, where exposed, are in many cases much crumpled and folded. The total thickness, however, is somewhere in the neighbourhood of 700 feet.

Belly River Formation. As a whole, the formation is composed of light grey and greenish-grey sandstones and friable sandy shales, the shales usually being in darker shades. These beds appear to be in the form of a great series of interlocking lenses, as, followed along the strike, the formation shows considerable variation; some lenses pinch out and new ones of different character and thickness take their place. The sandstones are fine-grained and, throughout, are interbedded with the shales; near the top they become carbonaceous and over much of the region this is a consistent coal-bearing horizon. The formation is mainly of freshwater origin; fossils are on the whole scarce; the prevailing types are unios and small gastropods which in places are associated in the same bed. Plant impressions are also found, especially in the vicinity of the coal seams, while some dinosaurian bones were collected from a bed near the middle of the series.

At no one place is a complete section of this formation seen, while in many places intense folding and small faults add to the difficulty of measuring the thickness. The estimated minimum thickness on the Crowsnest river is about 2,500 feet. The estimated maximum thickness on the St. Mary river is 1,600 feet.

Neither Clagget shales nor Eagle sandstone were recognized; their equivalent is probably included in the Belly River formation.

Benton Formation. The Benton underlies the Belly River formation with apparent conformity. It consists essentially of black to dark grey, fissile shales which, at the top, alternate with thin-bedded fine-grained sandstones. These shales carry a marine invertebrate fauna. They offer very feeble resistance to erosion and consequently exposures are rare; the sections are, therefore, patchy and the full thickness cannot be estimated. A partial section about 1,000 feet thick and showing the uppermost beds, may be seen on the Belly river, while greater thicknesses were observed farther to the west.

Blairmore Formation (Dakota?). This is the oldest formation recognized and only the upper part has been observed. Complete sections, however, may be seen in the Crowsnest region immediately to the west. It consists mainly of sandstones and friable sandy shales with occasional calcareous lenses. The colour in the case of the sandstone varies from grey to greenish-grey and brown, while the shales show greater variety—from black to light blue grey, green, and purple. Some of the black shales look very much like marine deposits, but no fossils were found in them. The contact of this formation with the overlying

Benton shales also appears to be a gradational one and without any indication of unconformity.

STRUCTURAL GEOLOGY.

As already mentioned the foothills are primarily due to the intense folding of the Cretaceous strata. The strike of the rocks shows a general parallelism to the base of the mountains to the west. North of the Crowsnest river the strike is about 5 degrees west of north, while to the south of this line it varies from 30 to 55 degrees west of north. In the southern part of the area the Lewis overthrust brings rocks of Pre-Cambrian age in contact with the Benton and Belly River formations. Westerly dips largely predominate, the sequence being repeated by strike faults with downthrow on the northeast side.

ECONOMIC GEOLOGY.

Coal, which occurs near the top of the Belly River formation, was at one time extensively mined at Lundbreck; but at present the output is limited to a strictly local demand. The seam now being worked shows considerable variation in thickness, but the average is 6 to 7 feet. The rocks are intricately folded, where this seam outcrops on the Crowsnest river, causing the same seam to be repeated at least three times within a very short distance. At the same horizon a coal seam about 4 feet thick is exposed on the Waterton river, about 22 miles north of the International Boundary.

The base of the St. Mary River formation is a persistently coal-bearing horizon throughout the entire belt examined and the seams have been prospected on practically every stream of any size which cuts these strata. Unfortunately most of the prospect tunnels are old and are caved in. The Leavitt mine on Lee creek, however, is in working order and shows a seam about 10 feet thick of fairly good bituminous coal with a few thin streaks of shale and clay interbedded.

The undeveloped character of this belt does not necessarily reflect on its possibilities as a coal producer. Other factors must be considered. In the first place, western Alberta abounds in coal and in the second place there is practically no home market. This makes it possible to work at a profit only the most favourably located and very best seams; while poor management and the desire for quick profits have wrecked other promising prospects.

Prospects holes for oil are being drilled by four companies. Two of these drills are located north of Crowsnest river and two are in the vicinity of the St. Mary river. In no case has any of the drills penetrated the entire thickness of the Benton shales.

Seepages of inflammable gas occur at a few scattered points and have influenced prospecting for oil in the district; up to the present, however, the results have been negative.

An isolated outcrop of sandstone on Pine creek has been prospected for its iron content. The iron is present as magnetic sand and apparently forms only a small lens in the Belly River formation.

To the many residents met during the season whose favours and information helped along the work, the writer is grateful. To Mr. R. E. McArthur, of Lethbridge, he is indebted for much information and active co-operation. Efficient service as assistant was rendered by S. A. Childerhose.

BORING OPERATIONS IN SOUTHERN ALBERTA.

(*S. E. Slipper.*)

The systematic collecting and correlating of data from wells in the process of boring for oil in Alberta was undertaken in December, 1913, and the writer, who was assigned to this work, remained in the field continuously until the autumn of this year (1915). A summary statement of the first year's work has already been published.[1]

In 1915 the area being explored for oil was extended to the prairie region south of the South Saskatchewan, where a few of the companies began boring operations. Two of the new wells struck artesian flows of fresh water at moderate depths.

The discovery of an available supply of fresh water in a district that has suffered greatly from arid conditions led to an investigation by the Department of the possible artesian water supplies in the area between ranges 8 and 20, west of the 4th meridian and from the International Boundary north to township 10. This investigation was made by D. B. Dowling from June to October, 1915, assisted by the writer.

The energy displayed during 1914 in boring for oil in southern Alberta had, in 1915, greatly diminished. At present there are six drills working in the Turner valley; one in the area south and west of the valley; two in the foothills west of the Sarcee Indian reserve; one in the field west of Olds (Monarch field) and two on the prairie, south of the South Saskatchewan river.

Reaction from the wild speculation of 1914, the financial conditions caused by the war, and the generally unsatisfactory results obtained, thus far, are the causes for the decrease in activity and the waning of public interest.

SUMMARY OF RESULTS OBTAINED.

Boring has proved that the Dakota and Kootenay formations, in the foothills are petrolific, and that if structural conditions are right they yield petroleum from several different beds when penetrated by the drill. Petroleum has been obtained, also, from thin sand members of the Benton, in very small amount.

However, none of the discoveries so far made can be considered seriously as a paying enterprise (with the possible exception of the Southern Alberta Company's well No. 1 which has not yet been fully tested). In fact, most of the oil finds so far reported have been mere seepages of no importance.

The oil is very light, with a varying specific gravity, approximating 50 degrees Baumé. It grades from light green in colour to colourless and has a paraffin base. Some of the product has been used in the crude state to run gasoline tractors.

In the Sheep River area all the oil discovered came from the Turner Valley anticline. The wells drilled on either side of this fold were unproductive of favourable results.

West of the Sarcee reserve, in one of the wells, a small amount of oil from the upper beds of the Dakota (?) was obtained. The well was "shot" without increasing the amount of oil.

The wells drilled in the prairie region south of the South Saskatchewan river have yielded a large volume of gas from a sand member in the lower Benton.

Gas has been met with on the Turner Valley fold also, in fairly large volume. These finds should prove to be of considerable economic impor a nce. In the Turner valley, one of the companies estimates its gas flow at about 4,000,000

[1] Summary Report 1914, p. 143.

cubic feet per day. This gas comes from sand in the Benton, Dakota, and Kootenay, the greater part being from the last named formation.

The Cretaceous formations overlying the Dakota have shown no evidence of being oil-bearing. The lower sandy portion of the Fort Benton is in some cases a minor exception to this general rule. It is probably safe to say that the upper beds are hardly worth prospecting for oil. However, there are gas horizons that may be of value to individual farmers and ranchers. When reached in shallow borings in many cases they supply the farmer with sufficient gas for light and power.

None of the bore-holes which were started in formations above the Benton have reached the Dakota, though one or two are over 3,000 feet deep. The rest, or most of them, have been discontinued.

These results do not seem to be very encouraging; nevertheless, two favourable deductions may be drawn from them. First, given a larger fold than the Turner Valley anticline and consequently a more extensive collecting area for the oil, paying wells might be obtained from the Dakota or Kootenay beds, and, second, since some of the data collected point to the possibility of the oil coming from deeper levels, larger pools of oil may be encountered by drilling deeper than the Dakota or Kootenay on the Turner Valley or similar folds.

Nearly all the wells drilled in the foothills area have been quite free from water; none of them has encountered water in the Dakota or Kootenay, even in beds below oil-bearing strata. The anticlinal theory for the collection of oil at the crest of folds postulates that the oil is supported in the upper part of the anticline by underlying water. Since the rocks are apparently free of water in this area it may be that the main pools are resting in the lower part of the synclines and monoclines. This may account for the anticlines yielding in small amounts a very light oil which has been brought up along the beds to the higher folds as a vapour in the gas, there condensed by the lower temperatures and maintained by the gas pressure.

Belly River and younger rocks are, generally, preserved on synclinal structures and, therefore, it would be very difficult, if not impossible, to reach the Dakota or Kootenay through the synclines.

STRATIGRAPHY.

Through the courtesy of the drilling companies, the Geological Survey has been enabled to obtain considerable information bearing on the stratigraphy of Cretaceous in the foothills area from samples taken at intervals from the wells.

The following description of formations is based on data obtained from the wells and does not apply to the stratigraphy of the prairie region.

Table of Formations.

Tertiary		Paskapoo, fresh water.
Cretaceous		Paskapoo, fresh water.
	Montana	Edmonton, brackish water. Bearpaw, marine. Belly River, brackish water.
	Colorado	Benton, marine.
		Dakota, fresh water. Kootenay.

Paskapoo. This formation in the drill samples exhibits alternating light grey, fine, calcareous sands and rather dark bluish shales in beds from 5 to 35 feet thick. It is the youngest formation in the area and a thickness of about 4,000 feet has been measured. A few coal beds are met with. The formation is thought to be a series of freshwater beds.

Edmonton. In well samples, it is very difficult to separate Edmonton from Paskapoo. Coal and carbonaceous shales have been observed at the top of the Edmonton. The sandstones of this formation are thinner, darker, and harder than those of the Paskapoo and the shales are thicker and of a green colour. A measured section of the Edmonton showed 1,300 feet of strata. No oil nor gas has been reported from these beds.

Bearpaw. Near the base of the Edmonton formation at Black Diamond P. O., one well (the only well drilling through this horizon) entered about 150 feet of black shales with thin, dark green sandstones and then penetrated the coal seam which overlies the Belly River. These black shales may represent the Bearpaw formation. However, it is believed that over most of this area little of the marine Bearpaw will be encountered and that the horizon will probably be marked only by the coal seam.

Belly River. The following is the log of a well passing through this formation.

Coal	4–5 feet
Black carbonaceous shale	60 "
Light grey sand	20 "
Green shale	130 "
Coal and sand	20 "
Grey sand	20 "
Green shale	10 "
Light grey sand	20 "
Green shale	10 "
Light grey sand	75 "
Green shale	40 "
Light grey sand	40 "
Green shale	20 "
Light grey sand	30 "
Green shale	40 "
Green sand	20 "
Green shale	60 "
Light grey sand	200 "
Blue shale	45 "
Dark sand	310 "
Black shale	10 "
Grey sand	40 "
Rapidly alternating light grey and grey sand and blue black shale gradually grading into Benton	350 "

A measured section gave 1,850 feet of strata.

Small flows of gas but no oil have been reported from the Belly River.

The *Claggett*, *Eagle*, and *Cardium* have not been recognized in the well samples.

Benton. This formation consists of a somewhat sandy, blue-black marine shale. There are numerous thin, fine-grained sandstone beds in the lower portion of the formation—one of these, which is about 100 feet thick and in places conglomeratic, has been named the Lineham member. It was at one time mistaken for the Cardium. These sandy beds are the source of some of the best gas flows. Small oil seepages, also, are found in them, but they are of no importance.

The formation is about 2,000 feet thick, but in many cases the apparent thickness is much greater than this owing to the tendency of soft shales to complex folding and minor faulting when under stress. This thickening is especially noticed on the crests of folds.

Dakota-Kootenay. Under this general term the Cretaceous underlying the Benton is classed.

Well samples show the formation underlying the Benton to be a rapidly alternating series of thin-bedded, hard sandstones and shales. The strata show a great variety of shades and colours; they include green and grey sandstones of various shades and grey, green, red, brown, black, and purple shales.

The upper bed is, in many instances, a characteristic black, coarse sandstone, very calcareous and containing much pyrite. This bed is the source of some of the oil and gas of wells in the Turner valley. Lower down the sandstone is more constant and the shale beds thinner. The prevailing colour varies from light to dark green.

Many of the beds give off gas in fair quantities and in addition to the oil in the upper bed, a little oil was found in another horizon lower down, but was soon exhausted. The thickness of these beds, which are considered to be Dakota, calculated from the well logs, is about 950 feet.

A coal seam underlying these upper beds is taken as the beginning of the Kootenay formation. No indication of the Kootenay conglomerate was observed in the drilling. Underlying the coal are a series of light grey sandstones and greenish shales about 210 feet thick; under these again are some 200 feet of black calcareous shales.

The lowest beds penetrated to date are brown and black sandstones.

All the sandstones of the Kootenay have given off gas in large quantities, which is saturated with liquid hydrocarbons. In one of the wells 6 barrels of oil is being obtained daily from these lower beds.

Jurassic. Formations of this period have not been explored by the drill and since they do not outcrop in Alberta east of the mountain area nothing is known of their character in this field. It may be supposed that they will be found to be similar to the Fernie shale, but possibly much thinner.

HORIZON MARKERS.

Horizon markers or characteristic beds are very convenient and necessary when separating well records into the different geological divisions.

No such beds have been noted in the Paskapoo or Edmonton and the dividing line has to be fixed by the general appearance of the strata composing these formations. The coal seam at the top of the Belly River is a dependable horizon, and the Benton shales are in themselves quite characteristic; the sandstone beds in this formation are too indefinite to be used for correlating purposes. The upper part of the Dakota may be recognized in many cases by the black calcareous sandstone mentioned above, by the characteristic variety of colours, and by the rapid changes from shales to sandstones. The beds that have been considered to be Kootenay consist of dark brown hard sandstones, and black calcareous shales underlying a coal horizon.

The gas sands in the Turner Valley sections have been used as horizon markers, but the data in this connexion are very incomplete.

NOTES ON THE STRUCTURAL GEOLOGY AND THE LOCATION OF WELLS.

The anticlines in the foothills are in general long, narrow, northwesterly trending folds. They terminate longitudinally by either plunging into monoclines or by breaking up into a series of small thrust faults. In many places the younger formations are eroded from the crests, leaving Benton shales exposed. The flanks of the folds are usually steeply dipping beds that have been subjected to minor folding and faulting.

Because of the high angle of dip, wells located at a distance from the apex of a fold will have to be drilled to depths in many cases prohibitive, to reach the Dakota and Kootenay oil horizons. These depths are sometimes increased, irrespective of dip, by minor folds and faults. It is this great depth to which drilling has to be carried that has prevented a thorough prospecting of the flanks of the Turner Valley fold.

The synclines have a trend parallel to the anticlines and as stated above are generally capped by Belly River and in some cases by Edmonton and Paskapoo. It is possible that the Dakota and Kootenay underlying the synclines are worth prospecting if the mechanical difficulties of drilling to such great depths can be overcome. An approximate minimum depth of 4,500 feet would be expected in horizontal beds if drilling began at the top of the Belly River.

No well should be located on beds higher than the Belly River with the expectation of penetrating the Dakota.

In conclusion it may be said that most of the structures in the foothills are complicated by thrust faults which possibly destroy the value of the folds as oil reservoirs by restricting the size of the gathering ground, and which make the ultimate success of any drilling operations in these broken areas extremely doubtful.

DRILLING PROBLEMS.

The Paskapoo, Edmonton, and Belly River strata being chiefly massive, soft sandstone and sandy shale present no difficulties to the driller. The Benton shales, on the other hand, are very friable and unstable and cave into the bore-hole so that casing has to be carried as close to the bottom of the hole as possible. Ironstone nodules and thin hard sandy beds in the shales tend to force the drill to the side of the hole, boring it very much out of alignment. The troubles met with in straightening these "crooked holes" have probably caused more delay in operations than any other difficulty.

The caving of the Benton shales also hinders the handling of casing in the hole, since the shales creep closely around the casing and hold it fast.

The alternating shales and sandstones of the Dakota, where they dip at high angles, are also difficult to penetrate with a straight bore-hole.

One well in the Turner Valley field has caused considerable trouble through the freezing of the sludge water in the bottom of the hole; the low temperature being caused by gas escaping under high pressure from one of the Kootenay gas horizons.

The drilling of the wells in the prairie region south of Bow Island has been delayed by heavy flows of gas and salt water occurring at about the same horizon.

REPORTED OCCURRENCE OF SILVER IN THE NEIGHBOURHOOD OF FOND DU LAC, LAKE ATHABASKA, SASKATCHEWAN.

(*Charles Camsell.*)

INTRODUCTION.

On receipt of instructions to make an examination of the region about the east end of Lake Athabaska, where discoveries of high grade silver ore were reported to have been made recently, I left Ottawa May 29 and proceeded by rail to Athabaska and thence by canoe by way of Athabaska river and lake to the trading post of Fond du Lac, the nearest point to the locality to be examined.

Fond du Lac was reached on June 27 and after a stay of two weeks during which all the localities where mineral claims had been staked were examined, the return journey was commenced on July 10. We returned by way of Peace river, but in consequence of delays due to stormy weather and the wreck of the Hudson's Bay Company's steamer, *McMurray*, Edmonton was not reached until August 26. The whole distance covered by rail, canoe, and steamboat from the time of leaving Edmonton until our return was approximately 2,000 miles, and the time consumed a little more than two and a half months.

The district examined and that in which the mineral claims were taken up is situated on the north shore of Athabaska lake about 20 miles east of the trading post of Fond du Lac, and extends along the shore of the lake from the mouth of Robillard river past Sucker bay and Pine Channel narrows to Camille bay. An isolated group of claims, the Paris group, lies a few miles west of Robillard river near the mouth of Grease river.

The distance to the centre of this district from Athabaska, the nearest railway point, is about 650 miles by way of Athabaska river and Athabaska lake, and as there are no regular passenger or freight boats plying the whole way between these two points the traveller must find his own means of transport unless he can connect with the casual trips of the fur traders who operate their steamers mainly for their own convenience. My own trip into the locality was made entirely by canoe, with two canoemen, but we were saved a great deal of time and hard work through the courtesy of Mr. Colin Fraser of Chipewyan who very kindly lent us a small canoe motor for the 200-mile trip down Athabaska lake.

An alternative route is by way of Peace river, but while this is safer and easier the distance from the nearest railway point on the Edmonton, Dunvegan, and British Columbia railway is about 150 miles longer.

Mineral claims were first taken up in this district in 1912 by some prospectors sent out by Lt.-Gov. G. H. V. Bulyea, and his associates, and a small amount of work was done. Other prospectors were in the same district in 1913 and 1914, but it was not until the early part of 1915 that a wider interest was aroused by the reported discovery of high grade silver ore, and in March prospectors began to rush in to stake claims. The influx of prospectors continued throughout the spring and early part of the summer until altogether about 150 men reached the district, nearly all of them travelling by way of Athabaska river. By the beginning of July interest in the district began to wane because no discoveries of high grade silver ore were being made, and at the time my party left there were not more than twenty-five prospectors remaining in it.

The first geological examination of the north shore of Athabaska lake was made in 1892 by J. B. Tyrrell who during a rapid reconnaissance noted the occurrence of the belt of norite which extends from Robillard river to the east end of the lake. In the summer of 1914 F. J. Alcock of the Geological Survey made a more detailed examination of the norite, and although he determined the presence of nickel in that formation he found no evidence of high grade silver deposits. His full report is now being printed for publication.

The reason for a further investigation this summer was the publication in many Canadian newspapers of an assay of silver ore said to have been obtained from the norite belt which yielded about $11,000 in silver to the ton. This sample of silver ore was reported to have been obtained by certain prospectors who spent the autumn of 1914 in the district and early in 1915 went out by dog teams to Edmonton.

Believing that the occurrence of this silver was similar to that of the high grade silver ores in Cobalt, Ontario, prospectors rushed into the district with the idea of taking up mineral claims in the locality where this sample was supposed to have come from. A number went in with dog teams in March and April, and several more started out from Athabaska by boat as soon as Athabaska river was free of ice. Most of these men had powers of attorney to stake claims for their friends and as a result some hundreds of claims were taken up and filed in the Dominion Lands Office at Edmonton or at Fort Smith. Most of those who took up claims were not prospectors by occupation and a few of those who were familiar with the conditions under which silver occurs at Cobalt were not sufficiently impressed with the region and returned without staking anything.

My efforts were directed to finding the locality from which the high grade silver ore was reported to have been obtained and to a general reconnaissance of a belt of country extending along the north shore of Athabaska lake from the mouth of Grease river to Camille or Fishing bay, a distance of about 20 miles, along which the mineral claims had been staked. The first was rather difficult because the original owner of the sample was not present in the district, and because different localities were given me by different individuals who were supposed to know.

CONCLUSIONS.

As a result of my investigations of the geology of the belt extending from Grease river to Camille bay on the north shore of the lake, the following conclusions have been arrived at respecting that belt:

No evidence could be obtained that silver ore assaying $11,000 to the ton occurs anywhere in the region examined, and in my opinion the sample that gave that assay result must have come from elsewhere and possibly from outside the district altogether.

The country rock of the district examined is mainly norite and more like the Sudbury field than that of Cobalt, and consequently shows much more evidence of being a copper and nickel bearing rock than silver.

There is undoubted evidence of nickel and copper occurring in the norite, but from the showings on the surface the ore-bodies appear to be too small and of too low grade to be economically important at present in a region so remote from railway transportation.

Little real prospecting has been done and very little development work; and, as far as we were able to determine, no high grade silver ore-bodies, or even bodies of copper and nickel ore such as could be worked at a profit in that region, have as yet been proven. There is, however, sufficient evidence of sulphide mineralization throughout the region embracing the north shore of Athabaska lake to justify a hope that deposits of nickel, copper, silver, or gold ores may yet be found that would be sufficiently valuable to work.

From a mining point of view the district is as yet unproven and there was no warrant for any excitement or stampede of prospectors into it.

Owing to the remoteness of the region, only high grade ore deposits can be worked at present, and prospectors should apply themselves to the search preferably for free milling gold quartz, or high grade silver deposits such as those at Cobalt. There is a vast area of virgin territory on the north side of Athabaska lake, unprospected and even unexplored, and in some of the belts of older sedimentary rocks lying in the granite or gneiss are many strong and well defined quartz veins. Gold in small amounts has already been found in some of these quartz veins and all of the areas are worth while prospecting for that metal. The chances for high grade silver deposits are not as clear as for gold, but sills of diabase do occur in the neighbourhood of the norite belt and these should always be carefully examined for calcite veins bearing native silver and the minerals usually associated with it.

So much time is consumed in getting to and from the district about Athabaska lake that intending prospectors should make up their minds to winter in the country and the kind of man required for that work is one who is able to combine trapping furs during the winter with prospecting for minerals in the summer months.

TOPOGRAPHY.

The country at the east end of Lake Athabaska forms part of the great Laurentian plateau, and the surface, though rocky and rough in detail, is consequently one of moderate relief. On the south side of the lake a north facing escarpment rises more or less easily from the lake shore to a maximum height of 400 feet above it, and beyond this is a level or gently undulating plain, sandy in character, wooded mainly by jack-pine, and underlain by sandstone. The north shore of the lake, being built up of igneous rocks, mainly norite and granite gneiss, is more rocky and rugged in outline and consists of a series of irregular ridges and valleys striking in general northeast and southwest. The ridges are strike ridges whose alignment has been determined by the strike of the rocks. And because these rocks dip to the southeast the ridges frequently show steep faces to the northwest and more gentle slopes to the southeast. The shore-line, too, shows the influence of geological structure in the islands and many deep bays by which it is indented. Such bays as Robillard bay, Sucker bay, Norite bay, and Camille bay all run far into the northeast along the strike of the rocks. This is in marked contrast to the contour of the south shore where the rocks are horizontal sandstones and the shore-line is regular and not deeply indented by bays.

The hills on the north side of the lake rarely exceed 100 feet in height in the immediate vicinity of the lake, but their height increases inland northward, until 3 or 4 miles back they appear to reach an elevation of 500 feet or more.

No streams navigable by canoes enter either side of the lake east of Grease river. Robillard river and Sucker creek are both small streams and cannot be ascended much beyond their mouths. In consequence, the only means of getting into the interior away from the lake shore is on foot, but except for the unevenness of the surface this country is not particularly difficult to travel over. It is all forested with spruce, jack-pine, poplar, or birch, but the woods are more or less open. There is very little soil or other loose material, and much of the surface is bare rock. Forest fires had already swept much of the country previous to the advent of the prospectors and during the spring many more were started with the deliberate intention of burning the moss so as to still further uncover the bedrock for prospecting.

GENERAL GEOLOGY.

The geology of the north shore of Athabaska lake was worked out in more or less detail by F. J. Alcock of the Geological Survey in the summer of 1915 and is described in a full report about to be published by the Survey. Nothing more than a brief general description is consequently necessary here.

The rocks of that portion of the north shore in which the mineral claims were located, namely from the Paris group near the mouth of Grease river to Camille bay, belong to one or the other of the following groups:

(1) A complex of highly foliated and often contorted crystalline rocks of a gneissoid character, the oldest formation in that district.

(2) The Athabaska sandstone, flat lying and undisturbed on the south shore of the lake, but somewhat disturbed and metamorphosed to quartzite on the north shore where it comes in contact with the norite.

(3) A foliated norite younger than, and intrusive into, the Athabaska sandstone as well as into the gneiss.

(4) Dykes and sills of diabase which are probably genetically connected with the norite.

The gneiss occupies the lake shore from Robillard river westward. It is the oldest of the four above-mentioned formations and is of no importance from an economic point of view. It is the typical Laurentian granite gneiss with some dark lenses of basic rock and dykes of lighter coloured pegmatite. It is much disturbed and contorted, but has a general trend to the northeast.

The Athabaska sandstone forms the south shore of the lake, but east of Pine Channel narrows it occupies also part of the north shore where it is somewhat disturbed. Its age is assumed to be Keweenawan. On the south shore it is a white siliceous sandstone lying in a horizontal attitude, but on the north shore of the lake, owing to the intrusion of the norite, it becomes a garnetiferous quartzite and has been tilted at a higher angle with dip to the southward. On the contact of the norite it becomes mineralized with iron sulphides and many mineral claims have been staked on it.

The norite occupies the area lying between the gneiss and the sandstone on the north side of the lake. It extends from the mouth of Robillard river eastward to the end of the lake, but east of Pine Channel narrows it lies a short distance back from the lake shore and is separated therefrom by a strip of metamorphosed Athabaska sandstone. It is distinctly foliated and cut by many small and irregular veins of quartz. The strike of the foliation varies from northeast to east and the dip is southward at an angle of about 40 degrees. It has apparently been intruded in the form of a great sill or series of sills between the gneiss and the Athabaska sandstone, the former below and the latter above. The actual nature of the intrusion of the norite, whether a single sill or a series of sills, has an important bearing on the occurrence of any ore deposits in it, but this was not definitely determined, though the weight of evidence appears to favour its having reached its present form by a succession of intrusions. It is cut by sheets of diabase and is mineralized at intervals along the same horizons by sulphides of iron. These bunches of mineralized norite constitute the principal "showings" of the district and on them the greater number of mineral claims have been staked.

Diabase dykes and sills intrude both the gneiss and the norite but they are generally of small size. They contain some calcite in vugs and small fracture planes, but no regular veins were noticed.

MINERAL DEPOSITS.

Practically all the mineral claims that have been located are situated in the norite, and with the exception of the contact phase of the sandstone and some of the dark bands in the gneiss this is the only formation that shows any evidence of important mineralization.

The norite is a siliceous foliated rock, striking northeasterly and dipping to the southward. At wide intervals on the same strike and at the same horizon in the formation are bodies or bunches of ore weathering red and consisting of pyrrhotite, pyrite, chalcopyrite, and arsenopyrite disseminated through a gangue of silicified country rock. The sulphides are not massive except in small cross fractures, 1 to 2 inches wide, which traverse these bodies. The width of these bodies ranges from 5 to 20 feet and the boundaries in this direction are fairly definite. The length is also variable and while most of them are only a few feet in length the maximum of those seen is perhaps 100 feet. Along the strike the sulphides gradually diminish in quantity until they disappear altogether. The bodies are isolated from each other and are not continuous; but by following out the strike of the foliation of the norite another body may be found several hundred feet away. In places quartz stringers 2 to 6 inches wide crosscut the formation and in these the principal sulphide is arsenopyrite with sometimes specular hematite, pyrite, or galena.

Deposits of this character are found in several places in the belt of norite lying between Sucker bay and Norite bay and extending along the strike of the norite from the islands about Channel point northeastward for several miles inland. Typical deposits of this character are those on the Norah, Victory, Excelsior, Garrett, and North Star mineral claims. The metals found by assay to occur in them are nickel and copper, but the average value is not high. Some platinum is also said to have been found.

Samples 1, 2, 3 were collected by the writer from the more important localities where some development work had been done and assayed both by the Mines Branch in Ottawa and by J. A. Kelso, director of industrial laboratories in the University of Alberta. Samples 4, 5, 6 were collected by F. J. Alcock during 1914. The results of analyses are as follows:

Analyses of Fond du Lac Ores.

	1	2	3	4	5	6
Copper	0·09	Nil	....	Trace	Trace	6·65
Nickel	Nil	Nil	0·10	Trace	0·20	1·07
Gold	....	Nil	Nil	Nil	Nil	Nil
Silver	....	Nil	Nil	Nil	Nil	Nil

1. From the Norah mineral claim, carrying disseminated pyrrhotite and chalcopyrite. (Analysed by H. A. Leverin, Mines Branch, Dept. of Mines).
2. From the Norah mineral claim. (Analysed by J. A. Kelso, University of Alberta).
3. From the Garrett mineral claim, formerly known as the Lake Point. (Analysed by J. A. Kelso, University of Alberta).
4. From the Norah mineral claim. (Analysed in the Laboratory of the Mines Branch, Dept. of Mines).
5. From the Lake Point mineral claim, now known as the Garrett. (Analysed in the Laboratory of the Mines Branch, Dept. of Mines).
6. Picked sample containing small quantities of pyrite, chalcopyrite, and pyrrhotite from one of the small fractures on the Paris claim.

On the Paris group of claims, or what was originally known as the Athabaska group, the rock is a dark fine-grained variety associated with a porphyritic granite gneiss. The rock outcrops in a low cliff on the shore of the lake and is sparingly mineralized with pyrite and pyrrhotite which is disseminated through it and gives a rusty stain to the outcrop. In narrow fracture planes there is a little more iron sulphide, apparently secondarily deposited, but nowhere does there seem to be any concentration of the sulphides sufficient to form an ore-body of workable dimensions. Assays show the principal valuable metal at this point to be nickel.

At this point native silver was said to have been found in the small fractures traversing the rock, but I could find no evidence of that metal.

The claims situated at the head of Camille or Fishing bay are of somewhat different character. Here the prevailing rock is a garnetiferous gneiss presumably altered Athabaska sandstone, intruded by sheets of norite. The outcrop of the quartzite is red with iron oxide and constitutes what is known as the lead on which the claims have been staked. The deposits are of a contact metamorphic nature with mineralization by pyrite and pyrrhotite as a result of the intrusion of the norite. The sulphides are disseminated through the gneiss over a considerable area along a well defined strike, but do not appear to be sufficiently concentrated anywhere to form important ore-bodies.

In conclusion it is the writer's opinion that, while the mineral deposits that have been taken up in the norite may be of value at some time in the future, unless more important discoveries are made the remoteness of the district from railway transportation and from any large centres of population, and the present undeveloped state of the surrounding country render their exploitation impracticable at the present time.

AMISK-ATHAPAPUSKOW LAKE AREA, NORTHERN SASKATCHEWAN AND NORTHERN MANITOBA.

(*E. L. Bruce.*)

The field season of 1915 was spent in the Amisk-Athapapuskow Lakes district of northern Saskatchewan and Manitoba, continuing the work begun in 1914. The micrometer surveys of both Amisk lake and Athapapuskow lake were completed and two canoe routes between them mapped in detail and a third in part. The great number of lakes in this district, some of which are nearly as large as the two lakes mentioned above, made it necessary that a considerable portion of the time should be spent in geographical work.

The more detailed examination of this district has shown that the area underlain by greenstone and allied formations is less than the preliminary work indicated. The main stream courses are so adjusted to the structure that they lie in the rocks of this class, while the interfluve districts are largely occupied by granitic rocks. This is well shown by the course of Sucker creek. From Meridian lake, less than 5 miles northeast of Amisk lake, this stream flows in a broad curve east, then south, and finally southwest into Amisk lake. At only one place in its course, and that close to the limestone escarpment, are granites exposed and yet the greenstone and schist band in which the stream and its lake expansions lie, is in many places less than a mile in width

The areas of conglomeratic rocks have proved to be larger than was at first supposed and prospecting has shown that in part of the sedimentary series at least, there are quartz veins carrying some gold values. The geological sequence as at present determined, is as follows:

Recent........................	Peat.
Pleistocene........................	Lake Agassiz clays.
	Till.
Ordovician........................	Dolomite.
	Great unconformity.
Pre-Cambrian........	Granite porphyry.
	Granite.
	Granite gneiss.
	Intrusive contact.
	Jasper conglomerate.
	Argillite.
	Arkose.
	Recrystallized arkose conglomerate.
	Unconformity.
	Granite (occurs as pebbles in the conglomerate).
	Diorite, greenstone, pyroclastics, autoclastics, and derived schists.

Greenstone Series. The rocks of this oldest series form a complex of rocks of different characters and different ages, which are usually highly altered and which lie below the conglomeratic series. They are largely volcanic in origin, with minor intrusives and sediments. Much of the greenstone is massive and some of it still retains its original pillow and amygdaloidal structures. In other places the intense metamorphism that it has undergone has changed it into chloritic schists. Associated with the ellipsoidal weathering greenstones on Schist lake there is considerable autoclastic material and in places large lenses of pyroclastics. At the island-blocked narrows of the north arm of Athapapuskow, these pyroclastics lie close to true conglomerates. In the one case, however, the fragments are plainly volcanic material with a greenstone matrix. In the other they are pebbles of various kinds in a sedimentary binding.

The intrusives of this complex are mostly basic in character—altered dioritic or diabasic rocks. They include, however, sericitic schists derived from more acidic varieties.

Conglomeratic Series. The fragmental rocks lying, with an erosion interval, above the greenstone series, consist of members originally very different. Part of the series has undergone very intense metamorphism and, being of different composition, the final results are quite dissimilar. In some of the conglomerates, the pebbles have been stretched, squeezed, and contorted and the matrix recrystallized. Original arkoses have been so completely recrystallized that they are now gneisses, while clay rocks have become fine-grained chloritic schists differing from the schists of igneous origin only in retaining in some cases a faint contorted banding due to original depositional differences. The great similarity in appearance between this rock and that of the older series, and between the recrystallized arkoses and the younger igneous rocks, makes mapping difficult and often very uncertain. The main area of these highly metamorphosed sediments lies in a northwest-southeast trending band, 4 miles in width, along the north shore of Amisk lake. The narrow channel between Missi island and the north shore of the lake lies between the north-south trending schists of the southern part and the northwest-southeast trending schistose conglomerates and schists of the northern part. This change is well marked by the courses of the streams and extends over nearly to the Athapapuskow section. It probably marks a great fault zone.

Besides the much contorted and recrystallized conglomerate there are areas of conglomerate and arkose containing jasper as the most striking constituent. In many places these rocks are not very much altered and show schistosity only along the edges of the lenses. Some small patches of soft black argillite are also associated with them. The series occurs in small amount at Beaver lake and covers an area of about 8 square miles on Athapapuskow lake. No unconformity has been proved to exist between this and the much contorted series, but the great difference in character between them may be due to a difference in age rather than to the effect of different metamorphic conditions in different localities.

The pebbles of the contorted series show that there was a pre-conglomerate granite, but, so far, this granite has not been found in place. Granite and quartz with a few greenstone fragments are the chief constituents of this conglomerate, while these, with the abundant and often large jasper boulders, are the fragmental materials in the jasper conglomerate.

Granitic Rocks. The granitic rocks found in place are chiefly later than the conglomerates. In the case of some of the varieties actual intrusive contacts occur, in others no contacts have been observed; but the general freshness of even the gneissoid granite, together with the absence of pebbles of similar granites in the conglomerate, is evidence that they are later than the fragmental series.

North of the Amisk-Athapapuskow district is a great area of gneissoid granites. The gneissoid structure seems to be original rather than the product of movement or recrystallization and may be the result of original injection of a granite batholith in older schistose rocks.

A great U-shaped area of massive granites and granite porphyry, with its base beneath the limestone escarpment, lies between Amisk and Athapapuskow lakes. This batholith is intrusive into arkose conglomerate near Wolverine lake northeast of Amisk lake. It is not constant in lithological character and may be complex in nature. Against basic rocks it is exceedingly basic with large amounts of hornblende, but farther from the contact becomes a fresh, light-coloured, grey to reddish granite. Within the granite mass are areas of bright red, coarse-grained porphyry with large, well-formed phenocrysts of feldspar. This is probably a differentiate of the main mass representing the final product of its consolidation.

Ordovician Dolomites. The Pre-Cambrian rocks are overlain by almost horizontal beds of dolomite of Ordovician age. The basal beds are in many cases of a deep brick red colour. Higher up they are variegated, while 20 to 30 feet above the base they are massive, buff-coloured, semi-crystalline dolomites. There is no basal conglomerate and the lowest beds observed were dolomitic with chert concretions developed in some localities. There are few fossils and these poorly preserved.

Glacial and Recent. Part of the district is covered by the lake silts of glacial Lake Agassiz. The northern edge of this lake passed south of Amisk lake, but it included part of the Cranberry lakes and Lake Wekusko. Northwest of this line the solid rock surfaces are covered only by small morainal deposits and by recent peat deposits.

ECONOMIC GEOLOGY.

Amisk Lake District.

Prince Albert Claims. Little work has been done on these claims since 1914 and there is nothing to be added to the description as given in the Summary Report for that year.

Kent Claim. The Kent claim lies a mile west of the northwest bay of Amisk lake. The vein is at the foot of a high bluff of deep green, chloritic schist. As exposed, it is 6 to 7 feet wide. It differs from the other veins of the district in having quartz of a bluish colour.

Graham Claims. The Graham claims lie north of Amisk lake and occur in much contorted arkose conglomerate. The close folding that the original sediments have undergone has produced a crumpling of the layers with a resulting opening of the bedding planes at the axes of the folds. Along these openings quartz, carrying some gold, has been deposited. As a result, these masses of quartz are not traceable along the strike of the schists for any great distance, but it seems probable that they may have considerable extent along the axes of the folds which dip almost vertically. These quartz lenses carry pyrite but no arsenopyrite.

Wolverine Lake Claims. Wolverine lake lies 2 miles north of the northeast bay of Amisk lake. One mile northwest of the lake a lenticular vein, varying in width up to 8 feet, has been traced for 2,000 feet and a large part of it has been stripped. It lies partly in greenstone schist and partly in a schistose conglomerate. It is parallel to the strike of the enclosing rocks and often breaks into a series of parallel stringers. The quartz is iron-stained and carries arsenopyrite. The soil covering the vein is heavily iron-stained.

Athapapuskow Lake District.

Hasset Claims. Considerable work has been done on claims on the west side of the north arm of Athapapuskow. A vein near the east edge of a large jasper conglomerate lens has been stripped and open-cut, but the values are not encouraging.

Flinflon Lake District.

Late in the summer discoveries of mixed sulphides were made at Flinflon lake and much staking and some development work have been done. The canoe route to this lake leaves the north arm of Athapapuskow by way of Trout creek which is ascended to Schist lake. At the north end of the long arm that trends a little west of north is a large creek. This is ascended to a lake from which a portage leads southwest to a smaller lake, and from this a portage leads into Flinflon lake. Only a brief visit was made late in the season. On the original claims, which are along the east side of the lake near the south end, cross trenching has been done, but as the ore is near water-level it has been difficult to get down to solid sulphides and at the time the claims were visited the trenches were filled with water with knobs of sulphides showing above it. The trend of the ore zone is northeast and southwest and in the main trenches the surface width is nearly 200 feet. Four hundred and fifty feet south of this, it has again been trenched across showing the same width. Between these two series of trenches there is, however, an elliptical horse of unmineralized rock 50 feet in width. The sulphides have also been found in trenches north of this main mass. Inland the land is low and solid rock has not been reached east of the sulphide zone and hence its attitude is unknown. The western part of the zone consists of pyrite. Eastward across the vein this gives place to banded pyrite, sphalerite, and galena, while the eastern part exposed shows considerable chalcopyrite. The banded ore has a dip of 45 degrees to the east. There is no quartz present.

The country rock of this district consists of ancient volcanic rocks—greenstones, pyroclastics, and autoclastics, some bands of later conglomerates, and intrusions of quartz porphyries which are probably genetically related to the ore deposition. These porphyries are believed to be connected with the granitic batholiths that lie within a few miles of the district. No careful sampling of the deposit was possible and the amount of development is not sufficient to show whether or not the values are high enough to bear the cost of treating a smelting ore.

Island Lake District.

Rich specimens have been found along the beaches, but the vein is not yet located.

Wekusko Lake District.

Kiski-Wekusko Claims. These are the first claims located in this district, being staked in the summer of 1914. Two main veins have been uncovered. No. 1 vein strikes north 5 degrees west and is vertical. It is somewhat lenticular, but well defined. It has been stripped for 450 feet and traced by cross trenches for an additional 250 feet. The quartz is white to brownish and carries tiny needles of black tourmaline and small amounts of pyrite and chalcopyrite. Gold is present in visible quantities. The walls are strongly impregnated with crystals of arsenopyrite. No. 2 vein lies 270 feet east of the point where No. 1 vein goes into the lake. It has a strike north 10 degrees west and is vertical. It runs up to 7 feet in width. The quartz is similar to that of No. 1 vein and the mineralization is of the same character. More arsenopyrite occurs in the quartz in this vein than in No. 1 and where it occurs in quartz is granular. A yellowish micaceous mineral is found along cracks and copper carbonates are formed where surface waters have reached the copper sulphides. Somewhat more tourmaline is present than in No. 1 vein and is massive or in the form of clusters of radiating needles. Gold is visible at half a dozen different places along the vein, associated with the sulphides or with the massive tourmaline. The country rock of both veins is an altered diorite. Farther east, agglomeratic rocks are present.

McCafferty Claims. These claims lie $1\frac{1}{2}$ miles east of the lake and northeast of the Kiski-Wekusko claims. The vein has a width at one point of 3 feet, but divides into two. The average strike is north 25 degrees east and dip 70 degrees east. The gangue is a white subvitreous quartz and the mineralization similar to that just described.

Rex Claim. The Rex claim lies on the west shore of Wekusko lake a couple of miles north of the Kiski claim. The vein is a short distance from the lake and strikes north 20 degrees east nearly parallel to the shore. It dips 65 degrees east. The width is $2\frac{1}{2}$ feet to 5 feet. The quartz is granular, white to brownish in colour, and has a platy structure parallel to the walls. Veinlets of white glassy quartz of a later age cut across the granular quartz. Sulphides are not abundant, but the walls are impregnated with arsenopyrite. Gold is present in visible quantities. The country rock to the east of the vein is a massive felsitic rock. To the west of the vein the rock is a somewhat schistose conglomerate, with pebbles mostly of white quartz, but with a few chloritic rock fragments present and some that have the appearance of a very fine-grained quartzite. This band of conglomerate follows the shore for some distance south, but disappears under the lake north of the Kiski-Wekusko claims.

FUTURE OF THE AREA.

Gold-bearing quartz veins have now been discovered in so many parts of the belt of basic rocks extending from Amisk lake to Wekusko lake that there seem to be good possibilities of finding gold in paying quantities. Careful examination requires time and work. This is especially true in the eastern part where the thick deposits of Lake Agassiz clays mantle the rock surfaces. All parts of the area are easily accessible by canoe travel, but thorough prospecting will demand examination of the country inland from the main routes, and attention concentrated on a few promising claims rather than dissipated over a large number.

ACKNOWLEDGMENTS.

The writer was efficiently assisted during the season of 1915 by L. G. Thompson, W. J. Embury, and D. G. H. Wright. Assistance was received from many persons in the district. Special thanks are again due to D. Mosher, L. Dion, and Thos. Creighton for accurate sketches of various canoe routes, and to S. Cotter of Cumberland House and M. Hackett of Wekusko lake, for their hospitality.

PEMBINA MOUNTAIN, SOUTHERN MANITOBA.

(*A. MacLean.*)

The work begun in this field in the summer of 1914 was continued to completion during the season of 1915. The first part of June was spent on the escarpment in tp. 1, range 5, and tp. 1, range 6, W. 1st mer., after which the valley of the Pembina was followed from Pembina crossing to the foot of Rock lake, at the western end of the field. The work was then transferred to the part of the escarpment between Morden and Treherne, where Pembina mountain becomes merged in the broken country known locally as the eastern side of the Tiger hills. These really form the northern limit of the escarpment, which is succeeded northward by the Assiniboine delta and the Assiniboine valley. The last camp of the season was located on the Assiniboine where, by reason of exceptionally low water, an unusual opportunity was afforded of seeing the Niobrara exposures in the vicinity of sec. 36, tp. 8, range 11. C. J. Moir rendered efficient service as field assistant.

In the latter part of July a short trip was made to the vicinity of Minnedosa and Millwood to examine the type Odanah and Millwood shales for the purpose of correlation with the beds to which these names have been applied in southern Manitoba. No fossils were found in the beds examined in either the northern or the southern areas; but the physical characteristics of the shales in the type localities leave little doubt that they are represented in the south by the beds to which the names Odanah and Millwood are applied in the following table.

Table Showing the Succession of Beds in Pembina Mountain, Manitoba.

No.	In southern and southwestern part of the field.	Thickness in feet.	In northern part of field.	Thickness in feet.
12	Lacustrine and beach deposits of Lake Agassiz..................	....	North of the Tiger hills is represented by the Assiniboine delta material..............................	....
11	Glacial till..................................	....	Covered for the most part by No. 11, except in river cuttings............	....
10	Hard steel grey shale breaking into flakes and splinters. Weathers to a dark rusty grey and is usually iron stained on joint and bedding planes (Odanah).........		The same as in the south, but erosion has removed more so it forms a thinner covering in the Tiger hills than in the southwestern part of Pembina mountain..............................	....
9	Heavy, waxy, tenacious clay, probably consisting largely of colloidal material (Millwood)..	50	Becoming thicker toward the north and at times containing thin beds of shale similar to No. 10..........	70
8	Chocolate brown shale, passing into dense, black, carbonaceous shale with earthy fracture. In the upper 30 feet the black shale alternates with beds of white, earthy clay, the former predominating..................	80	Becoming much thinner toward the north and represented apparently only by the upper portion in which at times the white bands predominate...........	20

No.	In southern and southwestern part of the field.	Thickness in feet.	In northern part of field.	Thickness in feet.
7	"Chalk": a bluish-grey, highly calcareous shale, fairly consistent in texture. Weathers to yellow or buff surface and breaks into columnar fragments......	25	In the north the yellow or buff weathering feature so marked in the southern exposures is much less pronounced.............	20
6	Grey shales similar to No. 4.......	25	Few exposures but probably similar to the same beds in the south	....
5	Calcareous shale (carbonaceous) more consistent than Nos. 4 and 6 but similar in appearance. These form the "cement beds"	8	Similar to the southern representatives................	8
4	Black calcareous shales, generally carbonaceous, fairly well bedded, weathering to a grey surface specked with white granules........................	80	The few exposures seen in the north are similar to those in the south. Thickness probably the same......	....
3	Black carbonaceous shale, streaked with yellow clay, and containing crystals of selenite and nodules and masses of pyrite. Calcareous and clay concretions, and septaria are scattered in bands and irregularly through it. Probably.............	200	Exposures in the north are few. Those on the Boyne (at Learys) represent the top of these beds, and those on the Assiniboine, sec. 36, tp. 8, range 11, represent the bottom, immediately overlying the limestone (No. 2)...............	....
2	Hard compact blue limestone, very fossiliferous..................	3	On the Assiniboine, sec. 36, tp. 8, range 11, has become thicker. The upper beds are granular when exposed and are known locally as sandstone...........	8
1	No exposures of these beds in the southern part of the field..........	....	Grey shale, in appearance much like Nos. 4, 5, and 6, but is much harder and more consistent, containing also a larger number of fossils. Only the top beds exposed, extent in depth unknown, probably.............	160

In the series, beds Nos. 1 to 7 inclusive are provisionally considered as Niobrara, while Nos. 8 to 10 are referred to the Pierre. This division is based mainly on physical characteristics, as, with the exception of a few fish remains in No. 8, the beds 8, 9, and 10 show no fossils. The transition between 7 and 8, and between 8 and 9, is very gradual, showing no sharp line of demarcation, so that the separation of the beds No. 8 from the Niobrara and their inclusion in the Pierre is due to the fact that they are less unlike the succeeding shale (Millwood) than the preceding Niobrara. The thickness of the top beds of the Pierre (the Odanah) is modified in this area by the factor of glacial and preglacial erosion. At the front of the mountain and toward the north it is comparatively thin, but in the southwestern corner of the field it is at least 250 feet in thickness. At Deloraine, Tyrrell gives the thickness as 292 feet.[1] At this place also it has been subjected to erosion, so that in other places it may

[1] J. B. Tyrrell, "Three deep wells in Manitoba," Trans. Roy. Soc., Can., 1891.

be much thicker, The thickness given to the lower beds of the Niobrara (No. 1) is that ascribed to them by Tyrrell in his section of a well at Morden.[1]

In last year's Summary Report on this area it was stated in error that the shale used at Learys for brickmaking was from beds No. 4 of the preceding table. A more careful examination shows that the material, used is from the upper portion of beds No. 3, the same as used at Walhalla, N.D. Mr. Hilder of Carmen, Manitoba, reports that on the suggestion of J. Keele of the Geological Survey, he has made tests of a mixture of shale from beds No. 3 and No. 10 with most satisfactory results.

LOWER CHURCHILL RIVER REGION, MANITOBA.

(*F. J. Alcock.*)

The season of 1915 was spent on the lower portion of the Churchill river, in the northern part of the province of Manitoba. A survey of the river and its lake expansions by means of compass and Rochon micrometer was carried from Southern Indian lake to Hudson bay and the geology of the adjacent region mapped. Assistance in the field was rendered by C. E. Cairnes.

In reaching the field, the new Hudson Bay railway running from Pas, Manitoba, was utilized as far as the steel is at present laid, *i.e.*, to Armstrong lake, 225 miles northeast from Pas. From there Armstrong river was descended to Nelson river and the latter followed to Split lake. From Split lake the usual portage route to Churchill river was used. This is a rather difficult route, consisting of narrow, shallow streams, small lakes, and long portages. It leads to Little Churchill river, which was followed to its junction with the main Churchill. During this season the water was extremely low in the small streams and even in the Little Churchill there were many places where the water was not sufficiently deep to float a loaded canoe, so that many long portages were necessary. With the help of four Indians and two additional canoes obtained at Split lake, the journey from Split Lake post to the mouth of the Little Churchill, a distance of about 150 miles, was accomplished in ten days.

On June 28 the main Churchill was reached and the survey upstream begun. Considerable quantities of ice were found along the banks and the island near the mouth of the Little Churchill was completely covered. In the first 23 miles upstream, the river has an average width of about 1,000 feet, and is very swift with a few rapids. It flows between banks of clay, in places 125 feet high; and no rock outcrop is met with for a distance of 20 miles.

Above this point, a long series of rapids is encountered, many of which necessitate portages. Trails for these were cut and marked. In places the river attains a width of one mile; in other places it contracts to a width of 150 feet where the whole current pours through narrow chutes. Four chutes and five waterfalls, varying from 8 to 20 feet in vertical fall, are found in this upper part of the river, together with long stretches of very dangerous rapids.

In this part of the river there are three lake expansions; Billard, Churchill, and Northern Indian lakes. Billard lake is 4 miles long and 2 miles wide. It is surrounded by low country, covered with small black spruce. The river immediately below the lake is wide and the country low and marshy. Churchill lake has a fairly regular contour. At its southern end it is so shallow that a rise or fall of the water of a few inches considerably affects its area. Northern

[1] J. B. Tyrrell, "Three deep wells in Manitoba," Trans. Roy. Soc., Can., 1891.

Indian lake has a very irregular boundary, with a length of shore-line out of all proportion to the actual area of the lake. It consists of a network of long bays which only in a few places unite to enclose islands. Above Northern Indian lake, the river is dominantly wide, with many blind bays, but, on approaching Southern Indian lake, two long narrow portions are encountered in each of which there are rapids. At Missi falls, the outlet of Southern Indian lake, the river drops 20 feet. This point was reached on July 27 and was the western limit of the traverse.

On the return journey, the wider stretches of the river and the lake expansions were surveyed on the opposite side to that which had been taken going up. The mouth of the Little Churchill was reached on August 13, and from there the survey was continued to Fort Churchill at the mouth of Churchill river.

Three miles below the mouth of Little Churchill, a portage route leads from Churchill river to Deer river. The regular route used from Split lake to Fort Churchill follows Deer river, as the main Churchill is dreaded by the Indian guides of Split Lake post on account of the rapids and the ice which obstructs the channel for the greater part of the year. This part of the river was descended by our party late in August. Many rapids were encountered, but none was nearly so troublesome as had been encountered in the upper portion of the river; and practically all the ice had disappeared. A canyon with vertical walls of limestone is more or less continuous for several miles; but in this portion the current is merely swift and fast time can safely be made by canoes. In middle or late summer the Churchill is undoubtedly much to be preferred to the Deer River route; and to a party travelling light, three or four days should be sufficient to go from the mouth of the Little Churchill to Fort Churchill. Fort Churchill was reached on August 21.

On account of the extremely low water at this season of the year it was impossible to return by the Little Churchill route to Split lake. Advantage was, therefore, taken of the Hudson Bay schooner, *Fort York*, which sailed from Churchill on August 29, arriving at York factory on August 30. On August 31 our party proceeded by canoe from York Factory to Port Nelson. At the request of Mr. McLachlan, the engineer in charge of the harbour construction at Port Nelson, and with the permission of the Deputy Minister of Mines, the writer remained there ten days, and was then brought out by boat to Sydney, Nova Scotia.

The Churchill River region is everywhere of low relief, few elevations reaching heights of 300 feet above the river. Geologically it is underlain by a complex of rocks of early Pre-Cambrian age and, along the lower part of the river, these are overlain by Ordovician limestone. The succession may be tabulated as follows:

Table of Formations.

Pleistocene and Recent.		Recent alluvium, marine clays, boulder clays.
Ordovician	Trenton	Thin-bedded, light-coloured magnesian limestone, fossiliferous, underlain by coarse red calcareous sandstone.
Pre-Cambrian	Granites and gneisses	Biotite granite gneiss, hornblende granite gneiss, amphibolite, granodiorite, porphyritic granite.
	Churchill quartzite	Dominantly a dark grey, fine-grained quartzite.
	Keewatin	Local areas of chloritic and sericitic schists.

Keewatin. Under this head are included areas of schistose rocks intruded by the granites and gneisses. The areas are, however, too small to be shown except on a large scale map.

Churchill Quartzite. Lying on either side of the river at Fort Churchill are ridges of a dense dark rock to which the term Churchill quartzite is here applied. It stands at a high angle and is cut everywhere by numerous small quartz stringers. It is overlain by Ordovician limestone and, though no contact with the regional granite was found, its attitude suggests that it is older than the granite.

Granites and Gneisses. These cover practically the entire upper portion of the region. The dominant phase is a red granite which in places is coarsely porphyritic. Well-banded gneisses, red and grey in colour, are also found with all gradations between granite and gneissic structure, and no sharp boundary could be drawn separating the two types.

Ordovician. On the lower portion of the river, Ordovician limestone is exposed, through which the river has cut a canyon. For the greater part of the distance, the river flows over the granite floor, exposing a complete section of the horizontal limestone. At one point a flat-lying sandstone, 15 feet in thickness, forms the basal member. The limestone reaches a thickness of at least 60 feet, is fossiliferous, and is apparently of the same horizon throughout. The uneven surface of the ancient floor upon which the limestone was deposited is well displayed in the limestone canyon, islands of red granite projecting in the middle of the river, at places, where on the adjacent banks the limestone descends beneath the surface of the river; but at no point were the irregularities more than 10 to 20 feet.

Pleistocene and Recent. A mantle of boulder clay at least 100 feet in thickness covers the region around the lower portion of the Little Churchill river. It gradually thins as one proceeds up the main river and in the region of Northern Indian lake, the coating is very scanty. Small isolated areas of clay containing marine fossils were found, the highest elevation being approximately 60 feet above sea-level.

From an economic point of view, the region is not promising geologically since the limestone and granites cover practically the entire region. Though the Churchill quartzite contains many veins, none was found to carry minerals of economic importance. Though only of local extent at Fort Churchill, the quartzite is reported to occur in greater areas to the north and may somewhere be found to be mineralized.

Mr. J. M. Macoun has made the following report on the flowering plants collected by one of my assistants, C. E. Cairnes.

"This collection of about eighty species is a valuable addition to our herbarium as they are the first specimens we have had from the lower Churchill river, except from the immediate vicinity of Fort Churchill. Nothing of special interest was found among the specimens collected below the mouth of the Little Churchill river, but the known range of practically all the species included in the following lists, representing plants collected between Missi falls and the Little Churchill river, has been greatly extended by this collection. Many of the species had not before been recorded north of the Severn river in these longitudes and one species, *Arnica Lowii*, Holm, was known only from Trout lake; *Euphrasia hudsoniana*, Fernald and Wiegand, a recently described species, had not before been collected inland, and one species of *Saxifraga* seems to be an undescribed species; it is at least unknown to me."

List of Plants Collected Along the Churchill River Between Missi Falls and the Mouth of the Little Churchill River.

Sisyrinchium angustifolium Mill.
Polygonum viviparum L.
Arenaria verna L. var.
" lateriflora L.
Ranunculus circinatus Sibth.
" Flammula L. var. filiformis (Mx.) Hook.
" Macounii Britton.
Anemone parviflora Mx.
" canadensis L.
Aquilegia brevistyla Hook.
Corydalis aurea Willd.
Erysimum, cheiranthoides L.
Saxifraga tricuspidata, Rety. f. subintegie folia, Abromeit.
" tricuspidata Rottb.
Potentilla Anserina L.
" Monspeliensis L.
" palustris (L.) Scop.
Rubus arcticus L.
" Chamæmorus L.
Astragalus hypoglottis L.
Viola pallens (Banks) Brainerd.
" nephrophylla Greene.
Epilobium adenocaulon Hauskn.
Sium cicutæfolium Schrank.
Primula Mistassinica Mx.
Gentiana Amarella L. var. acuta (Mx.) Herder.
Phacelia Franklinii Gray.
Mertensia paniculata Don.
Mentha arvensis L. var. canadensis (L.) Briquet.
Stachys palustris L.
Euphrasia hudsoniana Fernald and Wiegand.
Rhinanthus oblongifolius Fernald.
Pinguicula vulgaris L.
Galium boreale L.
Linnæa borealis L. var. americana (Forbes) Rehder.
Arnica alpina Olin.
" foliosa Nutt.
" Lowii Holm.
Aster salicifolius Ait.
Erigeron Philadelphicus L.
Hieracium umbellatum L.
Solidago (Too young for determination).

NORTH SHORE OF LAKE HURON, ONTARIO.

(*W. H. Collins.*)

The field season of 1915 was spent in continuing a study, begun in 1914, of the Pre-Cambrian formation along the north shore of Lake Huron. This work adds to our knowledge of a district already known to contain deposits of copper, gold, and cobalt ores. The district is also the seat of well established lumbering, and agricultural industries. The investigation was mainly undertaken, however, to ascertain the nature and order of succession of the Pre-Cambrian formations, that they might be safely correlated with like successions in Sudbury, Cobalt, and other geologically important districts in northeastern Ontario. With these districts reliably correlated it becomes possible to construct a nomenclature and geological column which will replace the various local ones hitherto in use, and relieve the geological literature of much of its present complexity.

The North Shore district is, roughly, a strip of country about 25 miles wide, extending from Sault Ste. Marie eastward for 125 miles. Instead of attempting to explore the whole of this territory, attention was concentrated upon a number of smaller key areas favourable for the elucidation of the Pre-Cambrian record. These areas were spaced at short intervals—10 miles or less, but in one case 27 miles—so that their geological successions could readily be correlated. Where uncertainty existed the interval was reconnoitered for the necessary supplementary evidence, but it was not mapped.

Seven of these key areas have now been mapped.

	Area mapped in 1914. Square miles.	Area mapped in 1915. Square miles.
1. Echo Lake area, around Echo lake	....	42
2. Bruce area, north of Bruce Mines	156	....
3. Thessalon area, near Thessalon	....	30
4. Blind River area, between Dean lake and Cutler	135	25
5. Whiskey Lake area, 15 miles north of Cutler	30	110
6. Espanola area, near Espanola	35	85
7. Round Lake area, near Naughton	42	
Total area	690	

In addition, geological reconnaissances were made in the neighbourhood of Killarney, of the islands in the North channel between Cutler and Little Current, and of parts of the townships of Patton, Scarfe, Mack, Montgomery, 167, and 161.

The principal results obtained in 1914 have been summarized in Museum Bulletin No. 8 issued by the Geological Survey. In 1915 these results were substantially verified and amplified by certain additional discoveries which are now in course of publication as another museum bulletin and will appear in advance of the present statement.

The progress made during 1915 is due in large measure to the co-operation of Dr. T. T. Quirke and A. McLeod, J. R. Marshall, E. W. Todd, and Arthur Benoit.

SUTTON, BARRIE, AND OTTAWA AREAS, ONTARIO.

(W. A. Johnston.)

Field work was carried on during the season of 1915 from June 1 until November 4. About six weeks in the early part of the season were spent in completing the geology of the Sutton and Barrie map-areas in Lake Simcoe district, Ontario. In this district six 15-minute areas, embracing about 1,250 square miles, have now been topographically and geologically mapped on the scale $\frac{1}{62500}$ or nearly 1 mile to 1 inch. Land forms are shown on the maps by contours at intervals of 20 feet. The topographical map of one of the areas (Orillia) has been issued; two (Brechin and Kirkfield) are in the hands of the engraver, and the remaining three (Beaverton, Sutton, and Barrie) are ready for engraving.

One of the most interesting points in connexion with the geology of Lake Simcoe district is the occurrence of the raised beach of extinct Lake Algonquin. The beach is well developed in all of the six areas surrounding Lake Simcoe. It is not horizontal as when formed, but rises differentially towards the northeast. The maximum difference of elevation of the beach in the district is nearly 200 feet. The altitude of the beach has been obtained by careful levelling at intervals of 1 to 3 miles throughout the district, so that it will be possible to construct an isobasic map and profile showing the character and amount of deformation of the beach in the direction of maximum uplift.

A few days in July were spent in an investigation of the "Trent outlet channel of Lake Algonquin." It has long been known that one of the outlets of extinct Lake Algonquin was by way of the Trent chain of lakes and rivers extending from Balsam lake near Kirkfield down to Rice lake below Peterborough. This area was examined; and raised, upwarped beaches were found and levelled at a number of places. The results of the investigation show that, at the highest stage of Lake Algonquin, there was no fall nor rapid near Kirkfield as has been generally supposed. At several places, however, farther down the Trent valley, there were falls and rapids in the ancient Algonquin river. The evidence will be discussed in a forthcoming bulletin on the subject.

The rest of the season was spent in the investigation and mapping of the superficial deposits and soils of the area covered by the topographical map (Ottawa sheet) issued by the Department of Militia and Defence. This sheet is bounded by longitudes 75° 30′ and 76° 00′ and by latitudes 45° 15′ and 45° 30′ and embraces an area of nearly 420 square miles. The scale of the map is $\frac{1}{63360}$ or 1 mile to 1 inch.

The mapping of the soils of the Ottawa district forms the economic basis for the work. The soils are classified, primarily, according to the mode of origin of the unconsolidated rocks upon which the soils are developed and, secondarily, according to the physical character of the soils themselves. The map will show the age and mode of origin of the different unconsolidated rocks which compose the superficial deposits, and also the various soils developed upon them.

The extent and character of the glacial and marine deposits, and the upper limit of late Pleistocene marine submergence in the Ottawa valley are matters of geological importance. Considerable information regarding these points was obtained in the Ottawa district and by means of short excursions eastward as far as Montreal and westward as far as Renfrew and Shawville further data were secured. Raised marine shore-lines have been levelled at a number of places from Rigaud mountain westward to Renfrew and it is hoped that the data obtained will throw some light on the limit of marine submergence and the character of the deformation of the raised marine shore-lines in the Ottawa valley.

A week in the early part of September was spent in Rainy River district in connexion with the International Joint Commission's investigation regarding water-levels of Lake of the Woods.

During the season's field work Irvine E. Stewart acted as assistant and for his hearty co-operation the writer is much indebted.

FORMATIONS ADJACENT TO THE NIAGARA ESCARPMENT OF SOUTHWESTERN ONTARIO.

(*M. Y. Williams.*)

PURPOSE AND SCOPE OF WORK.

The field season of 1915 was spent by the writer in completing the mapping of the Silurian formations outcropping along the Niagara escarpment of southwestern Ontario, including Manitoulin and adjacent islands. The geology of this region was studied during the field seasons of 1912, 1913, and 1914, by the writer, and a description of it was published in the Summary Reports for those years. Additional investigations were made during the past season, and a number of fossils, clay samples, etc., were collected. The field work is now complete, and a final report on the Silurian of southwestern Ontario is being prepared.

FIELD PARTIES AND METHODS.

The work was carried on by two parties; one, in charge of the writer, proceeding northward by gasoline launch, from Wiarton to Sault Ste. Marie; and the other, under G. S. Hume, proceeding southward, by horse and buggy, from Wiarton to the Niagara river. During the first part of the season, from June 8 to June 28, the southern party assisted the writer, and learned the required methods of surveying. The writer was assisted in the field by Louis Coderre, jun., from June 27 to August 17, and by G. E. Grattan throughout the season. G. S. Hume, who was in charge of the southern party, was assisted by C. S. V. Hawkins until August 29, after which N. C. Hart assisted him until the end of the season. Work was completed by the southern party on September 18, and by the northern party, October 26. The total mileage of geological boundaries run approximates 265 miles for the northern party and 700 miles for the southern party. The sketching case and Rochon micrometer served the purpose of the southern party admirably in the open and well developed country in which they were working. The writer used a 10-inch plane-table and Rochon micrometer, excepting in the thick bush where distances were measured by pacing. The base used was the standard topographical maps of the Department of the Interior, the intention being to publish to the scale of 12 miles to 1 inch.

The writer is indebted for assistance and advice to government officials and the residents of the various districts traversed; among these, special mention may be made of Mr. William Boyd of Kagawong, Manitoulin island, and Mr. D. Stewart of Marksville, St. Joseph island.

GEOLOGY.

The geological boundaries surveyed by the northern party were the Lockport-Cataract and the Cataract-Richmond, besides some Guelph-Lockport boundaries on the Bruce peninsula and the islands to the north. The southern party was concerned with the first two of the above-mentioned boundaries, and also in the Niagara peninsula with the various boundaries between the Ordovician system and the Lockport formation. Work was facilitated by the clear-cut nature of the escarpments which mark the edges of the main formations. In the north, however, the land in the vicinity of the escarpments is covered with second growth timber, which greatly interfered with mapping operations.

The Lockport formation consists of a thick series of dolomite beds and presents at its edge almost continuous cliffs from the Niagara river northward. These vary in height from a few feet to 250 feet, and, weathering greyish-white, form a very noticeable feature of the landscape. The Manitoulin dolomite, formerly known as the Clinton of Ontario, and more recently included in the Cataract[1] formation, also forms an escarpment. From Credit Forks (25 miles northwesterly from Toronto) northward, this escarpment is generally well marked, and at one locality near Manitowaning on Manitoulin island, it rises as a cliff 50 feet in height. Elsewhere the average rock face is rarely more than 15 to 20 feet high. Between this formation and the Lockport above, lie the Cabot Head shales, consisting in the south of sandy shale and sandstone, and in the north of 50 feet or more of fine-grained, red shale of clayey consistency with some interbedded limestone and green shale near the top. For fuller descriptions of all the formations, and especially those of the Niagara peninsula, the reader is referred to the summary reports by the writer for 1912-1914.

ECONOMIC GEOLOGY.

Besides the Lockport and Manitoulin dolomites, both of which have been used locally for making lime and for building material, the Cabot Head shale on Manitoulin island affords material for brick manufacture. J. Keele, chief of the ceramic division, Mines Branch, Department of Mines, has kindly furnished the following preliminary report on samples sent him by the writer of the red Cabot Head shale, and also the Ordovician shale occurring along the east side of Gore bay about 2 miles northeast of the town of Gore Bay.

"Lab. No. 367.—Red shale from West bay, Indian reserve. This shale is very plastic, smooth, and stiff, when tempered with water. Owing to its stiffness it is hard to work, and would be improved in this respect by the addition of sand.

"The material dries without cracking, with shrinkages within working limits, and burns to a hard, dense, red body at low temperatures.

"This clay appears to be suitable for the manufacture of building brick, hollowware blocks, and field drain tile. It may be possible to use it for roofing tile also.

"Lab. No. 369.—Grey shale from east side of Gore bay. This shale is fairly plastic when ground and tempered with water. It is not so smooth as No. 367, but is far easier to work.

"The drying qualities are good and the shrinkages low.

"At low temperatures it burns to a dense red body of a character suitable for the manufacture of wire cut and dry pressed bricks, hollowware and drain tile.

"A somewhat similar shale is worked for these products at Mimico and Meaford.

"Neither of the shales appears to be suitable for the manufacture of vitrified wares, as their range of vitrification is too short.

"These shales cannot be worked by the simple methods used in surface clays. A more expensive plant, including grinding machinery and down-draft kilns, would be necessary.

"The tests on the above samples are not completed."

The sample of red shale (Cabot Head) was taken from the road allowance on lot 16, concession IX, township of Billings. This locality is $1\frac{1}{2}$ miles west of West bay and about $2\frac{1}{2}$ miles from West Bay Indian village. A 50-foot section of the shale lies exposed along the road, covering a distance of perhaps one-eighth of a mile. A smaller exposure occurs on lot 28, concession IX, township of

[1] Sum. Rept., Geol. Surv., Can., 1913, p. 182

Allan, about 3 miles southeast of the town of Gore Bay. The clay is exposed in the road on both sides of a small hill and it is probable that large quantities might be obtained after stripping the surface soil. Because of its proximity to a good harbour at Gore bay, this occurrence appears suitable for exploitation. The vicinity is well supplied with good wood for fuel, which may be obtained at reasonable prices.

There are other less suitably located occurrences of the Cabot Head shale on Manitoulin island, one of the best being on lot 27 on the road between concessions IV and V, township of Bidwell, and 1¼ miles west of Lake Manitou.

GENERAL RESOURCES AND CHARACTER OF THE COUNTRY.

In southwestern Ontario, the Niagara escarpment, which has a general northwest trend, marks a decided rise in the elevation of the country to the westward. Along its immediate front, rough tracts of land with timber areas occur, but elsewhere, above and below the escarpment, the land is practically all cultivated. On the Bruce peninsula, the Lockport and overlying Guelph formation outcrops extensively, large areas being entirely devoid of soil covering. Most of the timber was removed some time ago, and forest fires destroyed the soil which had accumulated during the life of the forest. In consequence, the fertile farming areas are limited, and perhaps not more than a third of the surface of the country is suitable for agriculture. However, where soil of sufficient depth is found, it is almost invariably rich, and the vast areas of wild country afford good grazing ranges for cattle and sheep, large numbers of which are raised.

On Manitoulin island, the same conditions prevail. There, however, the agricultural areas are of larger extent and the wild lands are better adapted for grazing. The areas underlain by the Manitoulin dolomite have in general, poor, thin soil and where cleared are used mainly for pasture. For the past seven seasons, this island has enjoyed uninterrupted agricultural prosperity, owing for the most part to good weather conditions, improved transportation facilities since the building of the Algoma Eastern railway, and enhanced market prices. The country is still only partially cleared and developed, and affords splendid opportunity for the settler desiring cheap land and favourable living conditions.

Cockburn island is only partially settled, and the greater part of it is unsuitable for tillage, partly because of shallow soil, and partly because of the boulders which cover much of its surface.

St. Joseph island is underlain by rocks of Ordovician age, some exposures of Pre-Cambrian quartzite, etc., occurring along the northern shore. This island is covered more heavily by drift materials than any of the others. It has furnished a splendid cut of timber in the past, and still has many fine stands of maple, beech, and yellow birch. Agriculture has been carried on to a considerable extent, the northern end of the island, which is comparatively level and underlain for the most part by a fine red clay, being particularly fertile. Apples grow well on the island and large orchards are being planted.

The smaller islands of the Manitoulin group are not suitable for agriculture. A portion of the northeastern end of Fitzwilliam island was cleared and farm buildings erected, but farming operations were not successful because of the extremely shallow soil.

There is apparently more good land awaiting clearing and cultivation on the western end of the Manitoulin island and on St. Joseph island than in any of the other areas traversed. Transportation throughout the region is dependent upon steamers during the open season, except the portion served by the Algoma Eastern railway, which has its terminus at Little Current. During the winter, Georgian bay is frozen sufficiently solid to afford an excellent highway for traffic. The roads through the settled areas of Manitoulin, Cockburn, and St. Joseph islands are remarkably good, the Provincial Government having spent large sums of money on them. Rural telephones are in general use.

At the present time, the lumbermen are dependent mainly upon cedar, which is used for railway ties, posts, and shingles, and hardwood, which is becoming of increasing value for furniture manufacture. Fitzwilliam island and portions of the southern part of the Wekwemikong Indian reserve have the largest areas of merchantable timber still available.

Fishing is carried on throughout the waters traversed. The Dominion Fish Company and a few smaller companies have well established stations at Lion Head, Wingfield basin, and Tobermory on the Bruce peninsula; at Rattlesnake harbour on Fitzwilliam island; at South Raymouth, Providence bay, Gore bay, and Meldrum bay on Manitoulin island; and at Tolsmayville on Cockburn island. The total tonnage of salmon and whitefish obtained in these waters is very great, and judging by the reports of the fishermen, the efforts of the government have been successful in keeping up the supply of fish, at least in most of the fishing areas.

LONDON AREA, ONTARIO.

(*J. Stansfield.*)

INTRODUCTORY.

During the summer of 1915 a study was made of the geology of the London district, Ontario. The excessive rainfall throughout the season appreciably interfered with the work, so that it was not quite completed. The area under examination is bounded by the meridians 81° and 81° 30′ west, by Lake Erie, and by an east and west line 1½ miles north of the line of 41° 05′ north latitude. As the solid rock does not outcrop in this area, the observations were confined to the drift, except where boring operations enabled the bedrock to be studied.

The drift deposits have been mapped on the scale of 1 mile to 1 inch, using the topographical map of the Militia Department as a base (Port Stanley, London, and part of Lucan sheets).

Thanks are due to the engineers in charge of the waterworks of London, St. Thomas, and Port Stanley for their kindness in facilitating the study of the water-supplies of those towns, and especially to Mr. J. M. Moore, of London, for details regarding the water-supply of that town, gathered during a long period of years. Valuable information was obtained from well drillers and from commercial houses having private water-supplies, and to these, also, thanks are tendered.

TOPOGRAPHY.

The topographical features of the district are determined by the drift deposits and have little or no connexion with the configuration of the underlying bedrock. The level of Lake Erie stands at 572 feet above sea-level. The lake is bounded by vertical cliffs, usually from 100 to 130 feet in height, and broken at points where streams discharge into the lake. Small areas of beach sands have been formed at the mouths of the more important of these streams. The most notable of these beaches is that at Port Stanley. The highest point in the district is between 1,025 and 1,050 feet above sea-level, so that the area forms a plain which is only slightly diversified by morainic ridges, and by the valleys of streams draining these ridges and discharging into Lake Erie, directly, or by way of the Thames river. Kettle and Catfish creeks, discharging at Port Stanley and at Port Bruce, respectively, are the more important streams which empty into Lake Erie. As they approach the lake their beds are more and more deeply cut into the plain, whilst their tributaries become progressively more gorge-like toward the lake. The Thames river, formed by the union of the north and south branches at the western end of the city of London, is the most important drainage channel of the district, its chief tributaries in the district being the Medway river, and Oxbow and Dingman creeks. These tributaries have pronounced gorges at their points of dicharge, and the main river takes on the same character in the western part of the district. These deeply incised valleys illustrate the rapid cutting of post-glacial streams, acting upon the easily eroded materials of the drift.

The most important of the morainic ridges in the district is that which has been named, by Taylor, the Ingersoll moraine. It runs in a generally east and west direction, to the south of the south branch of the Thames, turning abruptly to the north to the west of Byron, and continuing to the north of the Thames as a ridge running almost directly north, through Ilderton. The latter has been named, by Taylor, the Milverton moraine. The Ingersoll moraine branches near Derwent and sends off a spur, toward the west-southwest, which can be traced as far as Littlewood, and may be called the Westminster branch of the Ingersoll moraine. Another morainic ridge extends to the northeast from St. Thomas, running parallel to and on the south side of the upper part of Kettle creek and reaching the same area of high ground from which the Westminster branch of the Ingersoll moraine starts. It would seem to join the Ingersoll moraine in this direction at about the limit of the area. This ridge seems to correspond to part of the St. Thomas moraine as outlined by Taylor. The ridge running toward the northeast from a point south of Dutton, included by Taylor in his St. Thomas moraine, is capped by gravel, and its determination as a moraine appears doubtful. A well-marked morainic ridge runs east-west between Kettle and Catfish creeks to the north of Union and Sparta. It may be called the Sparta moraine.

The greater part of the area has the character of a slightly diversified plain. The northern, central, and southern parts of the area, especially, have this character.

GENERAL GEOLOGY.

Within the area there are no rock outcrops; but well records show that the drift rests upon rocks of middle Devonian age. No intimate connexion can be established between the form of the rock surface upon which the drift lies and the present day superficial topography; but it may be said that, in a general way, the rock surface slopes toward the south a little more rapidly than the actual surface, so that the drift thickens in passing south toward Lake Erie.

The drift deposits of the district allow of subdivision according to the following general scheme:

Recent.	River alluvia; lake marls and peats.
Pleistocene.	Higher river gravels; shore sands and gravels.
	Till with associated kame gravels.
	Intra-glacial stratified clay, silt, and sand.
	Till.
	Intra-glacial stratified clay, silt, and sand.
	Till.

The full succession of these members is not everywhere exposed and it is usually impossible to determine any correlation between the exposures at separate points. The term till is here used to connote a non-stratified clay, carrying rounded and subangular pebbles or boulders, and occasional angular ones, and was laid down under glacial conditions either on land, or in water associated with glaciers or ice-sheets.

The greater part of the succession as given above is exposed in the cliff section east of Port Stanley. The till members undoubtedly correspond to the Erie clay of the older literature. The Erie clay has been held by Dr. Bell and M. B. Baker to have been deposited in water, and we have arrived at the same conclusion, at least as regards the till members which are exposed along the shores of Lake Erie within the limits of the area examined. Although most of the till exposed within the area has been deposited in water, that of the northern part of the area would seem to have been deposited upon land.

The till is a dark bluish-grey clay carrying in the southern part of the area a few small stones, occasional small areas free from stones being met with; whilst in the northern part of the area it carries more numerous and larger stones and boulders. The clay is tough, highly calcareous, breaks off in joint blocks, and weathers on exposed surfaces to a dark reddish-brown colour.

The intra-glacial series are dark bluish-grey in colour except where the exposed upper surface is weathered to a depth of 1 or 2 feet, to a yellowish-brown colour. The beds were undoubtedly laid down in lakes associated with the ice-sheets of the later part of the glacial period, and are the deposits included by Baker under the head of lacustrine clays. In addition to their use in the brick and tile industry they are of great importance as being the principal source of potable waters over the area. (The spring water at Springbank is derived from the higher river gravels of the Thames valley.) The stratified intra-glacial deposits are of importance as indicating changes in the physiographical and depositional conditions of the later stages of the glacial period. They have, as yet, yielded no fossils, so that a correlation with somewhat similar deposits at other points is not possible. There is an important difference between these deposits and those of the Toronto formation, These clays burn to a white or cream coloured product, by reason of the high lime content, whilst the clays of the Toronto formation burn red.

The sands and gravels exposed at the surface within this area may be treated under three heads:

River gravels.
Shore sands and gravels.
Kame gravels.

Kame gravels are especially to be noted as occurring on the northern slopes of morainic ridges to the south of the south branch of the Thames, indicating that they were built by glacial streams flowing from the south. The best examples of kame gravels are to be seen on lots 19 to 21, concessions I and broken front, Westminster township; on lots 19 to 22, concession V, Westminster township; and on lots 28 to 29, concessions VII and VIII, London township. The last mentioned kame is situated on the east side of the Milverton moraine, indicating that it was built by streams flowing from the west.

The shore sands and gravels belong to the shore-lines of the ancestors of Lake Erie. The Algonquin and Nipissing beaches have been destroyed in the gradual northern displacement of the shore-line, so that those beaches are no longer to be found in the area.

The shore-cliff is from 100 to 130 feet in height and is capped, in some parts, by a former lake floor sand with beach deposits toward the north, as seen just north of Sparta, where a shore-cliff is developed. These gravels extend as far as St. Thomas and there are broken continuations of sand and gravel in the western and northwestern part of the area; but whether they may be all referred to one period of submergence or to several will be known only after the determination of the levels of the various beaches.

The river gravels of the higher terraces of the Thames river are interesting, as indicating the existence of the former and much more important stream which drained the district. This was the river called, by Taylor, "Crease river," which carried the swollen waters derived from the northward retreating ice-sheet at the close of the Glacial period, to the southwest, depositing the finer solid materials far away in eastern Indiana and northwestern Ohio. The gravels, by their terraces of coarse pebbles in certain parts of the valley, mark definite stages in the deepening of the valley, until the present drainage system is reached, which is a small remnant of a once more notable stream.

ECONOMIC GEOLOGY.

The economic geology of the district may be treated under three heads, the first of which is connected with the bedrock and the second and third with the drift deposits. They are:

Oil.
Brick and tile manufacture.
Water-supply.

Oil.

There is a small producing oil-field situated on lots 13, 14, and 15, concession X, Dunwich township. It is operated by three companies, there being, in all, a total of about two hundred wells. The average production at the present time is about two barrels per month, per well, the highest production having been slightly less than twice that amount. The wells have an average depth of 400 feet and the producing horizon is a dolomitic limestone, probably the Onondaga. The oil is of excellent quality, is dark green in colour, and has about the consistency of water. Its specific gravity (0·42 Baumé) is much lighter than that of the Petrolia oil, and it brings a higher price, viz., \$1·97 per barrel. The oil is transported from the field by means of a short pipe-line to Dutton, whence it is shipped by rail.

Considerable prospecting for oil has been done during the past few years in the Thames valley, in the vicinity of Delaware, and drilling was actively pursued during the summer of 1915. Full details of the results are not yet to hand.

Brick and Tile.

The materials used in this industry, in the area covered, are the stratified clays and fine sands or silts of the intra-glacial series, or a non-stratified stoneless clay, which, in some cases, overlies the intra-glacial formation, but in others, shows no relation to deposits below, by reason of lack of exposures. This appears to be a stoneless variety of till.

The stratified intra-glacial series is utilized at the following points:

London tp., lots 12 and 13, concession XI.
Westminster tp., lot 33, broken front concession. Two yards.
North Dorchester tp., lot 13, concession B.
Southwold tp., lot 5, concession I.
Malahide tp., lot 1, concession VII.

The non-stratified stoneless clays are utilized at:

Yarmouth tp., lots 6 and 7, concession VIII.
Caradoc tp., lot 20, concession 1 north, on north side of Longwood road.

Ekfrid tp., the most western lot of concession VI.
Southwold tp., lot 10, concession VII.
Southwold tp., lot 7, on the concession north of the Lake road.
West Nissouri tp., lot 5, concession V.

The exposed face was not cleaned off at the locality in lot 7 of Southwold, owing to the fact that no work had been done during the current season, so that the identification of this clay as the non-stratified, stoneless variety may be doubtful.

All of the clays of the district, except that at the last locality mentioned in the list, burn white or light cream (greenish when over-fired) owing to the high calcium (lime) content of the clays. The upper layers of the exposures, usually to a depth of 1 or 2 feet, produce in many cases red products; but since the volume of this superficially leached material is small it is not important as a red-burning marketable product, although such a clay from lot 22, concession I, Westminster township, has been utilized on a small scale in the manufacture of flower pots. It is doubtful whether an attempt to use such a clay on a large scale would be successful. The clay in West Nissouri township, lot 5, concession V, is red-burning for the most part. The position of the deposit with reference to transportation lines, together with the steady market for tile in the immediate vicinity, has prevented the utilization of the clay for brick-making.

The problem of obtaining red products has been met in the past, in the London district, by the importation of bricks from Milton and Hamilton and other outside points. More recently, however, the problem has been partially met by the processes of the London Pressed Brick Company, on lot 30, concession I, Westminster township. Here a bank is worked which is capped by a stoneless clay, passing down into a stratified clay, with stratified sand below. The stratified clay was not well exposed during the season of 1915. The clay, in small pieces, is mixed with coal in a large heap in the yard and the whole is fired, the resulting burned pieces of clay being largely red or pink. This product is crushed, mixed with varying amounts of different pigments, pressed, and reburnt. Thus a series of pressed bricks of different colours is produced.

Water-supply.

A study of the water-supply at London, St Thomas, and Port Stanley was begun, but was not completed.

London has a population of approximately 50,000 people, and at present uses a little more than 4,500,000 gallons of water per day, on the average, the maximum consumption for the hotter months of the year, being 5,000,000 gallons per day. The supply is one of the finest in the country and is derived in part from springs, and in part from deep wells. At and around Springbank the flow of a number of springs has been collected and led into storage ponds from which it is pumped either directly to the city or into a storage reservoir on top of the hill above Springbank on the south bank of the Thames river. The yield from this source averages almost 4,000,000 gallons per day, throughout the year, and the system has reached its limit of expansion. A system of sixteen deep wells, known as the Beck wells, in the western part of the town, is capable of yielding a supply of 3,000,000 gallons per day, and is used, at present, to augment the supply from Springbank. The water is pumped by air-lift pumps and stored in a covered reservoir from which it is pumped into the city mains. The supply is drawn from the base of the drift series which overlies the bedrock in the Thames valley and like that at Springbank, is derived from rainfall. The supply from the well system is capable of increase, both by increase of the number of wells in the producing area, and by increasing the area in which the wells are placed. The limits of the possible area of production have not yet been outlined. The water from this stratum is also utilized by a number of private corporations. and institutions.

Wells driven into bedrock in the western part of London strike copious flows of sulphur water. One of these is utilized at a medicinal bath, and the water of another was formerly utilized for cooling purposes at the Carling brewery. In the eastern part of the town and also southeast of the town, for example in lot 20, broken front concession, Westminster township, wells driven into the rock reach a supply of water which is either non-sulphur-bearing, or only slightly so. The question as to whether this source could be utilized for the town supply is one which would bear examination and experiment.

The water-supply of St. Thomas is derived in part from Kettle creek, and in part from a number of deep wells in the valley of the creek. Thirty-six of these wells have been put down, some of which are unproductive. Formerly the natural flow of the wells was utilized, but now pumping is being done at some of the wells. The water of the creek is run into a settling reservoir, from which it is pumped to an aerator. It is mixed with the well water before reaching the aerator, and is treated with a weak alum solution on leaving it; it then passes to sand filters, and thence is pumped into the mains. The alum causes the precipitation of such suspended matter as is not deposited in the settling reservoir.

At Port Stanley the municipal water-supply is obtained from Lake Erie. A filter gallery has been constructed in the beach sand, close to the shore-line. It consists of a tank, 15 feet deep, with concrete sides and sand bottom. The water enters the tank through the open sand of the floor, being filtered by the natural filter provided by the beach sand. The water is then pumped to a tank reservoir on the top of the cliff, from which it is supplied to the mains.

At Lambeth a well was sunk during the past summer to obtain a water-supply for the village. The surface is underlain by gravel of varying coarseness which continues to the bottom of the well, 149 feet, broken only by 10 feet of clay at the 30 to 40-foot level. This 10 feet of clay has the appearance of till. The water-supply would seem to be derived, therefore, from an intra-glacial gravel series. It is a copious supply, and since the same water-bearing stratum covers a considerable area around Lambeth there is an ample supply promised for the needs of that village. The full capacity of the well has not yet been tested.

ROAD MATERIAL SURVEYS IN ONTARIO AND QUEBEC.

(*L. Reinecke.*)

During the season of 1915 road material surveys were conducted in the provinces of Ontario and Quebec. Information upon road materials was also gathered in the neighbourhood of St. John and Moncton, New Brunswick, by members of the Survey staff engaged in geological work in those areas.

The work in Ontario consisted of the examination and mapping of deposits of stone and gravel lying within 5 miles on either side of the proposed route for a macadam road from Ottawa to Prescott. In Quebec a survey was begun of the materials within hauling distance of a proposed road on the north shore of the Ottawa river from Montreal to Ottawa. The survey was completed from the city of Ottawa to the east boundary of Chatham township near the village of Grenville, that is, about halfway to Montreal.

The writer was assisted by F. H McCullough, K. A. Clark, Henri Gauthier, R. H. Picher, J. H. Macfarlane, D. H. Sutherland, and R. S. Adams. The individual interest taken by these men in their work enabled us to obtain a much greater amount of detailed information than would otherwise have been the case. F. H. McCullough efficiently directed the work of the party in Ontario for the greater part of the season.

OTTAWA-PRESCOTT ROAD.

The proposed route of the macadam road from Ottawa to Prescott follows a southerly course to the west of and near the Rideau river from Ottawa as far as Becketts Landing, near Kemptville. At that point it leaves the river and follows a direction slightly east of south through the villages of Kemptville and Spencerville to Prescott. The completed road will be nearly 60 miles long.

In the field work done last summer an attempt was made to examine and map every deposit of bedrock, field stone, and gravel that lay within wagon hauling distance of the proposed route; and, in order to do that, a belt averaging over 10 miles in width was covered for the whole distance. Near Ottawa, the area examined was extended to include the whole of the townships of Nepean and Gloucester; farther south the boundaries of the work do not follow township lines.

Bedrock.

Bedrock outcrops occur plentifully along the western edge of Nepean township and in a belt 3 miles wide along the south side of the Ottawa river. A few scattered outcrops are found in the south part of Gloucester, but large areas in both these townships are heavily drift covered. From the neighbourhood of Fallowfield, Jock river, and Manotick station, south to a line passing through Becketts Landing, outcrops are practically absent. From Kemptville south to Prescott exposures are found at intervals throughout the area examined, but there is no large area bare of drift.

The bedrock outcropping at the surface consists largely of rocks of Palæozoic age. A small area of Pre-Cambrian age was seen in the northwestern corner of Nepean township near Bells Corners and small outcrops of the same age in the area between Kemptville and Prescott. The Palæozoic rocks arranged in order of age from the oldest to the youngest are: Potsdam sandstones; impure limestones, dolomites, and sandstones of the Beekmantown; Chazy shales and sandstones, Chazy limestones; Black River limestones; Trenton limestones; Utica shales; and Lorraine shales and sandstones.

No really first-class deposits of stone of Pre-Cambrian age lie close to the proposed road, but a number of large deposits of diabase are found north of the Ottawa river to the northwest of Hull. The stone from any of them will make excellent road metal. One of them, used by the Ottawa Improvement Commission, lies some 3½ miles northwest of Hull in lots 10 and 11, range V, Hull township; the other is a series of four deposits extending from near the dynamite storehouse, lot 16, range VII, to the mountain road on the farm of Mr. Mulhvill, range VII, lot 21. Mulhvill's farm is about 10 miles by wagon from Hull. Another small deposit lies north of the road from Kingsmere to Old Chelsea, about 1½ miles from the latter place. The total amount of stone obtainable from these deposits is very great.

The sandstones of the Potsdam are best developed west of Bells Corners. They make good building stones, but are not suitable for road surfacing, as is shown by the accompanying table of tests.

Location.	Owners.	Type of stone.	Formation.	Specific gravity.	Water absorbed, pounds per cubic foot.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.	Cementing value.
Directly east of dynamite storehouse 1½ miles southeast of Kingsmere, Que., lot 16, range VII, Hull township	Canadian Explosives Co., Montreal	Diabase	Pre-Cambrian	3·00	0·11	4·0	10·0	18·6	10	157
Quarry, lots 10 and 11, range V, Hull township, north of mountain road 3½ miles northwest of Hull, Que.	Ottawa Improvement Commission, Ottawa	Diabase	Pre-Cambrian	3·01	0·01	2·8	14·3	18·9	8	163
Lots 20, 21, con. VIII, Oxford, ½ mile northwest of Oxford station	James Sanderson, Oxford station	Quartzite	Pre-Cambrian	2·60	0·46	4·0	10·0	19·4	9	20
On Grand Trunk railway, 3 miles northwest of Bells Corners, lot 3, con. A, Ottawa front	T. Rock, R. R. 1, Britannia Bay	Granite	Pre-Cambrian	2·82	0·16	4·1	9·8	16·9	8	40
Quarry, lot 6, con. II, Ottawa front, 2 miles west of Bells Corners	T. W. Tillson, R.R. 1, Britannia Bay	Sandstone	Potsdam	2·44	2·25	8·0	5·0	16·1	4	59
Quarry, lot 5, con. II, Ottawa front, 2 miles west of Bells Corners	Fred Droeski, Bells Corners	Siliceous limestone	Beekmantown	2·78	0·59	4·2	9·5	16·1	9	39
Railway cut at or near road crossing between cons. V and VI, Nepean, 2 miles southwest of Bells Corners	....	Calcareous sandstone	Beekmantown	2·72	0·63	3·6	11·2	17·5	8	53
Quarry, lot 16, con. II, Ottawa front, 1 mile northeast of Bells Corners	John Graham, Bells Corners	Siliceous limestones and dolomites	Beekmantown	2·82	0·32	4·9	8·2	18·8	10	101
Quarry, lot 18, con. III, Nepean, 1½ miles north by east of Fallowfield station	Wm. Burnett, Fallowfield	Sandstone and impure limestone and dolomite	Beekmantown	2·73	0·15	5·0	8·0	16·6	5	149
Quarry, lot 23, con. IV, Gloucester, on Metcalfe road, 2 miles south of Leitrim	M. Johnston, R.R. 1, Billings Bridge	Silty limestone and dolomite	Beekmantown	2·74	2·27	4·4	9·0	16·5	9	25
Quarry, lot 6, con. I, Marlborough, ½ mile northwest of Becketts Landing	Robert McCulla, R.R. 4, Kemptville	Siliceous limestone	Beekmantown	2·76	0·58	4·4	9·1	16·9	13	73
Quarry, lot 30, con. IV, Oxford, 1½ miles east by south of Kemptville	Mrs. Martin, Kemptville	Siliceous limestone	Beekmantown	2·76	0·80	4·0	10·0	16·8	10	46
Lot 18, con. V, Oxford, ½ mile northeast of Oxford Mills	Sam Harris, Oxford Mills	Impure limestones and dolomites	Beekmantown	2·73	1·95	4·4	9·1	16·6	8	42
Lot 26, con. VI, Oxford, 1½ miles south by east of Kemptville Junction	John Flannigan, Kemptville	Impure limestones and dolomites	Beekmantown	2·80	0·42	4·0	10·0	16·5	8	48
Lot 26, con. VI, Edwardsburg, directly northwest of Spencerville	T. Rickett, Spencerville	Impure limestones and dolomites	Beekmantown	2·82	0·65	5·4	7·4	16·7	8	52
Quarry on Prince street, Prescott	Town of Prescott	Impure limestones and dolomites	Beekmantown	2·80	0·44	4·8	8·3	16·3	12	64
Quarry, lot 11, con. I, Gloucester, south of Montreal road, ¾ mile east of Greens Creek crossing	S. O'Rourke	Limestone, shaly limestone, and shale	Chazy	2·71	0·21	5·0	8·0	16·1	7	29
Quarry, Rockcliffe park, Ottawa	Ottawa Improvement Commission, City of Ottawa	Limestone	Chazy	2·71	0·30	5·1	7·9	15·9	6	104
Quarry, lot 23, Junction Gore, Gloucester, Hogs Back, Ottawa	Richard O'Connor, Billings Bridge, R.R. 1	Limestone	Black River	2·70	0·26	4·7	8·5	15·5	6	20
Quarry, lot 23, Junction Gore, Gloucester, Hogs Back, Ottawa	Adelard Thibault, Billings Bridge	Limestone	Black River	2·71	0·11	6·1	6·5	15·0	5	53
Quarry, lot 33, con. II, Ottawa front, on Merivale road ¾ mile north of City View	Rideau Canal Supply Co., R. F. Foster, Manager, Slater St., Ottawa	Limestone	Black River	2·71	0·25	6·4	6·3	16·5	7	22
Quarry, lot 26, con. I, Gloucester, north of Montreal road, northeast of Roman Catholic cemetery	Rogers and Kirby, Ottawa	Limestone	Trenton	2·70	0·29	4·4	9·1	14·7	5	40
Quarry, lot 23, con. I, Gloucester, south of Montreal road, The Quarries	H. Robillard and Son, 195 Nicholas St., Ottawa	Limestone	Trenton	2·70	0·28	4·7	8·5	14·9	4	75
Outcrop, lot 30, con. VI, Nepean, 2 miles northwest of Fallowfield	A. M. Dewy, R.R. 2, Stittsville	Limestone	Trenton	2·70	0·52	4·8	8·3	14·2	5	81
Quarry, east of Brewery creek, and on west side of Hull, Que.	H. Dupuis and Sons, Hull, Que.	Limestone	Trenton	2·68	0·61	6·4	6·3	15·7	5	60

Beekmantown outcrops are found near Bells Corners in the southeastern part of Nepean and the southern part of Gloucester townships and from there south to Prescott. The Beekmantown consists of interbedded calcareous sandstones and impure, that is, sandy and silty, dolomites and limestones with occasional beds of nearly pure sandstone. The impure limestones and dolomites of the Beekmantown carry more or less sand and silt, and the tests made upon this stone indicate that the greater part of it can be expected to give satisfactory results upon macadam roads subjected to light traffic. Surface beds lying well above ground-water level are, however, apt to have lost a large proportion of their lime content by the leaching of surface waters. They are on that account soft and friable and should not be used on road work.

The Chazy, Black River, Trenton, Utica, and Lorraine formations are found in the western and northern portions of Nepean, and in the northern and eastern part of Gloucester townships.

Shales and sandstones make up the lower part of the Chazy and practically all of the Utica and Lorraine formations. These rocks are of no value for road purposes.

The upper part of the Chazy, the Black River, and the Trenton formations consist almost wholly of limestone beds with only occasional interbeds of shale. A good deal of limestone from these formations has and is being used in and around the city of Ottawa for the making of macadam roads and for concrete work. Because of this fact nearly every quarry south of the Ottawa river from which stone had been taken for road purposes was sampled. The results given below indicate that the limestone obtained from these formations lacks the toughness necessary to withstand any but the very lightest traffic. Observations on the roads in the neighbourhood of Ottawa lead to the same conclusions. Although the limestones bind readily in water-bound macadam surfaces they wear rapidly and the roads made of them become dusty in dry weather and muddy in wet weather.

Field Stone.

Field stone deposits were mapped and examined only in cases where the stones had been piled in fences or heaps. Field stone deposits are most plentiful on the higher land; very little stone of this character is found in the swamps; and since only a small proportion of high, dry land is uncleared, only a small part of the total deposit of field stone is unpiled and is not dealt with in this report. Nearly the whole belt examined contains more or less field stone. There are, however, a few large areas devoid of it; one of these, 3 to 4 miles wide, stretches southeast from Bells Corners across the Rideau river; another, a swamp area, lies in the eastern part of Gloucester township, and another north of Kemptville. Large quantities of field stone are concentrated in a belt from 4 to 8 miles wide, stretching from Leitrim southwest to Burritt Rapids. Field stone is also very plentiful south of Kemptville. The composition and size of these field stone deposits have been worked out in detail fence by fence, and pile by pile.

It is generally true that the average composition of the field stone deposits is related to the bedrock underlying the area in which it is found. For instance in the area from Manotick south the field stone fences generally carry an average of 60 to 85 per cent of Beekmantown impure limestone and dolomites. There are many fences and small areas in this part, however, in which the proportion of Pre-Cambrian boulders (granites, trap, and quartzites) comprises from 50 to 90 per cent of the whole deposit.

In certain other areas also, such as one near the Jock river and one immediately southwest of Johnston Corners, 50 per cent or more of the deposit consists

Composition and Physical Character of Deposits of Field Stone.

Location.	Field estimate of percentages of					Physical character.				
	Sizes.		Composition.							
	Over 2 ft.	Under 2 ft.	Lime-stone.	Hard. Granite, etc.	Soft. Sandstone, etc.	Specific gravity.	Water absorbed, pounds per cubic ft.	Per cent of wear.	French coefficient of wear.	Cementing value.
Lot 25, con. IV, Gloucester	....	......	5	70	25	2·51 to 2·83	0·11 to 0·90	8·9	4·5	68
Lot 9, con. III, North Gower	66	33	80	9	11	2·71 to 2·81	0·72	7·0	5·7	21
Lot 6, con. II, Nepean	75	25	24	5	70	2·46 to 2·78	0·32 to 1·18	13·2	3	45
Lot 29, con. II, Osgoode	40	60	18	57	25	2·35 to 2·81	0·21 to 1·71	7·4	5·4	43
Stockpile on road about 2 miles south-east of Pierces Corners, Marlborough	....	......	82	12	6	2·55 to 2·77	0·42 to 0·76	3·0	13·3	31
Lot 7, con. II, Marlborough	10	90	90	5	5	2·57 to 2·80	0·29 to 2·01	5·9	6·8	40
Lots 21 and 22, con. IX, Oxford	....	......	10	80	10	2·67 to 2·96	0·19 to 0·91	6·0	6·6	91

of soft shales and sandstone. The details of the variations in composition from place to place cannot, however, be effectively expressed in a summary report and no attempt is, therefore, made to do so.

The table given on page 150 indicates that there is a general relation between the proportion of soft material present in the deposit and the wearing quality of the stone on road surfaces. In other words, the wearing quality becomes poorer as the amount of soft material increases.

It is evident from the table that when the stone used includes much over 25 per cent of soft boulders, that is, sandstone, shale, or schist, the percentage of wear becomes excessively high and the material will not last long on a road surface.

A comparison of this table with the table on page 148 indicates very clearly, also, that where the field stone carries a high proportion of the same kind of stone as the bedrock underlying it, the stone quarried from bedrock is apt to be of much better quality for road purposes than the field stone. This holds true at any rate for the area underlain by Beekmantown limestones and dolomites; for these stones lose a great deal of their lime and consequently of their strength on being exposed to the leaching action of surface waters.

The amount of field stone lying within hauling distance of the road was estimated at nearly 800,000 cubic yards, that is, far more than enough to pave the road, but a large proportion of the stone cannot be used economically on a trunk road such as the one proposed, because of its poor quality.

Gravel.

East of the Rideau river a nearly continuous ridge of sand and gravel stretches from Bowesville in a southeasterly direction to Greely and from there along the old "Prescott" road to within 4 miles of Kemptville. In Nepean township west of the river only a few deposits are found. Several lie between Eagleson Corners and the mouth of the Jock river. South of the Jock there is a discontinuous ridge of sand and gravel from near the big bend of that stream going southerly as far as Kars in North Gower. A number of other and smaller areas lie scattered through North Gower and Marlborough. From Kemptville south to Oxford Mills gravel ridges are numerous and some of them are of excellent quality. From Spencerville south to Prescott, gravel is to be had on both sides of the road, but not in such quantity as farther north.

The results of laboratory tests made upon gravel from this area are given below. In the same table are included the field estimates of the average compositions of the gravels. The pebbles of silty limestone mentioned in the table have part of the qualities of the soft sandstones and shales, but because of their lime content they are somewhat tougher and have a cementing value. In general the wearing quality of the gravel varies directly in proportion to the amount of pebbles of soft rocks present, that is the more sandstones, shales, and schists the poorer the wearing qualities of the gravel. The amount of silty limestone present affects the wearing quality in the same way, but not to so great an extent. In the table below four out of every five samples follow this rule. The wearing qualities of the gravels mentioned in this table cannot be directly compared with those of the stone samples since the wearing test upon gravel is made only upon the pebbles over one-half inch in size, and all gravels contain a large amount of material under that size which would wear to dust more rapidly than the larger pebbles. Gravel of any particular percentage of wear is, therefore, of poorer quality than stone giving the same result when tested in the laboratory. The cementing value of the gravels tested was in nearly all cases very good.

MONTREAL-OTTAWA ROAD.

The route of the western half of the proposed macadam road between Montreal and Ottawa lies close to the north shore of the Ottawa river from Grenville west to Ottawa. The field work done this summer included this portion only. In that distance the river is broad and unbridged except at the city of Ottawa. Only deposits of stone lying north of the river were, therefore, considered available for the road in question.

From Ottawa eastward to Papineauville a series of clay terraces rise gradually from the river to the Laurentian hills a few miles to the north. The clay is in places overlain by sand and gravel, and underlain by flat-lying sandstones and limestones of Palæozoic age. The Laurentian hills, which along this part of the river rise from 50 to 500 feet above the clay, are made up of igneous and metamorphic rocks of Pre-Cambrian age.

In general it may be said that an abundant supply of stone can be obtained from outcrops of bedrock within 1 or 2 miles of the proposed road throughout the distance surveyed. This is true except for a stretch a few miles long east of the Gatineau river. Unfortunately all of the bedrock so situated is not suitable for macadam work; and because the stone varies very greatly in quality, the service obtained from this particular road after its construction, will depend very largely upon the care with which the surfacing material is selected.

The geology of the Laurentian plateau is of a complex character. The rocks are for the greater part gneissic, that is they are banded or foliated. Geologically, they consist of a group of altered sediments intruded by a series of igneous rocks which range from very basic to rather acid material. They have been called the Buckingham series by M. E. Wilson.[1] The more basic members of the series are for convenience called "augite syenite" in this report, the more acid are called "granite." Younger than these are intrusives of granites and pegmatites, and last of all dykes of diabase cutting everything else, except possibly some pink syenites north of Grenville.

The Palæozoic rocks to the south consist of sandstones and impure limestones and dolomites of Potsdam and Beekmantown age. Along the valley of the Ottawa and in depressions in the Laurentian hills are heavy deposits of bedded blue clay covered in places by yellow sand or yellow sand and gravel.

The Pre-Cambrian rocks are mostly foliated or banded and sometimes much contorted. All of them except the diabase dykes, and possibly some porphyries and syenites north of Grenville, appear to have been deformed by stresses in the earth's crust. The evidences of such deformation are the crystalline character of the sediments present, the generally banded character of both sediments and igneous rocks, and the broken or granulated character of the quartz and feldspar members in some of the later granitic intrusions.

The results of the tests made upon samples of rock from this district, which are given below, together with other considerations, indicate, that of the Pre-Cambrian rocks, the diabase intrusives make the best road materials; second in value to them but varying greatly in quality are the fine-grained and less foliated portions of the pyroxene-bearing igneous rocks. The more perfect the banding and the greater the evidence of shearing and granulation, the poorer the stone is for road purposes. There are exceptions to this rule as the result of tests upon foliated augite syenite near Buckingham shows.

The altered sediments are either soft crystalline limestones or gneissic or schistose rocks and are of poor quality. The later and lighter coloured pink and grey granites are not of good quality as the two tests upon them indicate. A fine-

[1] Summary Report of the Geol. Surv., Can., for 1913, p. 199.

Location.	Owners.	Field estimate of per cent of: Sizes. Boulders 3 ft. and over	Gravels ¼ to 3 inches.	Sand ¼ inch and under.	Impurities. Clay, etc.	Composition. Limestone pebbles.	Silty limestone pebbles.	Hard pebbles, granite, etc.	Soft pebbles, shales, etc.	Laboratory determination of physical characters. Specific gravity.	Per cent wear.	French coefficient of wear.	Cementing value.	Per cent voids, materials loose.	Per cent voids, material compacted
[1]Pit south of McKay lake, Rockcliffe Park, Ottawa.[2]	Chas. Keefer, Rockcliffe Sand and Gravel Co.	20	40	40	....	21	22	41	16	2·66	3·6	11·1	125	27·0	19·2
Pit, lot 13, con. II, ¾ mile southeast of Bowesville.	L. L. Lecuyer, Bowesville.	20	30	50	Some $CaCO_3$,[2] clay, and iron oxide	22	43	9	22	2·71	5·1	7·8	70	29·9	22·4
Pit, lot 19, con. III, Gloucester, on Bowesville road ½ mile southwest of Gloucester station.	Road allowance.	20	50	30	Some $CaCO_3$ and clay	45	....	20	35	2·71	9·0	4·4	35	31·7	21·1
Pit, lot 8, con. II, Gloucester, ½ mile north of Bowesville.	Michael Nolan, Bowesville.	35	35	30	Some $CaCO_3$	30	....	15	55	2·70	7·6	5·3	113	28·4	21·4
Pit, lot 26, con. IV, Gloucester, at Johnston Corners.	Allen Johnston, R.R. 2, Billings Bridge.	10	35	55	Some $CaCO_3$	20	....	20	60	2·70	8·2	4·9	88	32·0	24·6
Pit, lot 13, con. IV, Nepean, south of Jock river.	Andrew Todd.	50	30	20	Some $CaCO_3$	20	22	20	38	2·72	9·7	4·1	80	32·1	23·7
Pit, lot 12, con. V, Nepean, south of Jock river.	Wm. Little, Fallowfield.	30	45	25	Some $CaCO_3$	20	....	20	60	2·69	7·4	5·4	74	28·4	20·5
Pit, lot 25, con. V, Nepean, ½ mile north of Fallowfield.	Robert Wallace, Fallowfield.	10	75	15	Some $CaCO_3$	68	6	3	23	2·65	3·0	13·3	82	39·2	30·5
Lot 15, con. III, North Gower, 1½ miles north of North Gower.	W. J. Graham, North Gower.	35	45	20	Some $CaCO_3$ and clay	93	....	1	6	2·81	2·8	14·3	43	30·5	21·3
Lot 2, con. I, North Gower (unweathered part of deposit) 2 miles southwest of Manotick.	James Tobin, Kars.	15	50	35	Some $CaCO_3$, plenty of clay	25	15	10	50	2·65	8·6	4·6	80	33·6	25·8
Lot 2, con. I, North Gower (weathered part of deposit).	James Tobin, Kars.	15	50	35	Some $CaCO_3$, plenty of clay.	25	15	10	50	2·52	7·8	5·1	100	36·8	27·8
Lot 13, con. IV, North Gower, 2½ miles northwest of North Gower.	J. R. Beckett, R.R. 3, Richmond.	20	45	35	Traces $CaCO_3$, some clay	....	80	5	15	2·77	7·0	5·7	69	31·8	22·7
Lot 17, con. III, North Gower, 1 mile north of North Gower.	Nixon Craig	40	40	20	Traces $CaCO_3$	....	93	1	6	2·77	6·4	6·3	39	29·8	22·8
Lot 4, con. IX, Marlborough, 1½ miles southwest of Baxters Corners.	P. B. Bowrin, R.R. 3, Richmond	20	55	25	Some $CaCO_3$	....	90	5	5	2·75	4·6	8·7	51	31·4	21·1
Lot 26, con. II, Osgoode, 2 miles northeast of Osgoode station.	Canadian Pacific Railway Co.	15	60	25	Some $CaCO_3$	26	38	14	22	2·71	4·8	8·3	114	29·2	22·8
Lot 11, con. VII, Marlborough, 1½ miles southwest of Malakoff church.	J. McCurdy, Malakoff.	10	70	20	Smallamount $CaCO_3$	64	28	4	4	2·74	2·5	16	40	32·0	22·9
Lot 25, con. II, Oxford, ¾ mile west of Kemptville.	The Dominion Concrete Co., Kemptville.	varies greatly			....	90	....	2	8	2·75	3·4	11·8	45	29·5	22·8
Lot 18, con. II, Oxford, 3½ miles west of Kemptville.	J. J. Dolan, R.R. 5, Kemptville.	25	45	25	....	75	20	2	3	2·79	7·8	5·1	22	28·1	19·0
Lot 24, con. IV, Oxford, 1 mile south of Kemptville.	R. J. and A. Somerville, Kemptville.	30	40	30	....	93	6	0·5	0·5	2·81	2·4	16·7	25	28	19·7
Lots 23 and 24, con. III, North Gower, 1½ miles east of North Gower.	Robert Clark, Marlborough; and George Dolson, North Gower.	....	....	....	....	....	....	....	....	2·70	5·1	7·9	92	41	27·4
Lot 30, Rideau Front, Osgoode, 1½ miles southwest of Osgoode station on Rideau river.	Allan Mussell, Osgoode station.	2	47	50	....	30	11	25	35	2·72	2·6	15·4	76	30·6	22·0
Lot 4, con. III, Marlborough, 1½ miles east of Pierces Corners.	W. Moffatt, R.R. 1, North Gower.	10	60	30	Some $CaCO_3$	85	10	2	3	2·76	4·8	8·3	25	27·0	18·8
Lot 6, con. VI, South Gower, about 3 miles east of Kemptville.	John Coleman, R.R. 3, Kemptville.		varies greatly		Some shells, little $CaCO_3$	65	16	9	10	2·76	7·8	5·1	65	29·7	22·2
Lot 21, con. IV, Oxford, on railway 2 miles west of Kemptville Junction.	Canadian Pacific Railway Co.	0	60	40	Some $CaCO_3$	96	1	1	2	2·76	2·8	14·3	26	28·5	20·2
Lot 22, con. III, Oxford, about 2 miles southwest of Kemptville.	N. Seymour, Kemptville.	25	35	40	Shells, clay, and $CaCO_3$	93	6	0·5	0·5	2·79	2·0	20·0	50	26·5	20·0
Lot 27, con. V, Oxford, 1¼ miles southeast of Kemptville.	Oxford township.	25	50	25	Some $CaCO_3$	50	25	2	23	2·72	3·8	10·5	74	28·6	22·5
Lot 21, con. VII, Oxford, 1½ miles northwest of Oxford station.	Oxford township.	10	60	30	Traces $CaCO_3$ and iron oxide.	55	21	9	15	2·76	4·8	8·3	48	28·0	22·2
Lot 16, con. VII, Oxford, ½ mile northeast of Pattersons corners.	Oxford township.	2	25	73	do.	74	15	6	5	2·74	2·6	15·4	69	23·5	19·1
Lot 26, con. X, Oxford, 1 mile southeast of Millar settlement.	South part Edwardsburg and North Oxford townships.	25	35	40	No impurities.	40	53	5	2	2·66	3·2	12·5	45	25·5	18·8
Lot 21, con. X, Oxford, ½ mile south of Oxford station.	Oxford township.	30	35	35	Traces $CaCO_3$	36	49	10	5	2·69	8·4	4·8	53	26·5	19·5
Lot 24, con. VIII, Edwardsburg, 1¾ miles north of Spencerville.	Mrs. F. Whitley, R.R. 3, Spencerville.	30	40	30	Some $CaCO_3$ and silt	76	12	5	7	2·73	5·2	7·7	75	25·2	19·0
Lot 12, con. VII, Edwardsburg, ½ mile east of Ventnor.	John Spencer, Ventnor.	6	54	40	Trace to abundant $CaCO_3$.	85	5	5	5	2·71	1·8	22·2	67	25·6	20·0
Lot 30, con. VII, Edwardsburg, 1 mile west of Spencerville.	James Black, Spencerville.	15	48	37	Moderate amount $CaCO_3$	87	6	2	5	2·72	7·8	5·1	83	25·5	19·5
Lot 24, con. V, Edwardsburg, 1½ miles southeast of Spencerville.	Dr. P. A. McIntosh, Spencerville.	20	53	27	Traces of clay, $CaCO_3$ iron oxide	82	9	3	6	2·79	3·4	11·8	35	27·5	19·8
Lot 33, con. VI, Edwardsburg, 2½ miles southwest of Spencerville.	Henry Keeler, R.R. 2 Spencerville.	40	20	40	Traces $CaCO_3$	51	34	10	5	2·70	5·0	8·0	52	26·0	19·1
Lot 3, con. VI, Augusta, ⅓ mile east of Roebuck.	Miss Mary Johnson, Roebuck.	5	60	35	Traces $CaCO_3$	67	23	5	3	2·74	5·5	7·3	43	30·0	22·0
Lot 9, con. II, Augusta, ½ mile east of Maynard.	G. W. Robinson, R.R. 2, Prescott.	20	50	30	Plenty of clay, some $CaCO_3$	77	5	10	8	2·79	8·4	4·8	86	28·8	22·8
Lot 8, con. III, Augusta, ½ mile northeast of Maynard.	Wm. Robinson, R.R. 2, Prescott.	5	60	35	Traces $CaCO_3$ iron oxide	63	18	12	7	2·79	5·8	6·9	71	28·9	23·8

[1] The quality of the gravel in this deposit varies and the greater part of it is of decidedly poorer grade than this sample.
[2] $CaCO_3$ = Carbonate of lime.

grained porphyry found north of Grenville, however, proved to be remarkably durable.

Of the Palæozoic rocks the sandstones of the Potsdam are considered worthless. The experience of road engineers in other places and tests made upon exactly the same type of stone near Ottawa are the reasons for classifying them as such. On the other hand the impure dolomites and limestones of the Beekmantown compare favourably as a class with the pyroxene-bearing rocks of the Pre-Cambrian.

A list of deposits of the better class of stone is given below. The classification given is not final and will probably be modified upon further study.

Laboratory tests were made on nearly all the deposits listed, and the list should be read in conjunction with the table which follows it.

Ottawa to Buckingham.

Of the deposits of stone lying within 4 miles of the proposed road between the Gatineau and Lièvre rivers those considered the most suitable for the wearing course of macadam roads are:

(1) Two areas of impure dolomite and limestone in the village of East Templeton and just east of it.[1]

(2) A deposit of fine-grained, fairly massive, that is unbanded, pyroxene rock one mile northeast of Cousineau post-office and about 500 feet west of the town line.

(3) Another of the same type on the farm of Mr. Thos. Trudel, lot 19a, range II, Buckingham township, $1\frac{3}{4}$ miles west of the Lièvre river.[1]

(4) A few hundred cubic yards of diabase on the farm of Mr. Daniel Laframboise, lot 21, range III, Buckingham.

(5) An area of fine-grained kersantite north of the range road in range III, 2 miles southwest of Buckingham and seven-tenths of a mile west of the Lièvre river.[1]

Buckingham to Papineauville.

The best deposits of stone from the Lièvre river east to Papineauville area are as follows:

(1) A large diabase dyke about 20 yards wide which outcrops at intervals from the Bell graphite mine westerly to a point less than one mile northwest of Buckingham. It passes across the farms of Michael Gleason, Thomas Macnamara, and J. E. Belter.[1] North of Belter's house the dyke cuts across a hill of a dark reddish-black kersantite rock the fine-grained portions of which will probably also make good road stone.[1]

(2) In the town of Buckingham, stone from Cameron's lot just north of the Alexander hotel has been used on macadam roads in Buckingham with good results.[1] The deposit is practically exhausted. A dense augite syenite blasted from the river at the Buckingham Electric Reduction Company's works proved upon testing to be excellent road stone.[1] It has been used in tar macadam roads in Buckingham village. Some of the augite syenite in the hill directly west of Buckingham also showed up well in the laboratory test, but the stone from this large deposit must be selected with care.

(3) An area of augite syenite with portions in which the rock is comparatively massive lies in lot 20, range V, Lochaber, 3 miles north of Lochaber bay.

[1] A sample from this deposit has been tested, see folder p. 154.

(4) Impure limestones and dolomites of Beekmantown age are found in Thurso village and one-half mile to the east of it. The limestone in Thurso has been used with good results on a macadam road in that place.[1] Care should be taken to eliminate the weathered surface stone when using this limestone on the roads.

(5) A small outcrop of diabase lies just above the bridge over the Blanche river at Blanche Mills. Its position, however, will probably prevent its exploitation for road purposes.

(6) Limestones of the same type as No. 4 are found in the southeast corner of Lochaber township near Kings road.[1]

(7) Fine-grained, massive, augite syenite is to be had within one-half mile north of Kings road for the first 2 miles west of Papineauville.

Papineauville to Grenville.

(1) A deposit of diabase on the farm of Mr. Antoine Robitaille, one mile northeast of Papineauville, amount available 5,000 to 6,000 cubic yards.[1]

(2) Several deposits of diabase on the farms of Messrs. J. Blais and Kemp west of Charette lake and about 2½ miles by wagon road from the front road at Montebello. Amount available 250,000 to 300,000 cubic yards.[1]

(3) A few hundred yards south of Charette lake and west of Lac aux Bluets on the farm of Mr. Charette there are three large outcrops of diabase from which at least 100,000 cubic yards can be obtained.[1]

(4) A mile and one-half west of Charette lake, where an east and west road from that direction runs into the Montebello-St. Andre Avelin road, there is a small outcrop of diabase carrying about 4,500 cubic yards which could be easily quarried.

(5) Several small outcrops of diabase occur on either side of the railway up the Kinonge (or Salmon) river north of Fassett, and at Maholey Junction about 7 miles north of Fassett there is a large deposit lying on both sides of the railway.[1] The amount which can be quarried without difficulty at this point is about 350,000 cubic yards and the material can be shipped directly by rail from the quarry and deposited within one-half mile of the proposed road practically all the way from Ottawa to Grenville.

(6) Several hundred thousand cubic yards of diabase occur on the farm of Mr. Andre Deslauriers about one-half mile east of the road from Pointe au Chene to Avoca and 2½ miles north of Kings road at Pointe au Chene.

(7) About one-half mile southwest of No. 6 on the farm of Mr. Thos. Garland there is about 15,000 cubic yards of diabase in sight.[1] This lies in a notch on a prominent hill within a few hundred yards east of the Avoca road.

(8) On the farm of James Young, one mile north of Pointe au Chene, about 18,000 cubic yards of diabase are to be found, some of it lying directly on the Avoca road.[1]

(9) A few hundred yards north of Pointè au Chene and immediately east of the Avoca road, there is an outcrop of fine-grained augite syenite, laboratory tests upon which have given excellent results.[1]

(10) About 1,000 feet north of Kings road and the same distance east of Rouge river, there is a dyke of diabase over 100 feet wide from which more than 300,000 cubic yards can be quarried without serious difficulty. This deposit is in a most advantageous position for use on the road. The property is owned by the Riordan Paper Company, Limited, of Hawkesbury.[1]

[1] A sample from this deposit has been tested, see folder p. 154.

Location	Owner	Type of stone	Formation or age.	Specific gravity.	Water absorbed, pounds per cubic foot.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness	Cementing value.
Two miles northwest of Bassin du Lièvre, lot 19a, range II, Buckingham.	Thos. Trudel.	Fine-grained granite or augite syenite	Buckingham series, Pre-Cambrian.	2·78	0·06	3·8	10·3	19	7	91
Hill directly west of Buckingham.		Coarse foliated augite syenite	Buckingham series, Pre-Cambrian.	2·93	0·14	3·6	11·1	18·9	17	80
North of east-west road and 1 mile east of Buckingham near farm house.	J. E. Belter, Buckingham	Diabase	Pre-Cambrian	3·02	0·11	3·2	12·5	18·9	12	166
Two miles southwest of Buckingham, just north of road between ranges II and III, $\frac{7}{10}$ mile west of Lièvre river.		Kersantite	Pre-Cambrian	2·76	0·11	2·8	14·3	18·9	15	131
Immediately north of diabase on Belter's farm.	J. E. Belter, Buckingham	Fine-grained kersantite	Pre-Cambrian	2·87	0·03	2·8	14·3	18·4	17	234
Cameron's lot, north of Alexandra Hotel, Buckingham, Que.	....	[1]Augite syenite, fairly massive	Buckingham series, Pre-Cambrian	2·78	0·05	3·3	12·1	17·1	12	81
At Buckingham Electric Reduction Co.'s works, Buckingham, Que.	Buckingham Electric Reduction Company.	Massive augite syenite	Buckingham series, Pre-Cambrian	2·84	0·01	3·5	11·4	18·9	25	59
Lot 20, range V, Lochaber, 3 miles north of Lochaber Bay, Que.	....	Fine-grained augite syenite, fairly massive	Buckingham series, Pre-Cambrian	2·70	0·14	4·5	8·9	18·7	16	35
Railway cut, 1 mile west of Plaisance, Que.	Jos. King, Plaisance.	Fine-grained, foliated augite syenite	Buckingham series, Pre-Cambrian	2·89	0·08	4·6	8·7	18·2	6	80
Two miles north of Papineauville, $\frac{1}{4}$ mile west of St. Andre Avelin road.	....	Largely foliated granite	Buckingham series, Pre-Cambrian	2·83	0·30	4·9	8·2	17·0	10	48
Two miles west of Papineauville, $\frac{1}{2}$ mile north of Kings road, and west of mountain road.	....	Granite, coarse grained, fairly massive	Buckingham series, Pre-Cambrian	2·77	0·28	4·4	9·2	18·7	9	44
On mountain road 3 miles east of Fassett, $\frac{3}{4}$ mile north of Kings road	....	Grey granite, much altered	Pre-Cambrian	2·68	0·17	7·4	5·4	18·3	4	127
At foot of mountain $1\frac{1}{2}$ miles west of Pointe au Chene, $\frac{1}{3}$ mile north of Kings road.	....	Pink granite, sheared, not intensely foliated	Pre-Cambrian	2·62	0·67	4·4	9·0	18·7	6	65
East of mountain road, 500 feet north of Pointe au Chene.	....	Augite syenite, fine-grained, foliated	Buckingham series, Pre-Cambrian	2·98	0·00	3·6	11·1	18·8	14	45
On west side Charette lake, Montebello.	Mr. Kemp, Montebello.	Gabbro	Pre-Cambrian	2·96	0·18	3·2	12·5	18	11	90
Lot 84, Ste. Angelique parish, 1 mile northeast of Papineauville.	Mr. Antoine Robitaille, Papineauville.	Diabase	Pre-Cambrian	3·03	0·13	3·7	10·8	18·5	16	120
Two miles northeast of Montebello, $\frac{1}{4}$ mile south of Charette lake.	Mr. Charette, Montebello.	Diabase	Pre-Cambrian	3·05	0·11	3·4	11·8	18·7	15	123
Two miles north of Montebello, $\frac{1}{2}$ mile west of Charette lake, north of an east-west road.	....	Diabase	Pre-Cambrian	3·03	0·16	3·0	13·3	18·7	17	55
Maholey Junction, 7 miles north of Fassett, immediately west of railway.	Fassett Lumber Co.	Diabase, coarse-grained and badly altered	Pre-Cambrian	3·03	0·18	3·2	12·5	18·6	10	100
Same east of track.	Fassett Lumber Co.	Diabase, coarse-grained, fresher than preceding	Pre-Cambrian	3·06	0·07	2·8	14·3	18·8	12	86
Lot 2, range IV, Augmentation de Grenville tp., 3 miles north of Pointe au Chene, Que., east of mountain road.	Thomas Garland, Pointe au Chene.	Diabase	Pre-Cambrian	3·04	0·13	3·2	12·5	18·5	12	97
Lot 2, range II, Augmentation de Grenville 1 mile north of Pointe au Chene on mountain road.	James Young, Pointe au Chene.	Diabase	Pre-Cambrian	3·05	0·25	3·0	13·3	18·8	16	35
1,000 feet north of Kings road and just east of Rouge river, 2 miles west of Calumet.	Riordan Paper Company, Ltd., Hawkesbury.	Diabase	Pre-Cambrian	3·01	0·08	3·2	12·5	18·6	14	182
West of Calumet creek and first mountain road east of Calumet, $2\frac{1}{4}$ miles north of Kings road.	E. Brown, Calumet.	Diabase	Pre-Cambrian	3·04	0·08	3·0	13·3	18·6	14	162
Lot 13, range IV, Grenville, about 1 mile north of Kings road on mountain road east of Calumet.	A. McKay, Calumet.	Diabase	Pre-Cambrian	3·01	0·09	3·4	11·8	18·7	13	164
On Scotch road about 4 miles north of Grenville.		Basic diabase	Pre-Cambrian	3·01	0·04	3·4	11·8	18·5	11	91
Just west of Rawcliffe, north Grenville.		Syenite porphyry	Pre-Cambrian	2·69	0·12	3·0	13·3	19·4	35	53
Quarry east of north-south road in village of Thurso.	Thurso village.	Impure limestones and dolomites	Beekmantown.	2·71	0·08	3·4	11·8	18·5	14	67
Quarry at forks of Kings road and township line roads, $2\frac{1}{2}$ miles west of Plaisance, Que., lower beds in section.		Siliceous limestone	Beekmantown	2·80	0·21	6·1	6·6	18·9	18	63
Quarry at forks of Kings road and township line roads, $2\frac{1}{2}$ miles west of Plaisance, Que., upper 12 feet in section.		Impure limestones and dolomites	Beekmantown	2·83	0·34	3·9	10·3	17·1	14	40
Old quarry south of main road and west of wharf road in village of East Templeton.		Impure limestones and dolomites somewhat weathered	Beekmantown	2·77	0·63	5·2	7·7	17·3	7	120
New quarry east of wharf road, East Templeton.		Same fresh rock	Beekmantown	2·78	0·88	3·6	11·1	15·5	10	61

[1] The term augite syenite was applied in the field to a series of gneissic rocks of igneous origin varying in composition from basic to acid, and is used in that sense here.

(11) A few thousand cubic yards of diabase is found on the farms of E. Bigelow and E. Willman, one-half mile north of Kings road and one mile northwest of Calumet.

(12) A deposit of more than 6,000 cubic yards lies on the farm of E. Brown, west of Calumet creek and west of the first mountain road east of Calumet. It is 2½ miles from Kings road.[1]

(13) A dyke of diabase carrying altogether nearly 10,000 cubic yards crosses the same mountain road about 1⅓ miles north of Kings road. It lies on the farm of A. McKay.[1]

(14) The east end of a diabase dyke crosses Scotch road about 4 miles north of Grenville. Only a few thousand yards lie at the road, most of it on the west side. The dyke is found at intervals for a distance of a mile to the west and 100,000 cubic yards could be obtained from it in that distance.[1]

(15) Finally, a dense porphyry lying to the west of Rawcliffe post-office, has proven up well in the tests.[1]

A table showing the results of tests upon the better class of deposits in this area is given following.

Gravel.

Deposits of yellow sand are of frequent occurrence in the neighbourhood of the proposed road. These deposits are in places gravelly and in one or two instances the proportion of gravel is greater than that of the sand. Two of the more promising deposits encountered were sampled with the following results.

Results Upon Tests of Gravel from the North Shore of Ottawa River.

Location.	Composition.		Physical characters.					
	Hard pebbles.	Soft pebbles.	Specific gravity.	Per cent of wear.	French coefficient of wear.	Cementing value.	Per cent of voids, material loose.	Per cent of voids, material compacted.
One mile east of Papineauville, ½ mile north of Kings road.	88	12	2·69	4·4	9·1	71	34·0	27·0
Lot 12, range III, Grenville, 1 mile east of Calumet, ⅓ mile north of Kings road.	99	1	2·64	1·6	25	217	34·1	24·5

[1] A sample from this deposit has been tested, see folder p. 154.

SOUTHWESTERN PORTION OF THE BUCKINGHAM MAP-AREA, QUEBEC.

(*M. E. Wilson.*)

In the Summary Report of the Geological Survey for 1913, it was stated that in that year the writer undertook the geological investigation of the district lying northeast of the city of Ottawa, in Ottawa and Labelle counties, Quebec; and that in connexion with this investigation it was proposed that a regional map (approximately 430 square miles in area) extending from the Ottawa river northward to High Falls on the Lièvre river, and from the Gatineau river eastward to a point 2 miles beyond the town of Buckingham, be prepared, and published on the scale of 1 mile to 1 inch. It was also pointed out that since the various rock formations of this area had been intimately intermingled with one another it was impossible to indicate the detailed relationships of many of these on the areal sheet, and it was, therefore, proposed to supplement the larger map with a number of small, local maps of areas adjacent to the important mineral deposits of the district, on scales ranging from 100 to 500 feet to 1 inch.

In 1913, the southeastern portion of the map—approximately the township of Buckingham—was mapped, while the northern part of the district—East and West Portland and portions of Derry, Bowman, and Wakefield townships—was covered in 1914. In 1915, field work was carried on in the southwestern portion of the sheet—that is in Templeton and the adjoining portions of Hull and Wakefield townships.

The detailed maps prepared in the course of the three years work include areas in the vicinity of the following properties:

Dominion graphite mine, Quebec graphite mine, Bell graphite mine, N. American graphite mine, Walker graphite mine, Diamond graphite mine, Emerald phosphate mine, Villeneuve muscovite-feldspar mine, Poupore mica mine, Moose Lake mica mine, Battle Lake, Lake Rheaume, and Maple Leaf mica mines, Wallingford, Phosphate King, and Rainville mica mines, Blackburn mica mine, Dacy mica mine, Vavasour mica mine, Crescent (McLelland) mica mine.

The hearty co-operation afforded the writer by all those engaged in mining in the district, aided greatly in carrying on the work. Acknowledgments are especially due to Mr. H. P. H. Brumell of the Dominion Graphite Company; to Mr. C. Brown of Cantley; to Mr. A. Geister, manager of the Quebec graphite mine; to Mr. H. L. Forbes, manager of the Blackburn mine; to Mr. C. Kendall, manager of the Bell mine; to Mr. L. McLaurin; to Mr. E. Watt; to Mr. E. Wallingford, manager of the Wallingford Mica and Mining Company; and to Mr. B. Winning in charge of operations for O'Brien and Fowler.

I was assisted in the field during the past season by H. V. Ellsworth, W. V. Howard, M. S. Nelson, and Lucien Clermont, all of whom performed their work in a satisfactory manner.

Topography.

The district included in the Buckingham map-area lies on the border line between two physiographic provinces, the Laurentian plateau and the Champlain division of the St. Lawrence lowlands—the latter embracing that portion of the St. Lawrence lowlands over which stratified clay and sand were deposited during the Champlain marine submergence. The Champlain deposits not only covered the Palæozoic sediments, which are generally regarded as delimiting the St. Lawrence lowland province, but overlapped the Pre-Cambrian up to elevations of 600 feet above sea-level. For the purpose of physiographic description the Buckingham map-area can, therefore, be more appropriately divided into two somewhat different divisions, namely: the Laurentian uplands and the marine flats and terraces.

The first of these divisions includes all the rocky upland portions which protrude through the stratified clay and possesses the usual glaciated surface, juvenile drainage, and other features which characterize the Laurentian plateau. The maximum elevation of the upland areas in the Buckingham area is approximately 1,200 feet.

The second physiographic subdivision—the marine flats and terraces—on the other hand, includes all the lowland portions of the area; and in contrast with the rocky uplands, is underlain by stratified marine clay and sand. The surface of these deposits has not the same elevation throughout the whole of the Buckingham area, however, for in the vicinity of the Ottawa river the elevation of those portions of the flat which have not been dissected by the Ottawa river is approximately 400 feet above sea-level, while northward within the Laurentian highlands, flats occur at successively higher elevations until a height of 600 feet above sea-level is attained.

Since the Champlain clays and sands were deposited their surface has been modified in places in two ways : (1) by stream dissection and (2) by land slides.

The first of these processes—stream dissection—has resulted in the development of numerous broad, deep valleys along the waterways of the district, the widest of these, that along the Ottawa river, having a width of from 2 to 4 miles and a depth of over 200 feet. This flat is terminated on the north by an embankment 100 feet high extending continuously across the whole of the Buckingham area. On the east side of the Gatineau river in range VI of the township of Hull, a triangular mass of the Champlain deposits occurs which is separated from the outer river terrace by a flat over half a mile in width. It would seem probable that during an earlier stage in dissection this inner lowland was an outlet of the Gatineau river and that the elevated mass within the river flat is a remnant which the Gatineau failed to carry away.

The second of the modifications in the surface of the Champlain flat—the landslide areas—while not of great extent is among the most interesting physiographic features of the district. Only a few of these landslides have occurred since the region became inhabited, but numerous prehistoric slide areas can be recognized along nearly all the streams and rivers, by their broken and hummocky appearance which is strikingly in contrast with the uniform plain-like surface of the unbroken flat. The largest single landslide area in the whole district occurs along the north side of the Ottawa in lots 14 and 15 in ranges II and III of the township of Templeton. It includes an area of about 200 acres. Along the Lièvre river there have been two important landslides in recent years, the Poupore slide which occurred in October, 1903, and the La Salette slide which took place in April, 1908; the former of these was the more extensive, but the La Salette slide resulted in the destruction of part of the village of Notre Dame de la Salette and the death of thirty of its inhabitants.

All of these landslides in the Champlain deposits indirectly owe their origin to the presence of silty layers which when saturated with water behave very much like a lubricant so that, where conditions are favourable, the overlying clay beds slide over the silt as on a lubricated surface. The direct cause of the slides, however, is stream dissection which cuts away embankments and thereby makes the horizontal movement of clay over the silty beds possible.

General Geology.

A preliminary account of the geology of the southeastern portion of the Buckingham sheet was given by the writer in the Summary Report of the Geological Survey for 1913. The following outline is, therefore, merely a brief restatement of the description previously given, supplemented by such additional information as was obtained during the seasons of 1914 and 1915.

For the purpose of geological description the rocks occurring in the Buckingham map-area may be conveniently divided into four great groups: (1) the basal complex which includes all those rocks which have suffered regional metamorphism, (2) those Pre-Cambrian rocks which have not suffered regional metamorphism and in contrast with the basal complex may be regarded as late Pre-Cambrian in age, (3) the Palæozoic sediments, and (4) the Pleistocene and Recent deposits.

Table of Formations.

The succession of formations in the region, arranged in tabular form, is as follows:

Quaternary	Champlain	Marine clay and sand.
	Glacial	Boulder clay, gravel, and sand.
Palæozoic	Trenton	Limestone.
	Black River	Limestone.
	Chazy	Sandstone, shale, and limestone.
	Beekmantown	Limestone.
	Potsdam	White, rusty, pebbly sandstone.
Late Pre-Cambrian		Diabase.
		Lamprophyre.
Early Pre-Cambrian		Pegmatite.
		Granite-gneiss, syenite-gneiss, and syenite-porphyry.
		Pyroxenite (contact product).
		Buckingham series Pyroxene: granite, syenite, diorite, gabbro, and peridotite.
		Grenville series: sillimanite-garnet gneiss, vitreous quartzite, crystalline limestone.

DESCRIPTION OF FORMATIONS.

Grenville Series.

The oldest rocks to be found in the Buckingham map-area belong to a group of highly metamorphosed and crumpled sediments which are generally known as the Grenville series. It is believed that the rocks of this series were originally laid down as alternating beds of shale, sandstone, and limestone; but, owing to the contact and regional metamorphism to which they have been subjected, the limestone has been converted into crystalline limestone, the sandstone to vitreous quartz, and the shale to sillimanite-garnet gneiss. The reasons for this conclusion are twofold: (1) the chemical analysis of the sillimanite-garnet gneiss has shown it to have the chemical composition of a shale and thus the three rock types—sillimanite-garnet gneiss, quartz rock, and crystalline limestone—have respectively the composition of the three dominant members of normal sedimentary series and (2) these rocks occur interstratified with one another in a manner similar in every respect to the way in which normal bedded deposits usually occur.

Buckingham Series.

The Buckingham series is composed of a group of rocks, genetically related, and ranging in composition from pyroxene granite and granite-pegmatite to peridotite. These have been intruded into the Grenville series partly as thin bands injected between the beds and partly as large lenticular bosses. Since their intrusion they have been subjected to considerable deformation and are generally more or less foliated, the gneissoid structure being especially well developed in the thin "lit par lit" intrusions.

Pyroxenite.

The rocks of this class generally occur as irregular masses or bands, elongated in the direction of the strike of the quartzite, garnet gneiss, pyroxenic gneisses, and other rocks with which they are associated. The pyroxenite in its most typical occurrences is composed of a pale green, coarsely crystalline or granular pyroxene, throughout which are scattered irregular masses (boulders in the terminology of the miners) of blue or red microcline pegmatite and other rocks belonging to the Buckingham series. With this pyroxene is associated a large variety of minerals of which the most common are calcite, phlogopite, apatite, scapolite, tourmaline, pale green amphibole, quartz, chabazite, fluorite, pyrite, chalcopyrite, pyrrhotite, and titanite. The apatite and phlogopite contained in the pyroxenite generally occur as scattered crystals or aggregates or as very irregular veins accompanied in most cases by an abundance of pink calcite.

From a study of the character and relationships of the pyroxenite in the field, it seems evident that this rock is a secondary type formed from the limestone of the Grenville series by the action of pegmatitic solutions derived from the intrusives of the Buckingham series. Throughout the Buckingham area, the rocks of the Grenville series have been intimately intruded by pegmatite and other rocks belonging to the Buckingham series, so that the pyroxenite, while not generally occurring at the contact of the crystalline limestone and the intrusive, nevertheless occurs in a contact zone where the limestone has been subjected to attack by solutions emanating from the intrusive. The pyroxenite can, therefore, be best described according to its genesis as a pegmatitic contact zone deposit.

Granite Gneiss, Syenite Gneiss, and Syenite Porphyry.

In a number of localities the rocks of the Grenville and Buckingham series are intruded by bosses and dykes of granite and syenite. Although these rocks cut off the older series in such a manner as to indicate that they are considerably younger in age, they are generally foliated and on this account have been included in the basal complex. Lithologically, the granite and syenite are fresh grey to pink, medium-grained rocks consisting of granular feldspar or feldspar and quartz with biotite and hornblende as ferro-magnesian constituents. In some masses the rocks of this class were observed to be porphyritic.

Pegmatite.

Throughout the area the rocks of the basal complex, previously described, are intruded by numerous irregular masses and dykes of pegmatite. These intrusions are not all of the same age, however, for part of the pegmatite has been derived from the intrusions of the Buckingham series while other portions cut the masses of granite and syenite and have probably been derived from the latter. As far as could be determined in the field there was no criterion by which these two pegmatites could be positively distinguished from one another. In general, however, those pegmatites which have been much deformed belong to the older class, while the massive boss-like masses, for the most part, represent the younger variety.

Late Pre-Cambrian Intrusives.

The late Pre-Cambrian rocks are limited entirely to igneous intrusions of lamprophyre and diabase. These rocks are lithologically different from all the rocks of the basal complex and unlike the rocks of the complex have not been greatly deformed or otherwise metamorphosed. On the other hand, no rocks of similar composition have anywhere been observed to intrude the Palæozoic sediments which overlap the Pre-Cambrian at the south end of the area. They are, therefore, not only younger than the basal complex but also older than the Palæozoic and are late Pre-Cambrian in age.

Lamprophyre. The rocks of this class were observed to intrude the basal complex in the southern part of the township of Buckingham. They occur throughout this region in numerous small, irregular dykes, but the principal occurrence is an elliptical mass about $\frac{3}{4}$ of a mile in width and 2 miles long, situated in ranges IV and V of Buckingham township, a short distance east of the town of Buckingham.

The lamprophyre, both in the dykes and in the larger mass, is a fine-grained aphanitic to medium-grained rock with a well developed triangular jointage. When examined under the microscope the finer grained aphanitic portions of the rocks are seen to consist of small phenocrysts of plagioclase embedded in a crypto-crystalline groundmass. In the coarse-grained phases, however, it consists of crystals of albite enclosed in a matrix of biotite, quartz, blue amphibole (largely altered to pale green hornblende), and scattered grains of apatite, ilmenite, and pyrite. The rock thus has the composition of a kersantite.

In the Summary Report of the Geological Survey for 1913 it was stated that the relationship of the lamprophyre to the late Pre-Cambrian diabase dykes had not been ascertained, but since that report was written a diabase dyke has been discovered to cut across the large lamprophyre mass near its northern margin, thus showing that the lamprophyre is the older of the two rock types.

Diabase. In the Buckingham area the basal complex is intruded by a remarkable system of approximately east-west trending diabase dykes. These occur at intervals of from 1 to 3 miles in a north-south direction throughout the whole district and in some cases have been traced continuously across the whole width of the map-area, a distance of 25 miles. This distance does not represent the maximum length of the dykes, however, since some are reported to continue beyond the map-area for many miles. They range in width from a few feet up to 300 feet and consist of typical fine to medium-grained diabase which, under the microscope, is seen to be composed of labradorite, augite, and scattered grains of ilmenite.

Palæozoic.

The southern part of the Buckingham map-area is largely underlain by Palæozoic sediments which rest on the irregular but base-levelled surface of the Pre-Cambrian and have a regional dip towards the south so that the various formations outcrop in successive east-west trending belts. On the north side of the Ottawa river these sediments consist merely of scattered outlets of Potsdam or Upper Cambrian sandstone and Beekmantown limestone, but in the triangular areas of territory, in the vicinity of Cumberland, Ontario, in the part of the area south of the Ottawa, the Chazy, Black River, and Trenton formations are also represented. These outcrop in successive east-west trending cuesta escarpments continuous for many miles.

Pleistocene.

Glacial. In common with the whole territory formerly covered by the Labradorean continental glaciers, the bedrock surface of this district is partially hidden from view by glacial debris. The amount of glacial material originally present was probably greatly reduced, however, by wave-action during the Champlain marine submergence. It now consists chiefly of scattered boulders and a few local areas of boulder clay and gravel.

Champlain Clay and Sand. Throughout the lower portions of the Buckingham area, the glacial and older deposits are overlain by stratified marine clay and sand up to elevations of 600 feet above sea-level. The greatest vertical thickness of these deposits observed, was 110 feet. They vary greatly in character from point to point, but in general the clay beds predominate at the bottom and the sand at the top. The clay occurs generally in thin uniform beds, whereas the sand commonly contains scattered pebbles and is cross-bedded and ripple-marked. In the vicinity of the town of Buckingham, these marine sands in places have a wind blown surface.

Economic Geology.

The district included in the Buckingham map-area has long been noted for the great variety of its mineral deposits, some of which are commercially valuable and have been the basis of an active mining industry for many years.

Mica-Apatite. The mica and apatite found in the Buckingham district are generally associated with one another in the same deposit and have apparently originated in the same way and on this account can best be described together. Both minerals are evidently genetically related to the pyroxenite, since they either occur in the pyroxenite or in the rocks of the Grenville and Buckingham series near their contact with the pyroxenite. They occur for the most part as scattered crystals, or in irregular aggregates, or in veins, the size, form, and composition of the deposit varying greatly in different localities. As a rule, the deposits are small, irregular, and discontinuous and, for this reason, are exceedingly difficult to work; but, in a few exceptional localities, a remarkably persistent system of veins or an enormous single deposit of the aggregate type is present. The composition of the deposits is likewise exceedingly variable. They consist chiefly of phlogopite, apatite, pyroxene, and calcite, but the relative abundance of these minerals varies greatly, so that a deposit worked for mica may contain little or no apatite, while in a deposit in another locality the apatite may be the dominant mineral and the mica unimportant. Where calcite is abundant, there is very commonly a concentration of crystals along the margin of the deposit, the crystals projecting outward into the calcite.

With regard to the origin of these mineral occurrences, it has already been stated, in the section in which the pyroxenite was described, that it was believed they are a special type of contact metamorphic deposit, having been formed by the action of pegmatitic solutions emanating from the intrusives of the Buckingham series. Accompanying and following the formation of the pyroxenite there was developed a great variety of other lime-silicate minerals some of which crystallized out, partly as single crystals, partly in aggregates, and partly in veins, and in this way the deposits of mica and apatite were apparently developed.

Graphite. A preliminary account of the graphite deposits of the Buckingham district was published in the Summary Report of the Geological Survey for 1913 and need not be repeated here. The study of these deposits since the season of 1913 has shown that in every case the enriched deposits of disseminated graphite are found in the limestone of the Grenville series and generally where the latter has been partially silicated by the contact action of the rocks of the Buckingham series.

Feldspar. Throughout the whole of the Pre-Cambrian portion of the Buckingham area, there is scarcely a square mile of territory in which a mass of pegmatite of considerable size is not present, so that the possibilities of this district as a source of feldspar are almost unlimited. Since, however, the value of a feldspar deposit is dependent on a great variety of factors such as, the potash content of the feldspar, the absence of impurities in the feldspar, the uniformity in composition of the product shipped, the coarseness of crystallization of the pegmatite, the proportion of waste rock to be handled, the location of the deposit, cost of labour, and cost of transportation, it is obvious that the best occurrences of pegmatite from which feldspar can be mined, can only be located by the systematic prospecting of the most easily accessible portions of the area. If this method was adopted, numerous other deposits equally as good or possibly better than those which have been worked in the past, might be discovered.

MINERALOGICAL EXPLORATION OF EAST TEMPLETON DISTRICT, QUEBEC.

(*A. Ledoux.*)

INTRODUCTION.

Having been instructed by the Geological Survey to undertake a mineralogical exploration of East Templeton district, I spent three summer months of 1915 in examining the mineral deposits of that region. The object of this survey was to complete the data on the distribution and character of the various economic minerals in this district, their associations and modes of occurrence.

I wish to express my thanks to M. E. Wilson of the Geological Survey, who was working out the areal geology of the region, for help in the organization of excursions in a country unknown to me. Lucien Clermont of Montreal who was appointed as assistant performed his duties in a very satisfactory manner.

LOCATION.

The area examined comprises the townships of East Templeton and Hull. Our study was confined to the Archæan deposits and did not extend to the Cambro-Silurian rocks which outcrop in the most southerly portion of the district, on the shores of the Ottawa river.

Two important tributaries of the Ottawa, the Gatineau and White rivers, traverse the region in a direction about north and south; they are joined by a number of small tributaries flowing from lakes some of which are of considerable size. Villages and hamlets are numerous, and the roads are good, many of them having been constructed in view of the mining operations once very active in that district.

PREVIOUS WORK.

Owing to its proximity to Ottawa and to its many valuable deposits, the district of East Templeton was early visited by geologists and prospectors. Descriptions of the geology and mineralogy of the region are to be found in the reports of Sterry Hunt, Harrington, Chapman, Hoffmann, Ells, Osann, Obalski, Cirkel, and H. S. de Schmid. Most of these papers deal with the geology of the district or the mode of occurrence of economically important minerals such as mica, graphite, apatite, and magnetite; they are to be found in the publications of the Geological Survey and of the Mines Branch, Department of Mines, Ottawa.

A brief description of the geology of the district will be found in the report by M. E. Wilson in preceding pages.

MINERAL DEPOSITS.

Many economic minerals have been found in the region. Some occur in great abundance and have been extensively developed, although most of the mines have been abandoned or are inactive at the present time; others occur only occasionally and are to be considered, for the most part, as of mineralogical interest only.

From their chemical characteristics the various minerals of this district may be grouped as follows:

Elements	Graphite.
Metalloidal sulphides	Molybdenite.
Metallic sulphides	Galena, zinc blende, pyrite, pyrrhotite, chalcopyrite.
Fluorides, etc.	Fluorspar.
Oxides, hydrates, anhydrides, acids	Hematite, spinel, magnetite, ilmenite, limonite, quartz, opal, jasper.
Anhydrous silicates	(a) Feldspars: orthoclase, microcline, plagioclases.
	(b) Metasilicates: enstatite, bronzite, diopside, sahlite, hedenbergite, augite, tremolite, actinolite, hornblende, crocidolite, wollastonite.
	(c) Orthosilicates: scapolite, wilsonite, garnets, zircon, vesuvianite, muscovite, phlogopite, biotite, lepidolite, epidote.
	(d) Subsilicates: tourmaline, sphene.
Hydrated silicates	Prehnite, natrolite, chabazite, talc, chrysotile, kaolin, chlorite, serpentine.
Carbonates	Calcite, dolomite, siderite, malachite, azurite.
Phosphates	Apatite.
Sulphates	Barite, Michel-lévyte, gypsum.

Numerous samples of these minerals have been collected and are now being examined in the laboratory, their analyses to be given later on.

ECONOMIC GEOLOGY.

General Statement.

The region under consideration has been prospected for a number of years and many mineral deposits of economic importance have been discovered. A considerable number of mines were in operation about twenty years ago, most of which are now closed. The chief deposits are those of mica, apatite, graphite, barite, magnetite, hematite, asbestos, feldspar, diopside. Except the iron ores the metallic deposits are absent in this region, at least from the economic standpoint.

A great obstacle to the development of the mining industry in this district is the too wide distribution of mining properties. Every one thinks he is a born miner, and a number of ordinary farmers have secured mining rights in the vicinity of their houses and have set to work with generally two or three men and very poor equipment. Most of these small undertakings have inevitably failed. On the other hand transportation is sometimes a problem, as the railway is often at a distance of 15 or 20 miles and for heavy materials of low value, transportation by wagon absorbs any possible profit. As to transportation by boat, it is rendered impossible by the water falls and rapids in the streams. If mining were carried on in a more extensive manner, these waterfalls could be utilized for electric power; the installation of pumps, compressors, the utilization of drills and boring machines, and the building of cable conveyers would certainly go far towards reviving the mining industry and making the long abandoned mines productive and prosperous.

Graphite.

The most important deposit examined is the property of the North American Graphite Company located on a ridge east of Plumbago lake, which forms the boundary of East Templeton and Buckingham townships, range VI, lot 28 of the latter township. The plant and workings are extensive, but are not in operation at present; the drifts are filled with water.

Graphite occurs in this mine either disseminated in quartzites or gabbros, or in veins, associated with tourmaline pegmatites. The graphite in veins is very pure, its carbon content being almost 99 per cent. As for the disseminated graphite, the ore contains 20 to 30 per cent graphite which is separated by crushing and washing the rock. The concentration product must be carried to the railway station near Buckingham, 8 miles from the mine. The mine is reported to have been closed on account of the strong competition with Ceylon graphite on the British market.

We have examined the following other graphite deposits where this mineral is fairly abundant.

East Templeton township, range IX, lot 19 (Prudhomme property). Some fair sized scales of graphite are distributed in a crystalline limestone containing small quantities of green apatite and pyrite. The superficial part of the limestone is altered and transformed in a granular mass enclosing free scales of graphite.

Hull township, range XI, lot 13 (James Reynold's property). Occurrence similar to that of above deposit.

Canadian Pacific Railway trench south of Kirk Ferry. Limestone with disseminated graphite.

Molybdenite.

This mineral occurs in isolated flakes from 1 to 2 inches in diameter, in pegmatites, granite, or pyroxenite. It has been found in two mica properties of Hull township, the Flynn mine (range XV, lot 27) and the Winning Church Company mine (range XIII, lot 12). The quantity of molybdenite observed amounts to very little and would not justify any development. But if the mica mines in which it occurs were again in operation, it would possibly pay to pick and work the molybdenite-bearing rock fragments.

An analysis of one of the molybdenite samples gives 50·27 per cent molybdenum.

Iron Ore.

The deposits along the Gatineau river in Hull township and on the boundary line between Hull and East Templeton townships have been extensively developed, but are now abandoned. A detailed description of these will be found in the report by F. Cirkel.[1]

The mines near the Gatineau at Ironsides have produced magnetite chiefly. The ore is good, the metallic content reaching as high as 55 and 60 per cent.

[1] Report on the iron ore deposits along the Ottawa and Gatineau rivers: Mines Branch No. 23, Ottawa, 1909.

Titanium is absent and the phosphorus and sulphur content is very low; the gangue which makes up 25 per cent of the ore is made up of the following minerals: calcite, pyroxene, amphibole, chlorite, quartz, graphite, and pyrite. The ore is in several veins interstratified with limestone and gneiss, some of them having a thickness of 5 feet. The strike is irregular and discontinuous, probably on account of dynamic influences; the latter are also responsible for the formation of detached pockets of ore in certain places. The principal property which has been opened in this formation is the Forsyth mine; next in importance are the MacLaurin, Baldwin, and Lawless mines. These different workings follow a belt of limestones trending about east -west for a distance of over a mile.

The strike of the mineralized veins, the interstratification of the ore with the sediments, its extension over a long distance, the absence of all connexion with intrusive rocks, and, finally, the progressive grading of the ore into the country rock, limestone, or gneiss, are all evidences showing the sedimentary origin of these deposits. In my opinion they are beds of limonite chiefly metamorphosed by dynamic action; they have possibly also been influenced by mineralizing agents.

As regards the formations on the border of Hull and East Templeton townships, we mention the Haycock location (East Templeton township, range VI, lot 28, Hull township, range XI, lot 1). Here the mineral is chiefly hematite, either specular or earthy and reddish; it is found in syenitic gneiss cut by dykes of pegmatite and pyroxenite. Nevertheless the ore is of good quality with an average metallic content of 50 per cent. It was impossible to examine the ore in situ as the shafts were under water.

These various mines have produced a large quantity of ore and have probably been closed on account of the high price of fuel which precluded smelting operations on the ground; besides, there is no navigable river in the vicinity. It seems that it might be possible to establish some means of transportation at little cost as far as the Ottawa river, judging by the enormous quantity of water power available from the numerous waterfalls in the district. The reserves of iron ore in the district are probably more extensive than is indicated by the actual exposures and a magnetometric survey in this connexion would give valuable indications.

Feldspar.

This mineral, which is the most plentiful in the district, almost always occurs in association with others in the composition of the rocks. For direct use in the clay industry, feldspar must be very pure, and free from ferro-magnesian elements with the smallest possible percentage of quartz. In several pegmatite dykes of the district occur masses of differentiated feldspar fulfilling these conditions; we mention the following as instances:

Breckon mine, East Templeton township, range XIII, lot 23. White feldspar, probably orthoclase, occasionally holding pyrite which gives the mass a local brownish colour.

Quinville, East Templeton, range V, lot 26. Large quantities of pure feldspar both white and red.

Old phosphate mine of the MacGregor Lake Phosphate Company, East Templeton, range X, lot 14. White microcline very pure and plentiful, occasionally mottled with small grains of pyrite. The following is an analysis of this mineral which we have made at Professor T. L. Walker's mineralogical laboratory:

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	H_2O
63·56	17·87	0·62	1·11	0·27	13·48	2·12	0·55=99·58%

Greet mine, East Templeton, range X, lot 7. Pegmatite dykes with massive feldspar, with inclusions of pyroxene and titanite.

Templeton and North Ottawa Mining Company, East Templeton, range X, lot 15. Potassic feldspar with few inclusions.

Labelle and Bourke mine, East Templeton, range IX, lot 14. Syenitic pegmatite dykes almost exclusively composed of feldspar.

Ottawa-Maniwaki railway cut, south of Cascade station. The pegmatite dykes contain a very pure white feldspar.

Most of these deposits have been observed in old mica mines where feldspar might be obtained as a secondary product. We have referred only to the deposits where the feldspar is sufficiently pure to be utilized for refractory materials; as a matter of fact, the deposits are numerous and if feldspar could be disposed of for its potash content, East Templeton could furnish a very large supply of raw material.

Diopside.

This mineral, which up to the present has been of no practical value, is now being utilized in the manufacture of refractory material. Its iron content is probably of considerable importance in this regard. Diopside, sahlite, and hedenbergite are known to constitute an isomorphous series with the general formula:

$$Ca\ (Mg, Fe)(SiO_3)_2$$

We consider as diopside the varieties of this series of which the ferrous oxide content is below 3.5 per cent. If, for want of analyses, we tentatively judge from the colour, which is of a light green (the lower the iron content the lighter the green), we can mention in the East Templeton district a series of deposits generally observed in old mica mines:

Burke mica mine	Hull township		range XII, lot 1.
Prospects in pyroxenite	East Templeton township		range VII, lot 22.
Wallingford mine	"	"	range VIII, lot 16.
Templeton and North Ottawa Mining Company	"	"	range X, lot 15.
MacGregor Lake Phosphate Company's mine	"	"	range X, lot 14.
Trudel pits	"	"	range IX, lots 10 and 11.
" "	"	"	range V, lot 11.
Greet mine	"	"	range X, lot 7.
Blackburn mine	"	"	range XI, lots 29 and 30.
Rainville mine	"	"	range VIII, lot 15.
Trusty mine	"	"	range XII, lot 12.
Lake Rheaume mine	"	"	Gore, lot 3.

Some of the pyroxenite deposits might probably be worked for the same purpose as diopside, this rock being mostly composed of pyroxene and feldspar; scapolite, which it contains, not being apparently an obstacle. Pyroxenites are known to be very plentiful in the region.

Mica.

About one hundred mica pits have been visited in this district. The mica industry was very prosperous between 1890 and 1905, but most of the mines are now closed; the only deposits that were still being worked are those of the Wallingford Company, East Templeton, range VIII, lot 16; Sophia mine, East Templeton, range IX, lot 4; and Vavasour mine, Hull, range XII, lot 10. In the other mines, observations were difficult, the pits being under water or invaded by vegetation. A monograph of the mica industry by Hugh S. de Schmid was published in 1912[1], to which the reader may refer for detailed descriptions of the various mines.

As a conclusion from the numerous facts observed it would seem that the mica has been formed by mineralizers at the time of the intrusion of the pegmatites in the region, the mineralizers having especially affected the pyroxenites. This opinion is particularly based on the fact that most of the mica deposits are within the pyroxenite and a local enrichment is very often noted in the vicinity of the pegmatite dykes cutting the pyroxenite. However, the mica deposits are not confined to pyroxenite and some are found in gneiss. Besides, mica is very often found in great abundance in cracks or cavities which have been subsequently filled by calcite.

Mineralogically speaking the mica is in general a beautiful amber coloured or light brownish phlogopite. In some cases it is darker in colour and seems to grade into biotite; in others, the mineral is lighter and resembles muscovite. The value of mica is proportionate to the size of the plates obtained from its crystals; these plates must also be free from inclusions of pyrite or other minerals altering the electric resistance of mica.

The present stagnation in the mica industry is chiefly due to the lowering of prices, also to the too extensive distribution of mining properties and the antiquated methods of mining of most of the small mines. These deposits range among the very best in Canada and on the American continent.

Asbestos.

This mineral occurs in serpentine limestones. It belongs to the chrysotile variety, although hornblende asbestos has also been found. The material is contained in bands of various thickness, sometimes up to 1 inch thick, in yellow or green serpentines to which has been given the name of soapstone. The fibres are at right angles to the direction of these bands.

The chief deposits are in the limestones exposed east of Perkins Mills. Several shafts have been sunk but they are now abandoned and filled with water. There is another important deposit on the northwest side of Plumbago lake along the road leading to the Gilmour mine.

Apatite.

This is one of the most abundant minerals of the region and generally occurs in the pyroxenites. It is very often associated with mica and in several properties the two materials are mined together. The apatite of the region is green, brown, or purplish in colour; it belongs to the group of fluor-apatites, and often contains more than 3 per cent fluorine. It is generally found in compact masses as sugar apatite. It is associated with pyroxene, mica, calcite, and often constitutes the vein fillings deposited from fluorine and phosphorus bearing mineralizers. The scarcity of fluorite seems rather peculiar in these deposits. Apatite is seen occasionally in large crystals more generally enveloped in a calcareous gangue from which they are not easily extracted on account of their brittleness.

It does not appear probable that the apatite deposits will be taken up again for some time. Mining was formerly done on a large scale, but has been interrupted following the discovery of the Florida deposits. Transportation is another important problem in this case and there seems to be no prospect of a near solution.

[1] Mica, its occurrence, exploitation, and uses: Mines Branch, 1912, No. 118.

Barite.

This mineral has been observed in three places, occurring as thin vein fillings of probably hydrothermal origin. The most important deposit is that of the Foley property, Hull, range X, lot 7. Here barite occurs in a vein 4 feet thick cutting the crystalline limestone and the gneisses; it is found in the massive form and is generally of a milky white colour, and sometimes greenish. An open-cut has been made in the vein, but it is now filled with water. This is probably another case where the distance from the railway has caused the mine to be closed after a certain depth had been reached.

Another smaller vein is seen east of the Perkins road, East Templeton, range V, and still another of little importance in range VI, lot 10, of the same township. Finally, some fragments of massive barite have been observed on the dumps of the Haycock mine.

HARRICANAW BASIN NORTH OF THE GRAND TRUNK PACIFIC RAILWAY, QUEBEC.

(*T. L. Tanton.*)

During the past field season the writer was occupied in extending westward to the Ontario boundary the reconnaissance of the Harricanaw basin, in northern Quebec, which was started last year. The "Carte de la Region de l'Abitibi, 1911," 4 miles to the inch, published by the Department of Lands and Forests, Quebec, was used as a base map. The principal streams traversed were the Turgeon, Woman, and Okikodosik rivers. Track surveys were made of several tributaries which are not shown on the map, and land traverses were run into areas which could not be reached by canoe. The later part of the field season was devoted to a somewhat detailed examination of the country around Lake Chikobi and to an examination of mining claims on the upper Harricanaw river.

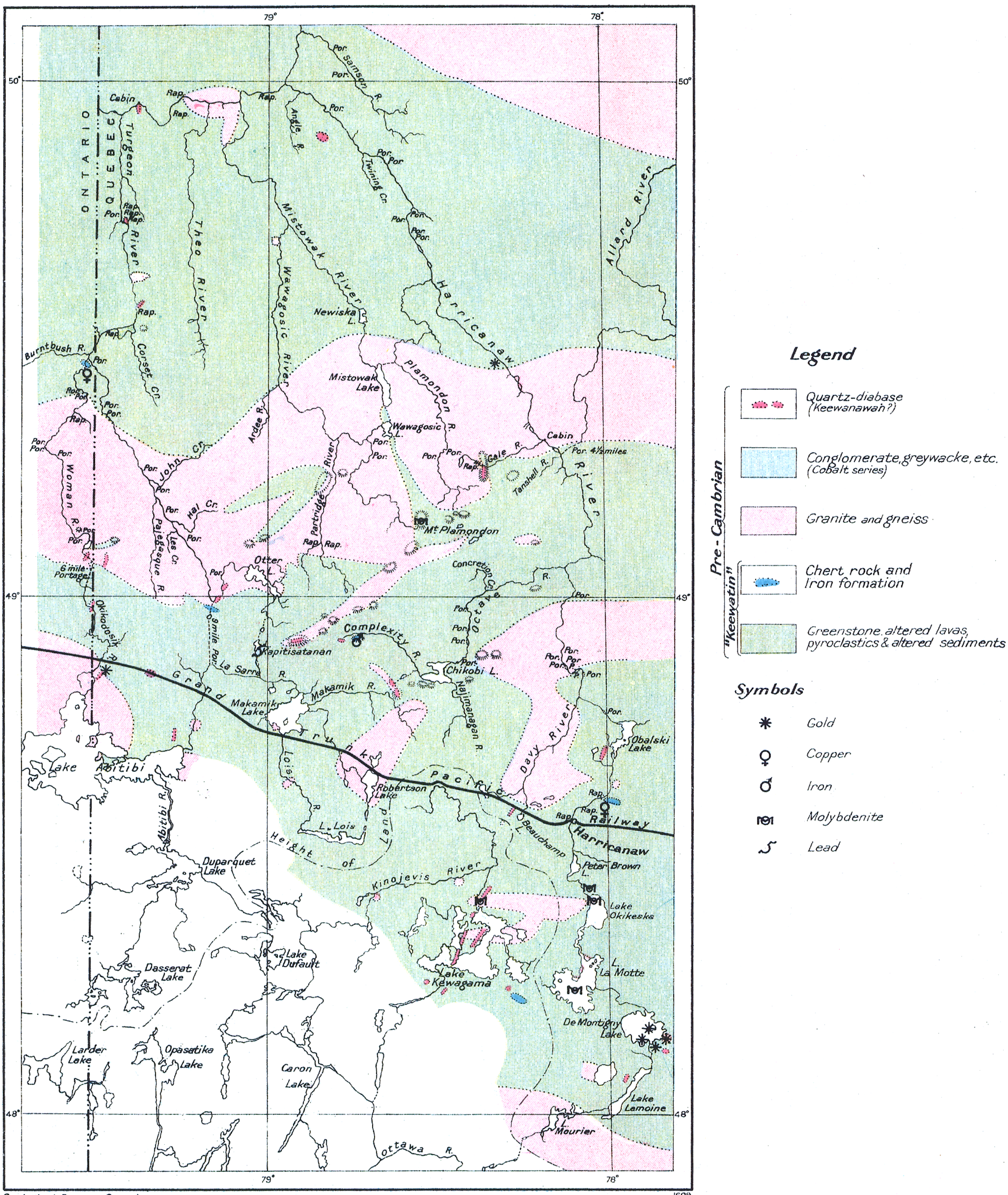
The writer was assisted in the field by George Hanson, C. B. Dawson, and R. K. Carnochan. Thanks are due Mr. J. J. Sullivan for facilitating the work in the upper Harricanaw region.

Harricanaw Basin along the Ontario-Quebec Boundary.

The greater part of the section of the "clay belt" which is drained by the Turgeon, Woman, and Okikodosik rivers, is muskeg. The headwaters of these streams, however, flow through rolling country and this area, together with the land along the drainage channels and a few irregularly distributed hills, supports a dense growth of spruce, balsam, poplar, birch, and jack-pine. The forest along the Okikodosik river is now being cut for pulpwood. Hay, barley, and root crops were successfully raised in the district this year, notwithstanding unfavourable weather conditions; and, although much work is required in clearing the land and in the building of roads, agricultural development will probably proceed steadily.

Rock outcrops are not numerous, being almost entirely restricted to rapids on streams, burnt hills, and lake shores.

Generally speaking, Turgeon river below the junction of Woman river is underlain by greenstones, altered lavas, and pyroclastics of various compositions. Little or no prospecting has been done in this region. The outcrops on Turgeon river above its junction with Woman river, are chiefly granite, and form part



Geological Survey, Canada.

Diagram of **Harricanaw-Turgeon** Basin, Quebec.

Miles
10 5 0 10 20 30

To accompany Summary Report by T. L. Tanton, 1915.

of a large batholith which extends to the west across almost the entire length of Woman river. During a rush three or four years ago a considerable amount of work was done on the granite of Woman river without exposing any valuable mineral deposit. The Okikodosik river from its headwaters to the railway, is chiefly underlain by greenstone, but the drift covering is so general that prospecting becomes a matter of great difficulty. A few quartz diabase dykes were found on Turgeon and Okikodosik rivers cutting both the granite and the greenstones.

The only mineral deposit observed in the region was one of chalcopyrite which occurs in small amount in quartz-calcite veins associated with a pale green porphyry, with feldspar phenocrysts, on the right bank of Woman river, 3 miles above its junction with Turgeon river.

This summer, the discovery of a pegmatite vein carrying galena with gold and silver values, in a fluorite-quartz-feldspar gangue, was reported by Mr. Ferland from lots 7 and 8, La Reine township, Quebec. This property lies 3 miles east-northeast from the mouth of Okikodosik river.

Chikobi District.

Lake Chikobi is situated about 22 miles east-northeast from Makamik station on the Grand Trunk Pacific. It may be reached from the station by a water route through Makamik lake and Makamik river together with about 5 miles of portage.

The district around Lake Chikobi is hilly and rock outcrops are relatively abundant. The rocks on the shores of the lake and in its neighbourhood are all greenstones, though granite was found to the east, south, and northwest at distances ranging from 3 to 12 miles. Time did not allow of intensive prospecting, but the following facts suggest that the field is worthy of attention.

The three hills south of the west end of the lake are of greenstone schists, abundantly mineralized with pyrite and cut by several large pegmatite veins. An assay of a 2-pound sample of this pegmatite, made by the Mines Branch, shows the presence of a trace of gold. The granite-greenstone contact nearest this point is 3 miles south of the lake. An assay of the pegmatitic quartz in the middle of the south shore of the main peninsula on Lake Chikobi yielded a trace of both gold and silver.

A small outcrop of banded iron formation was found about 10 miles northwest of the lake, on the south side of Complexity river. On the same ridge, to the northeast of the iron formation, ferruginous dolomite was found which is lithologically similar to the country rock which carries gold in Larder Lake district.

A small amount of molybdenite was found in a pegmatitic quartz vein on the south slope of Mount Plamondon. This point is 18 miles due north of Lake Chikobi and may be reached by travelling northwest overland from a point on the Octave river 11 miles below the lake. The granite and greenstone interfinger to the northeast and south of this mountain, so that a good opportunity is offered to study phenomena connected with contact metamorphism.

Gold Discovery on Harricanaw River near Allard Portage.

A ferruginous dolomite occurs on the left bank of Harricanaw river 14 miles north of Allard portage. This rock appears to pass gradationally into a light grey quartz porphyry to the north. The specimens from this locality were collected in 1914 but it was not until 1916 that gold was observed under the microscope in a thin section from this rock. Assay returns on the dolomite rock which carries numerous tiny quartz stringers, show the presence of 3·86 ounces of gold or $77.20 to the ton. Three other specimens of similar material from the same outcrop, which did not show the reticulating tiny quartz veins, gave the following results upon assay: 0·10 ounce, 0·10 ounce, and a trace of gold per ton.

Upper Harricanaw River.

Toward the close of the field season a short visit was paid to the gold camps on De Montigny lake [1]. For present purposes it is sufficient to note that the gold around De Montigny lake occurs in tourmaline-bearing quartz and pegmatite veins associated with a porphyritic granodiorite, which intrudes greenstone schists. The intrusive probably represents small marginal offshoots from the huge granite batholith to the south.

Molybdenite occurs in a pegmatite on a small island near the outlet of Okikeska lake, and in a pegmatite dyke cutting the mica schists on the right bank of the Harricanaw river just below Okikeska lake; it is also reported from some small islands near the centre of La Motte lake.

A chalcopyrite deposit of considerable interest was discovered by Mr. Tremblay, of Harricanaw, during the past year, on the southern slope of a ridge running east and west, 3 miles northeast of Harricanaw village. The country rock is a pale grey siliceous sericite schist, probably a metamorphosed rhyolite tuff, striking north 70 degrees west, with a vertical dip. The rock has been highly disturbed by both folding and faulting. An irregular quartz vein about 2 feet in width follows the strike, and this, and the country rock for an additional 6 feet at the sides, are abundantly mineralized with chalcopyrite. Unfortunately the copper deposit can be followed along the strike continuously for 20 feet only. The eastward extension of the vein can be traced in several small sulphide lenses offset to the north across the schistosity strike and it is probable that the westward extension has been offset to the south under the drift mantle. An assay of the ore in the vein, furnished by the owner of the property, gives the following values per ton:—

Copper	Gold	Silver
$48	$1.80	0·53

A greenstone near the railway 2 miles west of Beauchamp lake, which is richly impregnated with pyrrhotite, was staked this year by Mr. R. A. Benoit, of Harricanaw. This deposit has not been thoroughly tested as yet, but, so far as known, no nickel has been found associated with it.

Agriculturally the district around Harricanaw village has developed very rapidly. The land is gently rolling, fertile, and almost free from boulders. Early frosts and a superabundance of rain seem to be the worst troubles that farmers have to endure. It is expected that these evils may be ameliorated when more of the forest has been cleared.

HEADWATERS OF THE BROADBACK AND NOTTAWAY RIVERS, NORTHWESTERN QUEBEC.

(*H. C. Cooke.*)

The Nottaway map-area includes that part of northwestern Quebec lying between the Rupert river on the north and Lake Timiskaming on the south, and between Lake Mistassini on the east and the Ontario-Quebec boundary on the west. Of late years popular interest in the Nottaway area has been much increased, partly by the construction of the National Transcontinental railway

[1] For description of properties see report by J. A. Bancroft, Mining Operations of the Province of Quebec, 1912.

through its southern portion, which renders the whole territory now easily accessible; partly by the gold discoveries in the adjacent Porcupine camp, which suggest the possibility of other mineral finds; and partly by the discovery that the "clay belt" of northern Ontario extends over a large section of this district, with consequent stimulation of agricultural settlement. As a result of this increasing interest, much work has been done, both of a topographical and geological nature, by the Geological Survey of Canada and the Quebec Department of Lands, Forests, and Mines. The geology of a large part of the southern portion of the area has been worked out in detail by M. E. Wilson and J. A. Bancroft, while in the northern portion J. A. Bancroft, T. L. Tanton, and the writer have carried on geological and topographical exploration.

The writer has been engaged in the investigation of the basin of the Broadback river and the adjacent unexplored parts of the Nottaway River basin. This work was carried forward during the summers of 1912 and 1914, and the survey of the river from its mouth to points not far from its sources was completed. During the past summer the territory that lies between the Broadback and Waswanipi rivers and is drained by the tributaries of both, was traversed. This work included micrometer and prismatic compass surveys of Maikasksagi river, the south branch of the Broadback to its sources, and the east branch of Brock river, accompanied by a geological reconnaissance of the country explored. In addition, about three weeks were spent in carrying on similar work in another field, the basin of the Natagagan river.

Natagagan river is a large branch of Bell river and rises a short distance south of the Transcontinental railway, joining the Bell about 40 miles above Mattagami lake. It affords a good route, alternative to the Bell River route, into the country to the north and it is not so rough as the larger stream in seasons of high water. Its basin lies wholly within the "clay belt," the thick deposits of stratified sand and clay laid down in the bed of the great post-glacial Lake Ojibway. These deposits everywhere effectively mantle the rock surfaces beneath so that outcrops are to be found only where erosion has been most active, on the shores of the lakes and larger streams, and on the more prominent hilltops; thus effective work by the geologist or prospector is made very difficult. From a mining standpoint this is most unfortunate, as the larger part of the territory is underlain by the basic volcanic and intrusive rocks usually classed as Keewatin, in which, under better conditions, ore-bodies might be found. The only other rocks which appear here are granites, which occur in relatively small amount and intrude the basic rocks already mentioned.

The Natagagan basin has been repeatedly swept by forest fires and as a result, it bears very little timber. Up to the summer of 1914 much of it was almost impassable to the pedestrian by reason of the dense tangle of fallen logs and second growth which covered it. At that time, however, another fire passed through, and, while it destroyed most of the timber which then still remained, it almost completely consumed the dead wood and second growth, leaving the ground entirely clear over large areas. On this account this district should be attractive to settlers, since the amount of labour necessary to complete the clearing of the ground preparatory to cultivation would be extremely small.

The district drained by the Maikasksagi, Brock, and the south branch of the Broadback river is of much less interest. Its geology is of the same monotonous type as that of adjacent areas previously described by the writer[1]. The larger part of the area is underlain by granites and gneisses, with a few small patches of older volcanics, intrusives, and sediments, now badly altered and converted into schists. Little mineralization was noted in any of these rocks,

[1] G.S.C., Summary Reports for 1912 and 1914.

and the district does not appear to offer a promising field to the prospector for valuable minerals. From an agricultural standpoint the region is not an inviting one, as outside of the limits of the "clay belt," which extends about 15 miles east of Maikasksagi lake, the soil consists of sands, gravels, and coarse boulder drift, and supports a sparse growth of stunted jack-pine and a thick undergrowth of Labrador tea, blueberry, and other hardy northern shrubs. As for timber, much of it is small and worthless owing to the barrenness of the soil; but in the stream valleys, better shelter and abundant moisture have produced a more luxuriant growth of spruce and jack-pine. However, forest fires of late years have swept over large areas, so that at present the patches of really valuable timber are small and isolated, and are every year becoming fewer and smaller.

THETFORD-BLACK LAKE MAP-AREA, QUEBEC.

(*Robert Harvie.*)

During the field season of 1915 work was begun on the geological examination of the Thetford-Black Lake map-area of southeastern Quebec. The map, embracing an area of 225 square miles, was prepared by D. A. Nichols of the topographic division and will be published on a scale of 1 mile to 1 inch with contour intervals of 20 feet. Field work was commenced on May 26 and was concluded on September 25. John K. Knox as senior assistant ably performed an important share of the work, while Ovila Rolland and D. A. Y. Colquhoun also rendered efficient service.

The Thetford-Black Lake area is being examined in order to assist in every way possible the very important asbestos and chromite production from the serpentine rocks of the district. The mines of this district produce about three-fourths of the worlds output of asbestos, the yield for the last four years being valued at over $3,000,000 annually. The only workable deposits of chromite in Canada occur here.

The work was so planned that during the first season the principal areas of sediments would be examined with a view to having the structure of the district understood before proceeding with the study of the large and complex igneous masses. Half the total area was covered last season, but the remaining more difficult portion will require two more seasons' field work. The investigation has not yet reached the point where any considerable additional information may be published. Suffice it to say that so far as the work has proceeded, the general results of the previous workers, Logan, Ells, and Dresser, have been confirmed.

The asbestos industry has apparently adjusted itself to the changes brought about by the great war, the closing of the markets of Austria and Germany having been somewhat balanced by the expansion of the market in the United States. The production of chromite has, however, been greatly stimulated by the demand for war munitions. From 1900 to 1908 chromite was actively mined, but the output then abruptly declined to zero as the competition of the recently developed Rhodesian deposits became stronger. However, the disturbance of trade by the war has shut off or at least greatly reduced exports from the latter as well as from other foreign sources of supply and the American munitions manufacturers have been forced to look to the Canadian deposits for supplies. Chromite being on the list of prohibited exports, shipments are only permitted by special licence. In the course of last summer a feverish activity developed, urged on by the needs of manufacturers in the United States for an immediate and abundant supply. The demand has latterly become so insistent that any kind of material that at all approaches a chrome ore, as ordinarily defined, finds a ready sale. All available sources are being searched for ore, old dumps re-sorted, prospects and mines reopened, and every little pocket of ore gophered out and sold. At present the rush is for immediate production, but it is to be hoped that the present stimulus will also lead to the reasonable working of many of the properties and the development of ore reserves for a more stable industry. The chromite industry has suffered before on account of no attention having been paid to the necessity of reserves.

THE DISTRICT SOUTHEAST OF AND ADJOINING LAKE ST. JOHN, QUEBEC.

(*John A. Dresser.*)

My field work of this season was devoted to a study of the geology and natural resources of the district southeast of and adjoining Lake St. John in the province of Quebec. The district is geologically noteworthy for outliers of Ordovician sediments which here occur far within the limits of the great Pre-Cambrian area of northern Canada, and for the structural causes which have preserved them. The large development of anorthosite is another feature that gives interest to the district.

The chief natural resources are its excellent agricultural and forest products. The former are due to the very fertile soil, which has been preserved, within a region that is generally unsuited to agriculture, by the same peculiar geological structure that has preserved the Ordovician sediments on which this better soil largely rests. The immature drainage of the surrounding region affords valuable water powers whose development promises to make the district one of large industrial importance.

Previous geological investigations in the area covered by this season's work were made by Jas. Richardson in 1857; Dr. F. D. Adams and Rev. J. C. K. Laflamme in 1883-4, all of whom extended their observations over larger areas than are here described. G. A. Young in 1900 also examined an adjacent district on the northeast side of Lake St. John.

The objects of the present investigation were to note the general resources and economic possibilities of the region; also to ascertain the character, distribution, and relations of the Ordovician strata on the southwest side of the lake and to study the general structure of the region so far as circumstances would permit. The field work was performed between June 1 and September 26. With the township plans of the Department of Crown Lands, on a scale of 40 chains to an inch, as base, the rock exposures and other geological features were located by a stadia survey and plotted on the scale of the base map. My assistants for the season were L. J. Demers, and Harvey C. Rose, whose good services I am glad to acknowledge. Mr. H. A. Honeyman, M. A., inspector of schools, Hull, Que., also gave special and most valuable assistance for five weeks, especially in reviewing the flora and agricultural conditions of the district. I would also acknowledge with thanks many courtesies received from Mr. T. C. Denis, Superintendent of Mines, of Quebec, Mr. Jos. Girard, M.P., Col. B. A. Scott, general manager of the Quebec Development Company, Mr. Guy Tombs, general freight agent of the Canadian Northern railway, Montreal, and other officials of that railway.

SUMMARY AND CONCLUSIONS.

The Lake St. John district consists of two parts which are quite distinct from each other in economic value and in relief, as well as in the geological structure by which these features are controlled. Bordering the lake generally for a breadth of 5 miles or less, the altitude is between 550 and 350 feet above sea-level. The surface is comparatively level; the soil is deep and fertile, and the land is well tilled and quite thickly populated. To the south and west of this level area, the general altitude is between 800 feet and 1,000 feet above sea-level, or 500 feet to 700 feet above Lake St. John. The surface of this portion of the area is hilly and rocky, the soil is shallow and poor, and there are few inhabitants.

The lowland is underlain in many places by sedimentary rocks, of Ordovician age, and the conditions suggest that these rocks, now deeply eroded, formerly occupied the greater part if not the whole of the lowland. They are in nearly horizontal position and have not been greatly disturbed or deformed by dynamic agencies.

All the varieties of rock found on the highland also appear in places in the lowland, with the usual characteristics. They consist of granite and diorite gneisses having the usual character of these Laurentian rocks, with a small occurrence of crystalline limestone similar to that of the Grenville series. Anorthosites are intrusive into the Laurentian and a microcline granite, in places gneissic, intrudes both the Laurentian and anorthosite. Rarely, lamprophyre dykes of later age than the granite are found.

The relation between the lowland and the highland is one of faulting. Wherever the Ordovician strata have been found at the edge of the lowland there is evidence of fault contact. Within the lowland itself numerous faults have been found. An essential part of the faulting, perhaps all of it, took place since the deposition of the Utica.

Economically the two parts of this area are sharply distinguished from each other. The highland is an important lumbering district and this is the only industry of any value to which it gives rise. The lowland is essentially a valuable agricultural section.

HISTORY.

The general settlement of this district began between forty-five and sixty years ago, the lumbering operations along the upper Saguenay having attracted attention to the excellent farm lands around Lake St. John. For many years the only means of access was by way of the Saguenay river and, later, by colonization roads from Quebec and Baie St. Paul. With the building of the Quebec and Lake St. John railway between 1885 and 1890 settlements rapidly advanced.

The present population of the district is in excess of 55,000. Farming is the principal industry and practically the sole industry of importance besides lumbering and pulp and paper manufacturing which are extensively carried on in the eastern part of the district. Mixed farming is probably carried on as well and successfully here as in any area of equal size in Canada.

The people are principally of French-Canadian origin. A few English-speaking people are found in the manufacturing centres; there are none in the farming communities. Scotch family names are frequent, probably indicating the absorption of certain Highland regiments from Wolfe's army which were disbanded at Quebec after the conquest of Canada by the British in 1763, and were induced to settle in the then new country of the lower St. Lawrence.

LOCATION AND ACCESS.

Lake St. John is a rudely circular body of water, rather more than 20 miles in diameter. The area on which the field work of the past season was principally done has for its northern boundary the shore of the south half of the lake, or more exactly the shore-line from Pointe Bleue to the Petite Décharge. The length of this shore-line is approximately 35 miles. The work was carried south of the lake for about 8 miles, and west of it for a somewhat less distance. A short reconnaissance was also made as far as La Doré, 30 miles west of the limits of this area, and to Chicoutimi, an equal distance to the east.

The district is reached by rail from the city of Quebec by means of the Quebec and Lake St. John railway, a division of the Canadian Northern Railway system. In summer the Canada Steamships line also maintains a regular service by way of the St. Lawrence and Saguenay rivers between Quebec city and Chicoutimi, where connexion is made with the railway. Roberval, a principal town in the district, is 189 miles by rail, or approximately 120 miles, north of Quebec city, and about an equal distance west of Tadousac at the confluence of the Saguenay and St. Lawrence rivers.

DRAINAGE.

In the drainage system of the district, Lake St. John acts as a reservoir. It receives the waters of the Ashuapmuchuan, Mistassini, Peribonka, Ouiatchouan, and numerous smaller rivers and discharges all through the Saguenay to the St. Lawrence river. The Saguenay outlet consists of two principal channels called the Grande Décharge and the Petite Décharge which unite at a distance of 9 miles from the lake. At a farther distance of 20 miles the river reaches the level of tide water and thence to its junction with the St. Lawrence, 90 miles distant, forms the deep and beautiful fiord so celebrated in Canadian scenery.

The descent of 300 feet in the first 26 miles of its course causes many cascades and heavy rapids on the upper Saguenay. Important developments of these excellent facilities for obtaining water power are now under way and a large industrial advancement of the district is expected.

The inflowing rivers mentioned above carry immense amounts of sand and silt and Lake St. John appears to be rapidly silting up. It is an extremely shallow lake and is navigable with difficulty for all boats except those of very shallow draft.

GENERAL CHARACTER OF THE DISTRICT.

The district may be best considered in two parts; the highland, which is a part of the uplifted Laurentian peneplain of northern Canada, and the depression which is occupied in part by Lake St. John and the Saguenay river, and may be conveniently called the Lake St. John basin. The highland has the general character of the Pre-Cambrian "Shield." The surface is hummocky and irregular, but there is a noticeable accordance in the height of the rounded hills which have a general level of about 1,000 feet above the sea. The drainage is immature and lakes and swamps abound and waterfalls are numerous. It is a wooded region, spruce and pine being the trees of economic value, and is little occupied except for lumbering purposes. The soil is an unevenly distributed mantle of till with recent bog deposits in some of the valleys. The underlying rocks consist of Laurentian gneiss, anorthosite, and a later granite.

The basin ranges in elevation from 600 feet above the sea to the level of Lake St. John, which varies from 341 feet to 314 feet above tide water, according to the season. The soil is generally free from stones, and consists mainly of stratified clay and sands underlain by boulder clay. In places there are thick beds of recent peat and swamp accumulations.

In consequence of the value of the land for farming, much of the basin is thickly settled and the timber has been in a large part removed. Rock exposures are comparatively rare and in large areas the character of the underlying rocks can only be inferred. The solid rock formations include those found in the highlands except the Grenville, and in addition, considerable outliers of Ordovician age.

GEOLOGICAL FORMATIONS.

The geological formations that are distinguished in the Lake St. John district are given in the following table and a short description of each follows:

Quaternary	Recent	Alluvium. Peat bogs and swamp deposits.
	Pleistocene	Stratified clays and sands. Boulder clay.
	Unconformity.	
Palæozoic..................	Ordovician.........	Utica shales. Trenton limestone.
	Unconformity.	
Pre-Cambrian...........		Granite and gneiss. *Intrusive contact.* Anorthosite. *Intrusive contact.*
	Laurentian	Gneiss.
	Grenville	Crystalline limestone.

Grenville. Crystalline limestone was found in only two small exposures, amongst the rocks of the Laurentian system. Each exposure is less than 10 feet in width and scarcely 200 feet in length. They are nearly half a mile apart, but in structural alignment, and appear to be remnants of a single larger band. They occur in lots 1 and 3, range I of the township of Metabetchouan. The limestone is completely crystalline, and is much silicified near the granite and anorthosite by which it is intruded. It has the general features shown by the crystalline limestones of the Grenville formation in many parts of the southern Pre-Cambrian areas of Canada.

Laurentian. The gneisses of this formation are grey or slightly pink coloured, finely banded, and much deformed, and have the composition of diorite in many places. They are intruded both by anorthosite and by the later granite and are widely distributed in this district.

Anorthosite. The petrographic characters of this rock have been fully described by Dr. F. D. Adams, the Saguenay district being one of the type localities in his investigations by which the relation of the anorthosites to the Laurentian was first made known. ("Ueber das Norian oder Ober-Laurentien von

Canada, N. J. B. für Mineralogie," 1893. Translated in the Canadian Record of Science, 1896.) Its intrusive relation to the Laurentian granite is well shown near the locality of the crystalline limestone mentioned above. It occurs principally on the east and north sides of Lake St. John.

Later Granite. This is reddish granite. It is coarse in texture and the dark minerals are commonly in quite subordinate amount. In portions of the rock that have a gneissic structure, the rock becomes a pronounced augen-gneiss. The feldspar is essentially microcline, and hornblende is the most abundant ferro-magnesian mineral, though biotite is also present in places. This rock is intrusive through anorthosite as well as through Laurentian gneiss. It is prominently developed in the township of Roberval, but it occurs in many other parts of the district, especially in the vicinity of the crystalline limestones in Metabetchouan.

Trenton. This formation consists of a bluish-grey compact limestone which is highly fossiliferous. It is best exposed near Pointe Bleue on the Ouiatchouan river, and near Chambord Junction. It also appears at intervals for 35 miles east and 20 miles west of Lake St. John, and forms Ile Pierre à Chaux, within the lake.

Within the basin the limestones rest nearly in the attitude in which they were deposited. Over much of the area there is a uniform dip of 5 degrees toward the northeast, except where disturbed by local faulting.

Near the edges of the basin the limestone beds, wherever found, are tilted in such positions as to clearly indicate faulting with the downthrow on the basin side. The beds dip away from the contact in such places at angles of 25 degrees to 55 degrees, but the dip usually declines to 5 degrees within 200 or 300 feet.

Where the contact is exposed the underlying rocks are surprisingly fresh and show little evidence of weathering or decay. There is scarcely any basal conglomerate and where any is found it is only a few inches in thickness.

So far as can be learned, the surface of the underlying rocks possessed considerable relief at the time the limestone was deposited. Rounded hills of granite that rise 50 feet or more above the adjacent sediments in places where there is no evidence of later faulting, are now partially uncovered. If we add to this the thickness of the sediments, which is at least as much more and may be many times greater, and loss from the summits of the hills by erosion since they were uncovered it is evident that the district had at the beginning of Trenton time a relief that was perhaps comparable to that of the present day. How this surface was produced which had rounded hills suggestive of erosional forms, and composed of plutonic rock, and yet gave practically no volume of erosional detritus to the lower bed of the limestone is a question that as yet has not been satisfactorily answered.

Utica. This formation consists of dark grey or brownish shales, in some places bituminous, in others calcareous. In parts it is richly fossiliferous.

The Utica is exposed at Pointe Bleue, at the mouth of the Ouiatchouan river, and in parts of the township of Chambord. It also occupies the Isle de la Traverse. Like the Trenton, the Utica is in approximately horizontal position, but the prevalence of local faults through both formations makes it difficult to ascertain the thickness of the Ordovician in this district. It cannot be less than 100 feet and is probably several times greater; yet with the frequent faulting and thick covering of drift, estimates of the maximum thickness are little more than surmises.

Quaternary. The district has been heavily glaciated. A common direction of the glacial striæ is south 45 degrees west, but there are many local variations. On the highland the soil is principally till very little assorted by water action except in places along the valleys of larger streams. The drift mantle is thin and unevenly distributed.

In the basin the drift is deep, commonly between 100 and 200 feet in thickness. In descending order the deposits are:

River alluvium.
Peat and bog material—in places.
Stratified clays.
Sand and gravel.
Boulder clay.

Glacial moraines and small areas of boulder clay are occasionally exposed, but in general the soil is well stratified and free from stones for many feet below the surface. Traces of earlier shore-lines may be seen as high as 250 feet above the present lake, or 600 feet above sea-level.

STRUCTURE.

The geological structure which has caused the depression of the basin of Lake St. John is apparently a series of block faults. The walls of the basin in many places show well expressed fault scarps running for several miles in straight or slightly crescentic lines. These are separated from one another by small offsets of 1,000 feet or less, where the rim of the basin is cut by deep trenches which run out into the highlands. There is not yet sufficient evidence to show clearly whether these trenches are faults or folds. Their effect on the topography is to cause gaps in the wall or rim of the basin.

The contact of the Ordovician with the Pre-Cambrian at the edge of the basin seems in every case yet found to be a fault contact. There are also numerous faults within the basin which took place since the deposition of the Utica. They are normal or gravity faults which strike in two principal directions, west-northwest and east-northeast and in places show a vertical displacement of 100 feet or more. It seems evident that the accumulated displacement of these faults, together with the more effective erosion of blocks not depressed, is sufficient to account for the depression of the Lake St. John basin.

ECONOMIC.

The existing industries of the district are agriculture and the manufacture of paper pulp, both of which are being vigorously carried on. Limestone is quarried in many parts of the district both for use as a source of lime, and for road metal.

Granite of good quality is quarried for building purposes, and is used in the principal public buildings.

Clay is used for brickmaking in several cases. Some remarkable beds of clay on tide water at Terres Rompues seem worthy of attention for tile making and other clay industries.

Iron ore occurs in important quantities in association with the anorthosite rocks. In all cases known, however, it is highly titaniferous and so awaits improved or cheaper means of reduction.

A full report on the larger iron deposits in the Saguenay district, by Professor E. Dulieux, Laval university, Montreal, was published by the Department of Mines of Quebec in the present year.

The water powers of the district promise the largest industrial development for the future. Under the title of the Quebec Development Company, influential Canadian and United States capitalists are preparing for an extensive developing of the water powers, including the use of the entire discharge of the Saguenay.

ST. JOHN MAP-AREA, NEW BRUNSWICK.

(*Albert O. Hayes.*)

The field work of the previous year was continued from June 1 to October 14. The week of September 20 to 25 was spent at New Glasgow, N.S., arranging for the commencement of a study of the Pictou coal field. From September 27 to October 12, W. A. Bell, W. J. Wright, and the writer joined in a conference on the correlation of the Carboniferous formations which they have been studying separately in New Brunswick and Nova Soctia.

C. L. Cumming, C. W. Robinson, A. N. McIntosh, and R. C. Borden were appointed assistants. Mr. Cumming continued a detailed investigation of the igneous rocks in the vicinity of St. John and made a reconnaissance westward to the International Boundary. Mr. Robinson mapped the superficial geology. Mr. McIntosh mapped the road metals available along the principal highways and collected seventeen samples which have been submitted for analysis. Mr. Borden ably assisted in all phases of the work, especially in telemeter surveying. The writer gave his time to general supervision and to a study of the structure and stratigraphy of the sedimentary rocks. Fossils were collected from a number of localities, three of which may be mentioned here. An abundant fauna, consisting principally of trilobites, was obtained from calcareous nodules in the fissile carbonaceous shales of the Bretonnian division of the St. John group, at an excavation for Scovil Brothers' building on King street, St. John. Opportunities for collecting from this horizon are rare, since the city buildings and streets cover the fossiliferous rocks. No Silurian fossils have been found in the map-area, but a collection was made at Bone brook $1\frac{1}{2}$ miles northeast of Nerepis, N.B., on the farm of Mr. MacKenzie who kindly pointed out the locality. The Survey is also indebted to Dr. G. F. Matthew for information leading to the collection of a marine fauna at Markhamville, N.B., which may serve for a more accurate correlation of the Lower Carboniferous limestone and overlying conglomerates of the upper Hammond River valley.

Mr. Wm. Murdoch, St. John city engineer, and Dr. Wm. McIntosh, curator of the Natural History museum, have continued to aid the work of the Survey and their courtesy is much appreciated.

MONCTON MAP-AREA, NEW BRUNSWICK.

(*W. J. Wright.*)

Location.

The Moncton map covers a rectangular area extending 12·3 miles east and west, and 18·7 miles north and south, including portions of Albert and Westmorland counties. The astronomical boundaries are approximately as follows: latitude 45°51′ north to 46°7′30″ north; longitude 64°37′ west to 64°52′ west. The map was made in 1911 on a scale of 4,000 feet to the inch, with a contour interval of 20 feet to be published on a scale of 1 mile to 1 inch. The area includes the city of Moncton and suburbs, a portion of the oil-field at one time worked by the New Brunswick Petroleum Company, the producing wells of the former Maritime Oil-fields Limited, the gypsum deposits of Hillsborough and Demoiselle creek, the oil-shale of Albert Mines and Rosevale (Baltimore), and an interesting deposit of manganese oxides at Dawson Settlement.

Object and Progress of the Work.

The object of the work is to determine the stratigraphy and structure of the rocks of the Carboniferous system, the extent and importance of the various economic deposits, and to secure the information necessary for a report to be accompanied by a geological map based on the topographic map mentioned in the preceding paragraph.

The progress of the work has been recorded briefly from year to year by the Geological Survey in the Summary Reports for 1911-14, and in Guide Book No. 1, Part II, Excursion in Eastern Quebec and the Maritime Provinces.

This season's field work consisted chiefly in mapping the geological boundaries with plane-table and stadia, examining the roads and road metal, and collecting samples of ordinary shale and road material for laboratory tests. The field work for the map of the areal geology is almost finished; but, in order to make the report complete, it is necessary to examine in more detail the deposits of oil-shale, gypsum, and manganese, and the records of wells drilled for various purposes, and to visit several geological sections in neighbouring parts of New Brunswick.

Acknowledgments.

L. A. Gilbert and H. C. Lewis who acted as field assistants gave material assistance in carrying on the work. Mr. Gilbert spent most of his time investigating roads and road metals. Mr. Lewis handled the plane-table in a very efficient manner. L. Reinecke, of the division of road materials of the Geological Survey, visited the party and instructed Mr. Gilbert in methods of work. J. Keele, of the division of ceramics, spent two days in the examination of numerous beds of shale. Among the local people who were able to give special assistance to the work were Mr. C. J. Osman and Mr. F. M. Thompson of the Albert Manufacturing Company, Mr. Jas. Blight of the Wentworth Gypsum Company, Mr. Matthew Lodge and Mr. W. H. King of the New Brunswick Gas and Oil-fields Limited.

Gypsum.[1]

The gypsum deposits of the Moncton area are considered to be the largest and most important in the province of New Brunswick. The gypsum occurs in irregular bodies of all sizes, irregularly distributed in and through anhydrite. In some instances the deposits are overlain by conglomerate or boulder clay, and in others they appear at the surface and are covered only by a sparse vegetation. The greater part of the gypsum occurring at the surface appears to have been worked out, and most of the material is now obtained by mining.

The deposits are owned and operated by the Albert Manufacturing Company of Hillsborough, and the Wentworth Gypsum Company of Windsor, N.S. The quarries and mines of the Albert Manufacturing Company lie about 2 miles southwest of Hillsborough. They are connected by a narrow gauge railway about 5 miles in length with the Salisbury and Albert railway, the company's mill at Hillsborough, and the company's shipping piers on the Petitcodiac river.

The gypsum is obtained by mining and quarrying. Part of the product is shipped in its crude state by water to United States markets, and the remainder is manufactured in the company's mill, which is fitted with the most improved and modern machinery.

[1] For further details see "Gypsum in Canada" by L. H. Cole, Mines Branch, Ottawa.

The other two gypsum deposits in the Moncton area are owned by the Wentworth Gypsum Company. One of these deposits lies in the valley of Demoiselle creek and its tributary, Wilson creek. At present mining is carried on in two shafts which are less than one-half a mile west of the Salisbury and Albert railway. The gypsum is carried by rail in a crude state to the company's shipping piers at Gray island on the Petitcodiac river, a distance of about 18 miles, and thence in barges to the United States markets.

The other gypsum deposit owned by the Wentworth Gypsum Company lies about 2 miles south of Hillsborough, and 1 mile west of the Petitcodiac river. Extensive operations were started on it during the past summer and the results have been so encouraging that the company intends to construct a tramway to transport the gypsum to a shipping pier on the Petitcodiac river, near Edgett Landing.

Oil and Gas.

The presence of economic quantities of natural oil and gas in the Moncton area is now considered to be assured, and gas has become a very important item in the domestic and industrial life of the community.

In August, 1915, the Maritime Oil-fields, Limited, which has carried on most of the development work in the past, amalgamated with the New Brunswick Petroleum Company, Limited, the original holders of the lease, under the name "New Brunswick Gas and Oil-fields Limited.

The producing wells were all drilled by the Maritime Oil-fields, Limited. They are confined to what is known as the "Stony Creek field," which is located on the west side of the Petitcodiac river about 9 miles south of Moncton and 4 miles north of Hillsborough. Thirty-seven wells have been driven within an area of about 6 square miles to depths of 1,500-2,100 feet or more. The nature of the product is briefly as follows: nine wells yield gas alone; eight wells yield gas with traces of oil; nine wells yield gas and considerable oil; one well yields oil and small amounts of gas; three wells yield oil only, and seven wells are dry. Of the producing wells, gas is now used from sixteen and reserved in four. The better class of the gas wells are tested to yield 2,500,000 to 3,250,000 cubic feet in 24 hours. The oil has to be pumped; and since the wells are not pumped to their full capacity, the possible yield is not known. The best oil well is said to have averaged 2½ barrels of oil per day ever since the well was completed (in 1911).

Oil-Shale.

Oil-shale, yielding from 27 to 52 imperial gallons of crude oil and 38 to 92 pounds of ammonium sulphate per long ton, is known to occur at Albert Mines and Rosevale (Baltimore). Each of these properties is owned by a company, but the companies are not attempting development at the present time.

The most thorough examination of the Albert Mines property that has been undertaken, was begun by Mr. Jas. Caldwell. Test pits were put down at regular intervals to determine the depth of soil cover, and diamond drill cores were taken from two localities on Frederick brook. After the operations had reached this point work was suspended. This suspension of work is to be regretted, for Mr. Caldwell has had wide experience in oil-shale deposits, and his method of exploration would if followed up result in definite information regarding the properties.

More surface work was done at Rosevale, but the results of this work and of the information obtained by diamond drilling in 1912-13 are not available for publication.

It is necessary to modify statements made in the Summary Report for 1913 in reference to the oil-shale at Albert Mines. At that time, the evidence at hand pointed to the conclusion that an area about 1,000 yards long and 350 yards wide was underlain by oil-shale of good grade which was concealed in part by a thin cover of soil. Test pits put down this summer show that over part of the area at least the soil cover is from 2 to 8 feet thick, with an average of about 5 feet; and it is probable that this thickness is a fair average for the whole area. Furthermore, while several beds of the shale have been tested to yield 27 to 52 imperial gallons of crude oil and 38 to 92 pounds of ammonium sulphate per long ton, these results do not represent an average of all the shale in the area referred to. While almost any piece of shale coming from this area will burn, it has not yet been ascertained whether or not the average yield of all the shale is sufficient to warrant the mining of the whole body as a unit. If it should prove to be the case that only certain beds can be economically mined, then the question of profitable mining becomes uncertain; for, while the rich beds of shale which outcrop in Frederick brook appear to dip at low angles, the structure of the shales exposed elsewhere in the area, and in the tunnels, is exceedingly complicated.

Manganese Oxides.

A deposit of manganese oxides occurs at Dawson settlement, about 5 miles west of Hillsborough, and 1½ miles from the Salisbury and Albert railway.

The ore lies on the gently sloping hill-side where it has been deposited in the form of sinter deposits, built up by strong running springs. Three groups of springs occur at about the same elevation within a distance of about 1,200 feet, and each group is accompanied by a low cone of manganese oxide. One of these bodies is about 150 feet in diameter, and each of the others is about 500 feet in diameter. The ore-bodies are deepest near the springs, and thin out to nothing at the outer edges. Borings have shown that near one of the springs the ore is 26 feet deep.

The presence of this manganese deposit has been known for many years, and it is described by the late Dr. R. W. Ells in "The Geology and Economic Minerals of New Brunswick" published by the Geological Survey in 1907. A mill was erected on the property many years ago and a branch railway constructed to connect with the Salisbury and Albert railway, and considerable ore was shipped. At first the ore was kiln-dried and shipped loose; but the fineness of the material made it difficult to handle, and a briquetting machine was installed. The plant, after being in operation for a short time, closed, owing, it is said, to legal and financial difficulties. The buildings and branch railway are in ruins. Part of the machinery, including the briquetting machine, is stored on the premises as well as a considerable quantity of loose and briquetted ore.

The ore is so soft that it can readily be handled with shovels. The composition of the ore is given in the following table of analyses published in the 18th Ann. Rept. of the U. S. Geological Survey, part 5, page 311.

Average of Twelve Samples of Manganese Ore from Dawson Settlement, Dried at 212° F.

	Per cent
Manganese	45·81
Iron	9·95
Oxygen	31·01
Sulphur	0·03
Phosphorus	0·05
Silica	5·36
	92·21

Probably a large part of the remainder not accounted for in the above table is carbonaceous matter and water of hydration.

Clay and Shale.

Red and grey shales occurring at various horizons in the Carboniferous rocks, are widely distributed over the Moncton map-area, and small patches of glacial clay occur in the vicinity of Moncton. About 15 samples were collected from various localities and forwarded to Mr. J. Keele of the Mines Branch for testing purposes. The technical details in the three following paragraphs are taken from a preliminary statement furnished by Mr. Keele; but the complete account of the uses of the various samples is deferred until the tests have been completed.

In general the red shales are suitable for the manufacture of rough clay products for structural uses, such as wire-cut and dry-press bricks, hollow-blocks, field drain tile, and probably, for roofing tile. Some of them are too gritty and hard for use in the plastic processes of clay working, but could be used for making dry-pressed bricks. But those which are plastic when tempered with water have many good qualities which will recommend them to the manufacture of clay products, as they are easily ground, have good working and drying qualities, and burn to dense, hard, red bodies at low temperatures. Deposits of the plastic red shales occur in the vicinity of Moncton, Albert Mines, Stony creek, and Weldon creek. A sample of the red shales in the sea-cliff on the east side of the Petitcodiac river near Belliveau village, was found to contain too much lime to give a good body when burned.

Grey shales which overlie the oil-shales on Frederick brook are very smooth and plastic, and are suitable for the manufacture of brick and hollow-ware. A sample of the grey shale which is interbedded with the oil-shale contained too much carbonaceous material, and these shales are consequently useless to the clay-worker. The grey shale at the north end of the sea-cliff on the east side of the Petitcodiac river near Belliveau village was found to possess better qualities than the red shale from the same locality referred to in the preceding paragraph. Grey shales from the vicinity of Moncton and from Stony creek may be suitable for the manufacture of paving brick or sewer-pipe.

The stratified, stoneless, marine, Pleistocene clays which occur in many parts of New Brunswick, appear to be absent from the Moncton map-area. Unstratified Pleistocene clay occurring in the vicinity of Moncton is generally quite stony, but small areas of it are found to contain little or no stone and are worked at Lewisville for the manufacture of common red brick.

Roads and Road-Metals.

The country roads are made almost entirely from local material, and vary in quality from place to place. The city of Moncton is experimenting with various materials and methods of construction in order to lay out a definite policy for street building.

With the exception of the soft red shales and the more clayey boulder clay, almost any of the local material makes a fair road for ordinary country traffic, provided the road is well drained. Other things being equal, the best country roads are found where the underlying bedrock is one of the following: grey siliceous sandstone and conglomerate with calcareous cement, known locally as Millstone Grit (see Table I, samples Nos. II and III); a coarse, red-weathering conglomerate made up of poorly sorted subangular fragments with a calcareous cement (see Table I, sample No. VIII); or bituminous sandstone and shale of the Albert series (see Table I, sample No. III). Strange to say one of the best pieces of road in the area, taking into account the time of wear and the present condition of the road surface, is one surfaced with anhydrite.

In the city of Moncton, the following rocks are being subjected to practical experiment: limestone from Havelock, N.B. (see Table I, sample No. IV); fine-grained micaceous, and slightly bituminous sandstone from Blue cape (see Table I, sample No. I); and anhydrite from the quarries of the Albert Manufacturing Company at Hillsborough.

Samples of the various rocks and gravels which would be available for road metal were sent to L. Reinecke of the road materials division of the Geological Survey and were submitted by him for laboratory tests to Arthur H. Blanchard, consulting highway engineer, New York city. Reports have been received for all of the samples except a highly bituminous sandstone from the west shore of the Petitcodiac river $1\frac{1}{2}$ miles south of Stony creek. The results of the laboratory tests are given in Tables I and II.

The following quotation and table taken from "The physical testing of rock and road building" issued by the U. S. Department of Agriculture, Bull. No. 44, 1912, is inserted for the purpose of comparison and to make the significance of the figures in the tables that follow more apparent to the reader.

"Experience has shown that, in general, the following table of limiting values for laboratory tests may be used in determining a rock sample's fitness for use on roads, if taken in connection with the conclusions drawn below."

Limiting Values.

Character of traffic.	Results of tests.		
	Per cent of wear	Hardness.	Toughness.
Heavy	2·5 or less	18 or over	19 or over
Medium	2·5 to 5	14 to 18	14 to 19
Light	5 to 8	10 to 14	8 to 14

"The cementing value should in general run above 25 for all classes of traffic.

"The results of laboratory tests may be taken as a fair indication of the probable behaviour of limestones, but the tests for sandstones do not agree as closely as they should with results in practice."

Later (Oct. 1914), The American Society of Municipal Improvements adopted the following specifications: for a broken stone road without bitumen binder, the stone must have a French coefficient of wear of not less than 7 (equals per cent of wear about 5·7) and a toughness of not less than 6. For a broken stone road with bitumen binder, the lower course must have French coefficient of wear not less than 7, and a toughness of not less than 6; but the stone in the top course must have a French coefficient of wear not less than 11 (equals per cent of wear about 3·6), and a toughness of not less than 13.

Table I. Physical Properties of Stone and Gravel Used for Road Building in the Moncton Map-area.

	I	II	III	IV	V	VI	VII	VIII
Specific gravity	2·41	2·24	2·55 to 2·76	2·65	2·63	2·65	2·57	2·49
Water absorbed, lbs. per cub. ft.	2·70	3·95	0·24	0·95	1·33	.....	.....	.....
Per cent of wear	7·2	10·4	22·8	4·7	6·6	8·9	18·9	11·4
French coefficient of wear	5·6	3·9	1·8	8·5	6·1	4·5	2·1	3·5
Hardness	10·9	13·3	14·7	14·9	13·7			
Toughness	4	5	5	6	6			
Cementing value	287	344	139	92	126	308	204	250
Per cent of voids, material loose	.....	.....	.....	.....	.....	35·1	43·7	44·9
Per cent of voids, material compacted	.....	.....	.....	.....	.....	27·3	33·3	35·1

I. Sandstone from quarry at Blue cape, used in Moncton city.
II. Sandstone conglomerate from creek at bridge three-quarters of a mile above Upper Dover.
III. Bituminous shale, dump at East shaft, Albert Mines.
IV. Limestone from Havelock, N.B., used in Moncton city.
V. Limestone from the ridge west of Albert Manufacturing Company gypsum quarry.
VI. Gravel from Gray island.
VII. Weathered conglomerate treated as a gravel, from pit at junction of Albert Mines road with the Hillsborough-Albert road.
VIII. Conglomerate, weathered conglomerate treated as a gravel, from bluff along the Salisbury and Albert railway at Albert Mines.

Table II. Mechanical Analyses of Gravel and Weathered Conglomerates from the Moncton Map-area

	VI	VII	VIII
Per cent passing 200 mesh sieve	0·6	0·8	0·2
" " 100 " retained by 200 mesh sieve	1·0	0·6	0·2
" " 80 " " 100 "	0·4	0·1	0·1
" " 50 " " 80 "	3·5	1·5	0·3
" " 40 " " 50 "	4·4	1·2	0·2
" " 30 " " 40 "	5·4	1·5	0·4
" " 20 " " 30 "	14·9	2·3	0·8
" " 10 " " 20 "	17·0	6·2	2·7
" " ¼ inch screen " 10 "	15·6	14·5	6·9
" " ½ " " ¼ inch screen	6·8	19·5	8·4
" " ¾ " " ½ "	4·0	14·0	7·0
" " 1 " " ¾ "	2·2	9·6	7·4
" " 1¼ " " 1 "	1·7	9·9	8·6
" " 1½ " " 1¼ "	1·8	6·4	5·0
" " 2 " " 1½ "	12·8	6·0	14·8
" " 2½ " " 2 "	7·7	5·9	17·3
" " 3 " " 2½ "	.....	.....	13·2
" " 3½ " " 3 "	.....	.....	6·4
	99·8	100·0	99·9
Per cent of hard pebbles	.....	65·0	40·0
" soft "	.....	35·0	60·0

Per cent of hard and soft pebbles determined by L. A. Gilbert.

GOLD-BEARING SERIES IN NORTHERN PORTIONS OF QUEENS AND SHELBURNE COUNTIES.—INFUSORIAL EARTH DEPOSITS AT LOON LAKE ISLAND, LIVERPOOL RIVER, QUEENS COUNTY, NOVA SCOTIA.

(*E. R. Faribault.*)

INTRODUCTION.

During the field season of 1915, the writer was engaged in the continuation of the areal mapping of the northwestern part of Queens county and in the extension of this work into the northeastern portion of Shelburne county, immediately adjoining.

The work consisted chiefly in a geological and topographical survey of the Indian Gardens map-area, No. 108, and also in a revision of the geology of a part of the Caledonia map-area, No. 107, surveyed last year. In addition, a detailed survey was made of the geological structure of Whiteburn gold district, also a special survey of the deposits of infusorial earth discovered during last year's exploration, at Loon Lake island on Liverpool river. Plans of these two mineral deposits were also prepared in the field.

Field work was commenced on May 1 and continued until October 12. The assistants for the season were J. McG. Cruickshank and Percy Brown, and for part of the season W. P. Crowe and G. B. Page. The transit-stadia traverse of the boundary line between Queens and Shelburne counties, run last year by S. C. McLean, of the topographical division of the Survey, was used as a control line to tie up the surveys of the two map-areas.

A short description of the Caledonia map-area was published in last year's Summary Report, in which are given the location of the anticlines and the position along them of the principal domes, a structural feature that largely governs the occurrence of gold in economic quantity. Some more field work is still required, however, to complete the geological structure of certain parts of the area.

A special report on the infusorial earth of Loon Lake island is included in this report, accompanied by a plan giving the extent and thickness of the deposits, obtained by borings.

Gold-bearing Series in Northern Portions of Queens and Shelburne Counties.

WHITEBURN GOLD MINING DISTRICT.

The final report on the Whiteburn gold district must be deferred until the structure of certain portions has been worked out in more detail. The geological structure of this mining district is one of the most complicated in Nova Scotia. The rich gold veins worked in the district some years ago are all found interbedded in a zone of strata situated on the north side of a broad dome, on the western extension of the Brookfield Mines anticline. The dome is over 3 miles in width and is composed of four minor interdigitated folds or flexures. Along the anticlinal axes of these folds gold veins also occur which curve conformably with the strata and dip at low angles either to the east or west according as they occur on the eastern or western plunge of the dome. Several of these veins have been prospected a little, but so far without satisfactory results, although rich float has been found in their vicinity, indicating good values on some of them.

A knowledge of the geological structure of this complex dome is necessary to locate and trace out intelligently these curved veins, and it should be especially useful in planning development work to determine the extension of the rich ore-shoots beyond the present workings. So far, eighteen veins have been mined, to depths ranging from 50 to 200 feet, and for different lengths up to 1,500 feet along their courses. Mining operations were carried on from 1885 to 1894 inclusive and during that time about 10,000 ounces of gold was recovered from 7,000 tons of ore, giving an average yield of 1·43 ounces per ton.

INDIAN GARDENS MAP-AREA.

General Character of the Area.

The Indian Gardens map-area, No. 108, lies immediately south of the Caledonia map-area, and measures 18 miles east and west, and 12 miles north and south, covering an area of 216 square miles. The northern boundary crosses Lake Rossignol at Sam point, about the middle of the lake, while the southern passes immediately south of First Broad River lake and Jordan Great lake. The eastern boundary crosses Liverpool river 5 miles below Indian Gardens, and the western passes just west of Jordan river below Jordan Great lake and extends northerly to Tobeatic lake.

The northeastern part of the map-area is drained by Liverpool river, flowing south through Lake Rossignol, and Second and First lakes. It may be reached by wagon road, either from Caledonia to Lowes landing on Lake Rossignol, or from Liverpool to Indian Gardens, or by the tramway of the Sable River Lumber company starting from Wilkins siding on the Halifax and Southwestern railway and running north into the interior to within 4 miles of Lake Rossignol. The southwestern part is drained by the headwaters of the Jordan, Sable, Tom Tidney, and Broad rivers flowing south to the Atlantic. This area may be reached by canoe-route from the Screecher on Lake Rossignol, or by wagon road up Jordan river.

The country is flat, with occasional low hills of glacial drift having a north and south trend; and much of it is occupied by swamps, bogs, and meadows, and by a thick growth of low bushes which renders travelling on foot very difficult. It is well watered by numerous lakes and stillwater streams, affording good canoe-routes which are frequented every season by sportsmen and trappers. It is one of the best hunting grounds for moose in the province. Of late years, Virginia deer are also becoming quite numerous. The fur-bearing animals are the bear, raccoon, otter, mink, beaver, muskrat, wild-cat, fox, marten, skunk, ermine, and weasel. The beaver is protected; but, unfortunately, the law is not as rigorously enforced as it should be.

Much of the region has been burnt over repeatedly and is now covered with barrens and young growth. Most of the large timber has been culled; however, small areas of good spruce and hemlock, with some pine, still exist about Jordan Great lake and Sixth Mile lake. The region is uninhabited and nowhere fit for agricultural purposes, except on a few hills largely made up of granite debris drifted from the north.

An excellent water-power, probably the best in the province, is available on Liverpool river, at Lake fall, at the outlet of First lake (Indian Gardens). The following data on the efficiency of this power were obtained on October 11, 1910, by A. V. White, hydrographer for the Commission of Conservation[1].

Approximate area of watershed, 453 square miles.
Approximate head, 73 feet.
Estimated low-water 24-hour horse-power, 8 months, theoretical, 4,200 horse-power.
Note: Banks high near Indian Gardens, but low and flat from Pollard rapids to foot of Lake fall; distance from Indian Gardens to foot of Lake fall about 14,750 feet.

[1] Water-powers of Canada, Report Commission of Conservation, 1911, page 217.

Another water-power, of much less importance, however, is also available at the outlet of Jordan Great lake.

General Geology.

With the exception of a small expanse of granite occurring on the northwestern side of Tobeatic lake, in the northwestern corner of the sheet, the whole extent of the map-area is underlain by the Gold-bearing series. This sedimentary series has a thickness of over 30,000 feet and is divided, lithologically, into two conformable formations: a lower one, known as the Goldenville formation, chiefly composed of thick beds of quartzite with intercalated layers of slate; and an upper one, called the Halifax formation, essentially made up of slate. These rocks are closely folded into broad anticlines and synclines, the axes of which have a general northeast and southwest trend. As a result of the folding and subsequent erosion, the Halifax slate formation occurs along the trough of the synclines, while the Goldenville quartzite formation is exposed along the crest of the anticlines. Much economic importance is attached to the location and structure of the anticlinal folds and domes, because practically all the gold veins are found aggregated on domes of pitching anticlines. In the neighbourhood of the granite mass, to the south of Tobeatic lake, the quartzites and slates are metamorphosed into gneisses and schists.

On account of the heavy drift covering and the general swampy nature of the region, rock exposures are very scarce, and in some parts completely wanting, more especially in the southwestern portion of the map-area about Jordan Great lake, Sixth Mile lake, Porcupine lakes, and Earl Dunraven big bog. For this reason, the region does not offer features of as much geological and economic interest as otherwise it might.

At least five anticlines and as many intervening synclines traverse the area in a southwesterly direction, but the axes of these have not yet been located in a satisfactory manner and more field work will have to be done to trace them more accurately and determine, if possible, the anticlinal domes. As far as known at present, the anticlines occur in the following order from south to north:

(1) Tenmile Lake anticline crosses the southeastern corner of the map-area, passing a short distance to the north of Duck pond and to the south of First Broad River lake.

(2) Fifteenmile Brook anticline occurs 4 miles north of No. 1 and its axis runs southwesterly along the south side of Kempton brook and lake, then passes a short distance south of the outlet of Third Broad River lake.

(3) Molega anticline, $4\frac{1}{2}$ miles northwest of No. 2, passes a short distance north of East brook and runs southwesterly across Second lake, thence along the north side of First West Brook lake and across Earl Dunraven big bog and the headwaters of Sable river. On the south side of Second lake the fold assumes a decided plunge to the east, and there a few veins have been prospected for gold on what is known as Mrs. Howe's prospect.

(4) Whiteburn anticline, 5 miles farther northwest, crosses Lake Rossignol at Sam point and Southwest bay, where its axis curves more southerly and runs across Fifth, Sixth, Silver, East Jordan, and Jordan Great lakes. The location and structure of the fold have not yet been well defined. The fold appears to plunge northeasterly for the whole distance, and from Southwest bay the Goldenville quartzite is underlaid by a great thickness of banded, light-grey and bluish-grey, knotted, micaceous, argillaceous, and siliceous schists, which are probably the lowest known strata of the Gold-bearing series. These strata are similar to those occurring at about the same horizon on the first anticline south of Liverpool. Much quartz has been observed along its course, from Lake Rossignol to

Silver lake; and gold is reported to have been found on Fifth lake and at the north end of Silver lake.

(5) Harlow Brook anticline lies about 2½ miles north of Whiteburn anticline, on Harlow brook and Jordan river; here a few exposures have been observed forming an anticline that was not recognized farther east. A short distance south of this anticline, gold is said to have been found while the dam was being built at the outlet of Jordan Great lake.

Economic Geology.

No minerals of economic value, besides gold, have been found in the area under study. Loose pieces of quartz have been observed at several places along the anticlines, especially on the Whiteburn anticline. Gold float is reported to have been found on the Molega, Whiteburn, and Harlow Brook anticlines, as already mentioned above. Two quartz veins were opened several years ago by shallow pits at Mrs. Howe's prospect, on the south side of Second lake, near the outlet, but they do not appear to carry gold in economic quantity. A small quartz vein showing free gold is also reported to have been found a short distance west of Fifth lake and north of Sixth Lake brook, but the report was not verified as the vein could not be located.

Prospecting for gold over this area does not generally appear to offer much chance of success, on account of the heavy drift covering the surface nearly everywhere. The most favourable places for prospecting may possibly be found along the eastern plunge of the Whiteburn anticline, where it crosses the midde of Fifth lake and the north ends of both Sixth and Silver lakes. At these localities, the bedrock is exposed or covered only thinly with drift, and much loose quartz as well as a few small veins have been observed on the shores; while on Silver and Fifth lakes, gold is reported to have been found. It is perhaps better, however, to defer any definite conclusion on the possibility of finding minerals in economic quantity, until the geology of the whole area has been studied more thoroughly.

Outside of the western boundary of the map-area, some little distance west and southwest of Little Tobeatic lake, rich gold float has been found, and the locality was prospected last summer by Mark Anthony who reports the surface drift to be so heavy as to hinder the finding of the gold-bearing veins.

Infusorial Earth Deposits, at Loon Lake Island, Liverpool River, Queens County.

Introduction.

During the field season of 1914, while surveying the Caledonia map-area, infusorial earth was discovered by the writer at Loon Lake island on Liverpool river and in the Summary Report for that year the deposit was reported as possibly occurring over a large area. In view of the increasing demand and the many inquiries received recently for this material, the locality was re-examined last summer to ascertain the economic importance of the deposit. A detailed survey was made of the river for a distance of one mile, and borings were made to determine the extent, thickness, and quality of the deposit. A plan of the area surveyed is here published.

Location.

The deposit of infusorial earth is situated in the northwestern part of Queens county, at Loon Lake island on Liverpool river, halfway between Kejimkujik lake and Lake Rossignol. (Between these two lakes the river is called locally the Kejimkujik river). It lies $8\frac{3}{4}$ miles directly west of Caledonia, the terminus of the Caledonia branch of the Halifax and Southwestern railway. From Caledonia the locality is reached by a good road through West Caledonia settlement to David Canning's farm, distance $8\frac{3}{8}$ miles, thence by wagon road, distance $3\frac{1}{8}$ miles, giving a total distance of $11\frac{1}{2}$ miles by the present road.

The area surveyed extends along the river for a distance of one mile, from Loon lake down to the southern end of Loon Lake island, and includes the whole of this island which is formed by two outlets of the lake flowing in a southerly direction. The eastern channel drains the greater part of the water running out of Loon lake, the western one being almost dry in the summer season. At the eastern outlet of the lake there is a fall of 9 feet, called Loon Lake falls, below which the river expands into a wide still water flowing between low ridges of glacial drift. The western channel is made up of three short rapids, and three still waters. At many places the still waters are bordered by narrow meadow flats, which in the spring are flooded, but in the summer season produce a luxurious growth of meadow-hay and cranberry vines.

Description of the Deposits.

The deposits of infusorial earth are all confined to the meadow-flats bordering the river. At the time of this investigation, September 22, the water was exceptionally low, and in most places natural sections of the deposits could be observed and measured along the river bank. The extent of the deposits was determined by a series of borings made with a hand auger, and the measured thicknesses of infusorial earth are recorded in inches on the plan.

The data thus obtained show that, almost everywhere along the river banks, the flats are composed entirely of infusorial earth resting on rock debris or bed-rock, but away from the river the deposits gradually thin out towards the margin and are underlain by layers of clay and coarse gravel. The infusorial earth is generally white in colour and pure throughout the whole thickness of the deposits, being seldom contaminated by impurities, or interstratified with layers of foreign matter. The material is loose, powdery, and much like chalk or very white clay in appearance. It occurs compact, or in thin beds, one-sixteenth to one-quarter inch in thickness, lying horizontally. A very little colouring matter between the beds, apparently marks successive depositions on the river bottom. The deposits are overlaid by 4 to 6 inches of decayed vegetable matter, supporting a strong growth of marsh-hay, cranberry vines, and small shrubs, the roots of which sometimes extend a few inches down into the pure infusorial earth. The porous nature of the material affords excellent drainage, apparently favourable to the growth of cranberry vines.

The deposits were laid down long after the Glacial period and subsequent to the deposition of the alluvial clays and gravels, when the still waters were at a higher level and wider than at present, and when the flow was but little affected by spring freshets, a condition favourable to the development of diatom infusoria. The subsequent cutting down of the river bed at the foot of the still water had the effect of lowering the water-level and increasing the flow to such an extent as to not only preclude the development and deposition of diatoms, but also to wash away the greater part of the existing deposits, leaving only small remnants in coves unexposed to the currents.

The right bank and the upper part of the western channel, and the shore of Loon lake were not examined for infusorial earth. It is very probable that small deposits also occur in the flats along the channel there, but not likely along the lake.

The exploitation of these deposits should not present much difficulty on account of water, because while the operations are conducted on one channel that channel could easily be partly drained by diverting the water into the other one, and by deepening the bed of the river at the rapids below the still water.

Infusorial earth was also observed at Grady meadow, 1½ miles lower down the river. No borings were made there, but so far as it could be observed on the river bank the material appears to be of good quality and over 2 feet in thickness. It is possible that other cranberry and meadow flats bordering the numerous still water streams in this level part of the country may be composed of infusorial earth deposits and an examination of these flats with the aid of a large hand auger might lead to the discovery of more important deposits than the one just described.

Estimated Amount and Value.

The time available for this investigation was too limited to get all the data necessary for a complete and close estimate of the amount of infusorial earth contained in the deposits under study. Although incomplete, the following figures based on the data obtained from the area examined are given, as they will give an approximate idea of the economic value of the deposits.

The total area covered by these deposits, as far as examined, is estimated at 485,000 square feet. The thickness varies from a little less than 1 foot to 4 feet. Assuming that, on an average, 1½ feet of material in good condition for the market could be extracted from the above area, the total amount available would be 727,000 cubic feet. The apparent density of the dry, crude infusorial earth being about 0·45, equivalent to 28 pounds per cubic foot, there would thus be a possible production of 20,370,000 pounds or 10,185 tons of air-dried material in the deposits.

The price of the product ranges from $10 to $20 per ton, according to its purity, the uses for which it is employed, and the degree of preparation when placed on the market.

The production of crude, air-dried material in the United States,[1] for 1913 was 6,586 tons valued at $69,240, and for 1914 was 11,012 tons valued at $109,899, giving an average value of about $10 per ton.

The production in Canada for 1913 and 1914 all came from one deposit situated at Bass River, Nova Scotia. At Bass River the material is sorted, dried, ground, very carefully sized, and delivered to the market in seven different grades.[2] The output of this product in 1913 was 620 tons valued at $12,138, and in 1914 was 650 tons valued at $13,000. This would give an average value of $20 per ton of partly prepared product. This product is all shipped in bulk to the United States where it is further graded and prepared in the form most suitable for the purposes for which it is required. Part of such product is then reshipped to consumers in Canada, in small packages and at much higher prices. Thus, all the infusorial earth used in Canada is imported.

[3]The estimated amount of crude infusorial earth consumed in Canada in 1913, as reported by fourteen firms, was 96 tons; and the amount of tripolite (grease brick), as reported by one hundred and forty-five firms, was 116 tons equivalent to 87 tons of crude material. The total amount imported is certainly much higher than these figures would indicate.

Since going to press, the preliminary report on the mineral production of Canada for 1915 issued by the Mines Branch, Department of Mines, gives the production of partly prepared infusorial

[1] Mineral Resources of the United States for 1914, Part II, page 561, U.S. Geol. Survey.
[2] "Annual Report on the Mineral Production of Canada for 1914," page 173, Mines Branch, Depart. of Mines, Ottawa.
[3] "Report on the Non-metallic Minerals used in the Canadian Manufacturing Industries," by H. Frechette, page 107, Report No. 305, Mines Branch, Depart. of Mines, Ottawa, 1914.

earth from Bass River, Nova Scotia, for that year, as 317 tons, valued at $12,119, giving an average value of $38.23 per ton. The output is said to have been shipped to Great Britain, where at present there is a great demand for the product.

Composition, Properties, and Uses.

Infusorial earth, called also diatomaceous earth and kieselguhr, is a light earthy material which from some sources is loose and powdery, and from others is more or less firmly coherent. It often resembles chalk or clay in its physical properties, but can be distinguished at once from chalk by the fact that it does not effervesce when treated with acids, and when air-dried it is much lighter in weight than clay. It is generally white or grey in colour, but may be brown or even black when mixed with much organic matter.

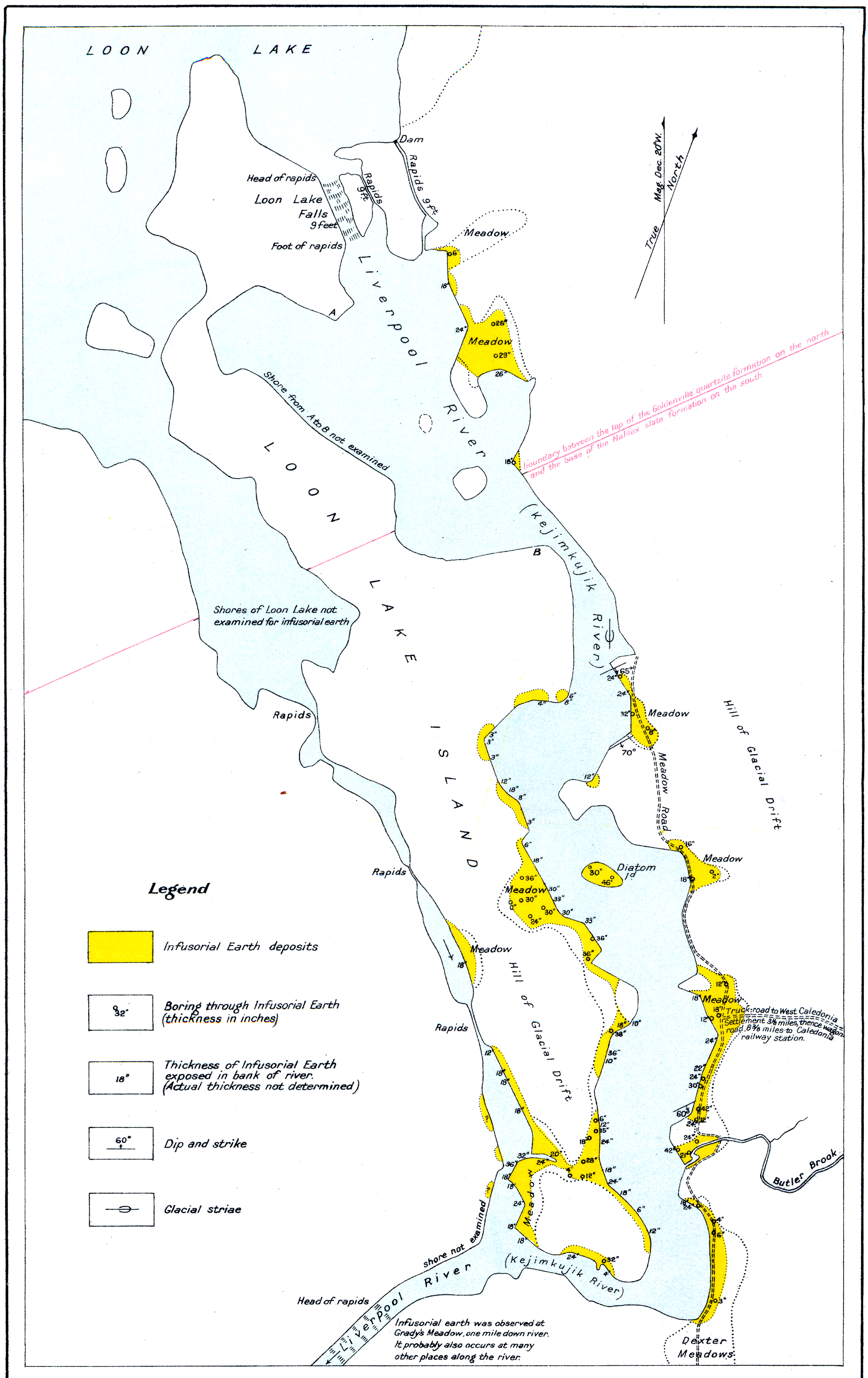
Infusorial earth is made up of minute flinty skeletons of certain aquatic forms of plant life known as diatoms, deposited in lakes and rivers. It is essentially composed, chemically, of hydrous silica, in the opaline state, but often contains mechanically mixed such impurities as sand, clay, vegetable matter, etc., which decrease its value.

On account of its physical and chemical properties, it is susceptible of many industrial applications. In an article[1] on "the kieselguhr industry" of California, Percy A. Boeck describes in detail the properties of infusorial earth in connexion with the most important of its applications. These properties are outlined as follows:

I. Physical properties.
 (a) Form:
  (1) Enclosed air cells: Light weight, filler or diluent, thermal insulator, sound deadener, absorbent, filter.
  (2) Large exposed surface of cells.
  (3) Fine state of division.
  (4) Sharpness of cells.
  (5) Weakness of cells.
 (b) Refractory nature.
 (c) Colloidal condition.
 (d) White colour.
II. Chemical properties:
 (e) Inorganic or siliceous composition.
 (f) Solubility in alkalis.
 (g) Insolubility in acid (except hydrofluoric) or neutral solution.

Heretofore, infusorial earth has been largely used as an abrasive in the form of polishing powders and scouring soaps; but of late its uses have been considerably extended. Because of its porous nature, it is used extensively by sugar refiners for filtering and clarifying; in the manufacture of dynamite as a holder of nitroglycerine; and in preparing artificial fertilizers especially as an absorbent of liquid manures. Its porosity also renders it a nonconductor of heat, and this quality in connexion with its lightness has very greatly extended its use as an incombustible insulator in packing material for both high temperature in ovens, furnaces, evaporators, steam pipes, and boilers and for low temperature in cold storage, icehouses, refrigerators, and safes. On account of the same physical properties, it has found extensive use as a fireproof building material and a sound deadener in various cements, light terra-cotta, bricks, and artificial stones, also in the paint industry as a wood filler. It has been used in the manufacture of glazing for tiles and bricks, of ultramarine and various pigments, of aniline and alizarin colours, of rubber goods, paper, water glass, tooth-powders, sealing wax, fireworks, gutta-percha articles, records for talking machines, Swedish matches, solidified bromide, papier-mâché, and many other articles. There is a steadily growing demand for it.

[1] Metal and Chem. Engineering, Vol. XII, No. 2, pp. 109-113.



Geological Survey, Canada. 1606

Infusorial Earth Deposits, Loon Lake Island, Liverpool River, Queens County, N. S.

Feet
500 0 500

To accompany Summary Report by E. R. Faribault, 1915.

REPORT OF THE VERTEBRATE PALÆONTOLOGIST.

(*Lawrence M. Lambe.*)

Field Work.

Two collecting parties were sent into the field this year, one to the Milk River district of southern Alberta to explore the whole of the Cretaceous area north of the International Boundary, traversed from west to east by Milk river, the other for further work in the Edmonton formation on Red Deer river, Alberta.

The Cretaceous rocks in the Milk River district, for the most part of Belly River age, were known, from the early reports of Dr. G. M. Dawson and others, to hold dinosaurian remains in a fragmentary state; but whether more perfectly preserved dinosaurian and other reptilian material was obtainable by careful collecting was not known. With the object, therefore, of testing these beds as a whole, Charles H. Sternberg in charge of a party, and assisted by C. M. Sternberg, spent the month of June in exploring this area. It was found that throughout this district vertebrate remains occurred only as scattered fragments and the party was directed to spend the remainder of the season collecting from the rich dinosaurian beds of the Belly River formation on Red Deer river, in continuation of the work of 1914 when such good results were obtained.

Mr. Sternberg states that in a thorough search over the exposures along the Milk River ridge west of Milk River station and 12 miles eastward to Verdigris coulée the beds were almost barren of vertebrate fossils, only a few fragmentary bones being seen, but that at the last named locality some good fossil plants were obtained: that considerable time was spent in the deep gorge of Milk river near the International Boundary where the erosion has been entirely in Belly River rocks with many evidences of shallow and brackish water deposition. Here, and also on Lost river where the extensive exposures were examined, the party found only a few fragmentary bones of dinosaurs, but fresh and brackish water shells occurred in abundance. The area explored at this time extended from the western end of Milk River ridge on the west to Lost river on the east, a distance of slightly under 100 miles, and included Verdigris coulée northwestwardly.

Not finding remunerative exposures in the Milk River district, Mr. Sternberg and his party moved north to Red Deer river and camped on One Tree creek, 4 miles south of Steveville (mouth of Berry creek), descending the river later to Love Land ferry, about 12 miles below the eastern end of Dead Lodge canyon. In extensive exposures of the Belly River formation the party was successful in discovering some very fine dinosaurian and other reptilian remains among which may be mentioned a skeleton of *Stephanosaurus marginatus* Lambe (the Hooded dinosaur) which included a well preserved skull but lacked the tail, one front foot, and one hind foot. Some excellent armoured dinosaur material was also obtained. The work in the Belly River "bad lands" on Red Deer river extended through July, August, and September, the result of the season's collecting, filling forty-seven large packing cases, having an aggregate weight of 20 tons.

On the conclusion of the Red Deer River work C. M. Sternberg, who had covered the Milk River district on horseback in June, visited a number of localities north and west of Milk River ridge, viz., Big island at Big Island bend of Belly river where exposures of the Belly River formation occur, and the following where the Edmonton formation is seen—Scabby butte, Gooseberry canyon of St. Mary river, Belly butte, and Kimble, without finding vertebrate remains sufficiently well preserved or in large enough numbers to warrant an expedition to this part of the country in the near future.

The second collecting party was under the direction of George F. Sternberg, in the Edmonton formation on Red Deer river. Leaving Ottawa early in May, over five months were spent in the field. The exposures along Red Deer river from a few miles above Content, a small settlement near Tail creek, to opposite Rowley, a distance down the river of about 40 miles, were subjected to a close search for fossils.

From Content to the Ross ranch about 2 miles above the mouth of Big Valley creek there was a noticeable paucity of vertebrate remains. Opposite Big Valley creek, however, is one of the largest areas of Edmonton beds on Red Deer river and here were collected the first good specimens. From here down to the last camp of the season opposite Rowley, a distance of about 20 miles by river, remains of about nineteen individual dinosaurs were collected, of which one skeleton is nearly complete. The 1915 collection from these Edmonton beds is contained in forty-nine boxes having a total weight of about 8 tons.

Toward the close of the season Mr. George Sternberg spent six days in making an exploratory trip along Battle river from Ferry point, 12 miles north-east of Donalda, down to Hardisty, at the mouth of Iron creek, a distance of about 70 miles by river, giving particular attention to the beds of the Edmonton formation outcropping in the river valley. The exposures are much overgrown with shrubs and grass, making it poor ground for prospecting. No vertebrate fossils were observed.

Research and Office Work.

My time has been given, apart from the direction and superintendence of the work of the division as a whole, principally to the study of the vertebrate Cretaceous fauna of the west, especially to that of our recently discovered dinosaurian forms of the Belly River formation of Red Deer river, Alberta. As a result of the study of the Ceratopsia an illustrated paper entitled "On *Eoceratops canadensis*, gen nov. with remarks on other genera of Cretaceous horned dinosaurs," was completed and published as Museum Bulletin No. 12, May 7, 1915. This paper deals with the phylogeny of the horned dinosaurs of the Cretaceous in the light of the knowledge gained by our many recently discovered generic types. Considerable time was also given to the study of the very complete and well preserved type of the flesh-eating dinosaur Gorgosaurus from the Belly River formation to be described in a forthcoming illustrated memoir. The greater part of the manuscript has been written for a "Popular Illustrated Guide to the temporary exhibit of Fossil Vertebrates" which will appear shortly.

Since the latter part of March drawings in connexion with work in progress have been made in a most satisfactory manner by Arthur Miles. These are principally of ceratopsian type material from the Cretaceous of the west, and of the type skeleton of the carnivorous dinosaur *Gorgosaurus*. Mr. Miles has also been engaged in preparing illustrations for the Popular Museum Guide.

Miss E. F. Goodman has been occupied in cataloguing collections and in general museum and clerical work. Progress has been made with the card index of specimens and considerable attention has been given to the labelling and proper display of the public exhibit, as well as to the care and arrangement of the rapidly increasing duplicate and study collections. In performing the duties of her position Miss Goodman has rendered valuable assistance. Among the collections catalogued during the year are: the 1913 field collection from the Belly River formation of Red Deer river, Alberta; *Stenomylus* remains from the Miocene of Nebraska, and mammal material from the Patagonian beds of Patagonia by exchange with Dr. F. B. Loomis of Amherst college, Amherst, Mass.; a purchased collection of fishes from the Lower Carboniferous and Old Red Sandstone of Scotland; and a purchased collection of vertebrates, principally mammals, from the Oligocene of Wyoming.

With a view to making known as fully as possible the latest discoveries of the Geological Survey in vertebrate palæontology, lantern slides of a number of the most interesting specimens recently placed on exhibition in the museum were sent early in April to nine of the leading universities of Canada. These slides are intended for the use in these institutions of the professor of geology or other instructor under whom the study of geology comes. Upon request, copies of descriptive labels (in popular language) which accompany these specimens in our museum are also sent. By this means the latest progressive steps in Canadian palæontology, resulting from the study of vertebrates discovered principally by the Geological Survey palæontological field parties, will be brought before a very large number of students.

The lantern slides, of which there are fifteen in a set, illustrate the following specimens:—

Skull of the Hooded dinosaur, *Stephanosaurus marginatus* Lambe, from the Belly River formation, Red Deer river, Alberta.

Skin impressions of the same from the trunk region and tail.

Skeleton of Trachodon, panel mount, from the Edmonton formation, Red Deer river, Alberta.

Skin impression of the same.

Skull of the High-nosed dinosaur *Gryposaurus notabilis* Lambe, and of the horned dinosaurs *Styracosaurus albertensis* Lambe, *Chasmosaurus belli* Lambe, and *Centrosaurus apertus* Lambe, all of which are from the Belly River formation on Red Deer river.

The fish *Platysomus albertensis* Lambe, from rocks of supposed Permian age near Banff, Alberta.

The turtles *Aspideretes subquadratus* Lambe, from the Belly River formation of Red Deer river; and *Testudo præextans* Lambe, from the Oligocene of Converse county, Wyoming.

The skeleton (free mount) of Titanotherium also from the Oligocene of Converse county, Wyoming.

Public Exhibits.

During the year the following dinosaurian specimens from the Belly River formation (Cretaceous) on Red Deer river, Alberta, were, on their completion as mounts, placed on exhibition in the Hall of Fossil Vertebrates:—

(a) A skull of the horned dinosaur *Centrosaurus apertus*, about 4½ feet long, belonging to the collection of 1913. The mandible of this individual was not found and one modelled in plaster has been used in the mount. Cat. No. 347.

(b) A perfect skull of *Centrosaurus apertus*, with the lower jaw in place, collection of 1914. Cat. No. 348. The specimen has a total length of nearly 5 feet, and is probably the most complete skull of this species known. These two skulls illustrate the great size attained by the Cretaceous horned dinosaurs.

(c) A left hind limb of the carnivorous dinosaur *Gorgosaurus libratus*, exhibited as an open mount. As it stands the head of the femur is 7 feet above the base. Following its curves the leg has a total length of 9 feet 6 inches to the tip of the longest toe. Collection of 1914. Cat. No. 350.

(d) The distal end of the tail of a heavily armoured dinosaur with a covering of thick bony scutes in place. This massive end to the tail is in this particular specimen about 20 inches long, 18 inches broad, and 8 inches deep. Collection of 1914. Cat. No. 349.

Laboratory.

In the laboratory Mr. Sternberg and his assistant preparators, besides completing the mounts already mentioned as having been placed on exhibition during the year, and preparing numbers of specimens for study and present retention as duplicate material, have in hand approaching completion, as museum mounts, two skulls of the horned dinosaur *Chasmosaurus belli* and the almost perfect skeleton of *Gorgosaurus libratus*, the latter 29 feet in length, and judged to be the most complete of the flesh-eating dinosaurs so far discovered. The *Chasmosaurus* skulls, as free mounts, will add greatly to the attractiveness of the horned dinosaur series already on exhibition. The huge skeleton of *Gorgosaurus* will claim the attention it so richly deserves.

The method of support adopted in mounting large specimens for exhibition, seen to particular advantage in the heavy skulls of dinosaurs placed on view during the past year, calls for special notice. By the use of a single upright from which proceed supporting steel and iron bands of a minimum necessary strength, adjusted to lower and inner surfaces, the specimen appears to the best advantage to the onlooker to whom the upright rod beneath is the only portion of the supporting framework visible.

Field work claimed the attention of the preparators toward the end of May, and work was not resumed in the laboratory until early in October.

Additions to the Vertebrate Palæontological Collections During 1915.

Collected by Officers of the Geological Survey.

MacLean, Alex.—

Fish remains from the Pembina district, Acc. No. 98, as follows:—

(a) Fragments of the jaws with tooth bases, four vertebræ, parts of the neural and hæmal spines at the base of the tail, etc., of an actinopterygian fish, apparently belonging to the genus *Cimolichthys* (*Empo* of Cope), from Pembina mountain, Man. The remains are evidently of one individual and were found in a railway cutting in the northwest corner of sec. 15, tp. 6, range 8, W. 1st mer. Also the impression in shale of a fish scale from the same locality. Geological horizon probably base of Pierre.

(b) One plesiosaurian vertebra from a cut on the north side of a ravine in the northwest quarter of sec. 21, tp. 1, range 5, W. 1st mer., Man. Geological horizon probably Niobrara.

(c) One Selachian tooth apparently referable to the genus *Corax*, Agassiz, from a cut in an old weathered slide to the southwest of Miami, Man. Geological horizon probably Niobrara.

Hyde, J. E.—

Thirty-six fragments of limestone bearing fish scales and spines from shore of harbour of North Sydney, N.S., from bed below, and 200 feet south of, outcrop of main seam. Coal Measures. Acc. No. 94.

Kindle, E. M.—

One palæoniscid fish, collected by J. A. McLennan, 2 miles east of Castle Mountain railway station, near Banff, Alberta, on trail to Johnson creek. Acc. No. 100.

Sternberg, Charles H., C. M. Sternberg, and party.—

A large collection of vertebrate remains, principally dinosaurian, from the Belly River formation of Red Deer river, Alberta. (Received at Ottawa, October, 1915.) Acc. No. 101.

A tentative list only, as below, of the more important specimens included in the collection of 1915 can be given at this date of writing as the greater part of the collection is as yet unpacked.

[1](1) Fifteen caudal vertebræ, in place, from the distal half of the tail of the carnivorous dinosaur *Gorgosaurus libratus*.

(2) *Stephanosaurus marginatus;* 12 feet of the vertebral column, inclusive of 7 feet of the tail, pelvic arch and hind limbs, two scapulæ and parts of fore limb and neck.

(3) One hind limb of *Gorgosaurus libratus*.

(4) Sacrum of a trachodont dinosaur.

(5) *Stephanosaurus marginatus;* 7½ feet of the distal end of the tail.

(6) The tail extremity with defensive scutes of an armoured dinosaur.

(7) Armoured dinosaur; pelvic arch, part of tail, limb bones, etc., with dermal scutes.

(8) *Stephanosaurus marginatus;* 15 feet 7½ inches of the vertebral column, inclusive of 7 feet of the tail, pelvic arch, hind limbs, scapula, and most of the ribs.

(9) *Stephanosaurus marginatus;* a nearly complete skeleton, with well preserved head, the tail, one front and one hind foot missing.

(10) Part of a skull of *Chasmosaurus belli*.

(12) Armoured dinosaur; sacrum and some vertebræ with dermal plates in place along neural spines.

(13) Fragments of skull of Chasmosaurus.

Many loose specimens representative of the varied fauna, principally reptilian, of the Belly River formation, as well as invertebrates and plant remains.

Sternberg, George F., and party.—

A large collection of vertebrate remains, principally dinosaurian, from the Edmonton formation on Red Deer river, Alberta. (Received at Ottawa, Nov. 8, 1915.) Acc. No. 102. As in the case of this season's collection from the Belly River formation a provisional list only of some of the principal specimens obtained can be given at present, as under:—

[2](2) A nearly complete skull, about 14½ inches long, of a small trachodont dinosaur, which may prove to be undescribed.

(4) A nearly complete skull of ? *Saurolophus osborni*.

(6) Complete skull, fore limbs, and trunk including the pelvic arch of a small trachodont dinosaur apparently the same as No. 2.

(10) Plesiosaurian reptile of which most of the skeleton, exclusive of the head, is represented.

(16) A very fine skeleton of a trachodont dinosaur lacking only 3 or 4 feet of the distal end of the tail, and the left ilium.

In addition there are about eight other individual trachodont dinosaurs represented by well preserved material; also the following:—

One vertebra, with both of the anchylosed ribs, of an armoured dinosaur.

Part of the neck frill of the horned dinosaur *Anchiceratops*.

Many separate specimens representing the vertebrate fauna of the Edmonton formation, as well as invertebrates from the same horizon, principally shells and plants.

Presented.

Newcombe, Dr. C. F., Victoria, B.C.—

The upper left second molar of *Desmostylus hesperus* Marsh, a Sirenian of Pliocene (or ?Miocene) age, known from California, Oregon, and Japan. Specimen marked Alaska, locality unknown. Acc. No. 99.

[1] These numbers refer to Mr. Sternberg's notebook.
[2] Field numbers of George F. Sternberg.

Hyde, Professor J. E., Queen's university, Kingston, Ont.—
A fish spine, over 16 inches long, from the Point Edward formation (Carboniferous) at Point Edward, near Sydney, N.S. Provisionally referred to the genus *Gyracanthus*. Acc. No. 97.

Sternberg, George F.—
Scapula and coracoid of *Tylosaurus* from Beaver creek, Logan county, Kansas, U.S.A., Niobrara (Cretaceous). Cat. Nos. respectively 346, 346a.

Purchased.

A skeleton of *Equus scotti* Gidley, from the Pleistocene of the Staked plains of Texas, at the head of Rock creek, Briscoe county, Texas (collection of Dr. Edward L. Troxell, 1914). Acc. No. 96. This skeleton is in a splendid state of preservation and lacks only three cervical vertebræ and the sacrum. This one-toed Pleistocene horse was a long faced type. According to the author of the species it was "about the size of the largest western pony, but with a longer body, a much larger head, a shorter neck, and a back and steeply sloping sides very much as in the ass or quagga."

A collection of mammoth remains from the Pleistocene gravels of Yukon purchased, through D. D. Cairnes, from H. C. Crowhurst. The collection is made up of the following specimens—cranium with lower jaw, three tusks, one humerus, sacral vertebra, and eight teeth.

REPORT OF THE STRATIGRAPHICAL PALÆONTOLOGIST.

(*E. M. Kindle.*)

Field Work.

Field work by members of the division of stratigraphical palæontology has been carried on during the past season in the provinces of Ontario, Alberta, and British Columbia. This work has aimed, among other things, at acquiring more precise data for the delimitation of geological boundaries of systemic and lesser rank, a better knowledge of the vertical range of guide fossils and particular faunal groups, and the extension of our knowledge of the geographical distribution and the significance of particular faunal facies.

Mr. L. D. Burling was engaged from July to October in studying the Cambrian faunas and stratigraphy in the Rocky Mountains and Yoko parks and in the Mount Robson district in British Columbia. The Grand Canyon section in Arizona was also studied at the end of the season. Extensive collections of Cambrian fossils were made and important accessions to our knowledge of the Rocky Mountain Cambrian stratigraphy will result from this work.

Mr. M. Y. Williams has continued his work on the Silurian rocks of Ontario in the Georgian Bay district. While the work of Mr. Williams has not been limited to problems belonging essentially to the division, it has yielded a collection of Silurian fossils from that region and will extend our knowledge of these faunas in the area studied.

My own field work was done in the Rocky mountains of British Columbia and Alberta and in southern Ontario. The month of July was spent in Rocky Mountains park in getting data for a popular guide to the palæontology of the park and in collecting and studying the Devonian fauna of the region.

The work on the Rocky Mountain Devonian faunas and stratigraphy was continued during the month of August by the study of sections at Wardner, B.C., Nordig, Alberta, and at various points in Jasper park. In this work I had the efficient assistance of J. A. McLennan. Later in the season three days were spent in studying important sections at Sylvania, Ohio, and at St. Mary, Ont. A short trip was also made to Kingston at the invitation of Prof. M. B. Baker to examine certain Ordovician sections.

Many problems in stratigraphical palæontology include features which are so closely analogous to those belonging to the field of biology, called in recent years ecology, that the elucidation of the former may be greatly facilitated if the investigator devotes a portion of his time to the latter. This idea is in no sense new, since it was exemplified in the work of such distinguished palæontologists as the late Dr. Whiteaves and Sir William Dawson. It is, however, so often lost sight of by palæontologists that its restatement here may be permissible and even desirable in alluding to the relationship of some of my field work, which may be designated as researches in sedimentation, to stratigraphical palæontology. These investigations have for their basic object the interpretation of the ancient fossil life and sediments in the light of an intimate knowledge of the conditions under which existing plants and animals live and finally become a part of the geological record through burial under sediments now accumulating.

During the first part of the field season I resumed the investigation of the problems of sedimentation in Lake Ontario, which had been begun the preceding year. A 30-foot gasoline launch, furnished with dredges for collecting molluscan shells and apparatus for taking bottom samples at any depth, was used in this work. Bottom surveys were made in detail in certain selected areas and a series of bottom samples was taken along a line crossing the lake from Wellington to Fair Haven, New York, in depths up to 500 feet. This work, which was under my personal direction during the first and later parts of the season, was entrusted to my assistant, E. J. Whittaker, during the middle of the summer. The very satisfactory results attained in prosecuting this work, which was always laborious and at times hazardous owing to an ususually stormy season, are due in large measure to the perseverance and enthusiasm of Mr. Whittaker.

Office Work.

A large portion of the old collections of invertebrate fossils belonging to the Geological Survey has been gone over during the year and a card index prepared. Miss A. E. Wilson, who has been engaged with this work, has had the assistance of Miss Godwin and W. Cross. This index when completed will make it possible to locate any particular lot of fossils among the many thousands of stored specimens.

Mr. E. J. Whittaker has been occupied while in the office with the preparatory work of the section.

Revision of palæontological manuscript referred to this section has taken a considerable amount of the time of members of the section.

Some progress has been made on the card catalogue of the Devonian fossils of North America.

Office work has included the preparation of the usual number of special reports by Mr. Burling and myself for members of the staff on collections of fossils from various parts of the Dominion. A considerable number of fossils have also been determined for persons not connected with the Survey.

All of the time which could be spared from routine office duties has been devoted to research work on problems which are under investigation. The results of such parts of this work as have reached the stage of publication may be found in the publications cited below.

Publications.

The following list of papers, which represents the published results of the work of the section for the year, has been brought together for convenience of reference.

Burling, L. D.—
Shallow water deposition in the Cambrian of the Canadian Cordillera: Ottawa Naturalist, Vol. XXIX, 1915, pp. 87-88.

Kindle, Edward M.—
Limestone solution on the bottom of Lake Ontario; Amer. Jour. Sci., Vol. XXXIX, 1915, pp. 651-656.
A New Bathymetric record for attached algae and diatoms in Lake Ontario: Jour. Ecology, Vol. III, No. 3, 1915, pp. 149-152.
Notes on the geology and palæontology of the Lower Saskatchewan River valley: Mus. Bull. No. 21, 1915, pp. 1-25.
Report of the Stratigraphical Palæontologist: Sum. Rep., Can., Geol. Surv., Dept. of Mines, 1914 (1915), pp. 122-130.

Kindle, E. M., and Burling, L. D.—
Structural relations of the Pre-Cambrian and Palæozoic rocks north of the Ottawa and St. Lawrence valleys: Mus. Bull. No. 18, 1915, pp. 1-23.

Williams, M. Y.
The Ordovician rocks of Lake Timiskaming: Geol. Surv., Can., Mus. Bull. No. 17, 1915, pp. 1-9.
An Eurypterid horizon in the Niagara formation of Ontario, Geol. Surv., Can., Mus. Bull. No. 20, pp. 1-21.

Wilson, A. E.—
A New Ordovician Pelecypod from the Ottawa district: Ottawa Naturalist, Vol. XXIX, 1915, pp. 85-86.

Additions to the Invertebrate Palæontological Collections During 1915.

Collected by Officers of the Geological Survey.

Alcock, F. J.—
A collection of Ordovician fossils from limestone, 50 and 75 miles from Fort Churchill on Churchill river, Man. Access. No. 281.

Annes, E. C.—
(See Burling and Annes.)

Bell, W. A.—
A crustacean fragment from the Carboniferous formation at Kennebecasis island, N.B. Access. No. 253.
Fossils from the Windsor formation at Springville, Pictou county, N.S. Access. No. 298.
(See Hayes, Wright, and Bell.)

Burling, L. D. and Annes, E. C.—
A large collection of Cambrian fossils from the vicinity of Robson peak, G.T.P.R., B.C.
A collection of Cambrian, Ordovician, and Silurian fossils from C.P.R., Golden, B.C.

A collection of Cambrian and Devonian fossils from Banff, Alberta.
A large collection of Cambrian and Ordovician fossils from many sections along the C.P.R., between Castle mountain, Alberta, and Field, B.C.
Fossils from the Grand canyon, Arizona. Access. No. 288.

Burling, L. D. and Schofield, S. J.—
A collection of Cambrian and Devonian fossils from the mountain north of the upper end of Upper Columbia lake, B.C. Access. No. 289.

Cairnes, D. D.—
A small collection of Mesozoic fossils from Wheaton district, Yukon. Access. No. 278.

Camsell, Chas.—
A collection of Devonian fossils from the Chutes, Peace river, Alberta.
One piece of fossiliferous rock from the Cretaceous of Takla lake, B.C. Access. No. 280.

Dowling, D. B., and Slipper, S. E.—
Fossils from the top of the Bearpaw formation at Rye Grass flat at the mouth of Belly river, from the lower part of the Bearpaw at Lethbridge, and from St. Mary river.
Fossils from the pale beds of the Belly River formation from the mouth of St. Mary river, Pothold reserve, and from Big Island bend, Oldman river.
Fossils from the yellow beds of the Belly River formation and from the vicinity of Taber on the Oldman river, and at Middle coulée.
Fossils from the brackish water horizon from Verdigris coulée, Milk River station, Pendant d'Oreille police outpost, Etzikom coulée, Chin coulée, Fortymile coulée, and several places on the South Saskatchewan river.
Benton and Jurassic fossils from the flanks of Sweet Grass buttes, Montana. Access. No. 290.

Dowling, D. B.—
Fossils from Jumpingpound, Edmonton rocks. Access. No. 257.

Dresser, J. A.—
A large collection of fossils from Lake St. John and vicinity, Que. Access. No. 291.

Harvie, R.—
Some pieces of Utica shale from the east bank of the Rideau river, Cummings Bridge, Ottawa. Access No. 251.
A small collection of fossils from the vicinity of Montreal and from the Eastern Townships. Access. No. 267.

Hayes, A. O.—
A collection of Cambrian fossils from vicinity of St. John, N.B. Access. No. 268.
Fossils from the Windsor formation at Markham, N.B. Access. No. 290.

Hayes, A. O., Wright, W. J., and Bell, W. A.—
A collection of fossils from the Windsor formation at Markham, N.B. Access. No. 297.

Hume, G. S.—
(See Williams and Hume.)

Johnston, W. A.—
A collection of freshwater shells from Lake Algonquin deposits of Lake Simcoe district.
Some marine shells from the Pleistocene deposits of the Ottawa valley. Access. No. 303.
A large collection of Ordovician fossils from central Ontario. Access. No. 302.

Kindle, E. M.—
A collection of Palæozoic and Mesozoic fossils representing the entire section from Cambrian to Cretaceous from Rocky Mountains park and from Jasper park, Alberta.
Ordovician fossils from Kingston, Ont. Access. No. 295.
A specimen of Cambrian oolitic limestone and mud cracks 6⅓ miles northwest of Banff, Alberta. Access. No. 311.
A collection of Ordovician fossils from Hogsback, Ottawa. Access. No. 282.
Fossils from the Ordovician and Recent shells from Ottawa and vicinity. Access. No. 271.
Fossils from Sylvania, Ohio, and St. Mary, Ont. Access. No. 313.

Kindle, E. M. and Whittaker, E. J.—
Moulds, etc., of ripple-marks from Lake Deschênes, at Britannia and Aylmer. Access. No. 308.

Lambe, L. M.—
A collection of fossils from Cap-à-l'Aigle, Que. Access. No. 274.

MacKenzie, J. D.—
A collection of fossils from the Hazelton-Aldermere area, B. C. Access. No. 293.
A piece of fossiliferous coal from Camp Trilby, Graham island, Q. C. I. Access. No. 256.

McLearn, F. H.—
20 boxes of Mesozoic fossils from the Blairmore district, Alberta. Access. No. 315.

McLennan, J. A.—
Salt crystal pseudomorphs in shaly limestone from Roche Miette, Pocahontas, Alberta.
Concretions from Exshaw, Alberta. Access. No. 310.

Rose, B.—
3 specimens from the Pierre formation west of 3rd mer., Saskatchewan.
2 specimens from the Foxhill series west of 3rd mer., Saskatchewan. Access. No. 260.

Schofield, S. J.—
(See Burling and Schofield.)

Slipper, S. E.—
(See Dowling and Slipper.)

Sternberg, C. H.—
Some fossils from the Belly River series from Canal creek, Alberta. Access. No. 286.

Sternberg, Geo.—
Some fossils from Edmonton or Belly River formations at Drumheller and Steveville, Alberta. Access. No. 258 A.

Stewart, J. S.—
A collection of fossils from the St. Mary River, Bearpaw, and Benton formations of southern Alberta. Access. No. 292.
Ripple-marks in Edmonton sandstone from North Fork of Oldman river. Access. No. 306.

Twenhofel, W. H.—
Carboniferous material from Kansas, U. S. A. Access. No. 263.

Whittaker, E. J.—
Moulds of ripple-marks on sand from Fairhaven, N. Y.
A large series of bottom samples in different types of sediments from various points in Lake Ontario.
Specimens of coal subjected to wave action. Access. No. 309.
Ordovician fossils from vicinity of Kingston, Ont. Access. No. 299.
"Honeycomb rock" from 150 feet of water 16 miles southeast of Brighton, Lake Ontario. Access. No. 307.
(See Kindle and Whittaker.)

Williams, M. Y.—
Fossils from the Cataract and Lockport formations of Manitoulin island. Access. No. 300.

Williams, M. Y. and Hume, G. S.—
Fossils from the Cataract formation of southwestern Ontario. Access. No. 301.

Wilson, A. E.—
A collection of Collingwood fossils from Ottawa, Ont. Access. No. 266.
Some Silurian and lower Devonian fossils from Catskill, N.Y. Access. No. 305.

Wright, W. J.—
(See Hayes, Wright, and Bell.)

Young, C. H.—
Utica fossils from vicinity of Ottawa and a piece of fossiliferous rock from Percé, Que. Access. No. 277.

Acquired by Presentation.

Adams, F. D. and Dick, W. R.—
A collection of Cambrian and Devonian fossils from Kootenay pass, B.C. Access. No. 285.

Beaulieu, Germain.—
A piece of fossiliferous rock from Lanoraie, Beauce county, Que. Access. No. 273.

Burpee, Lawrence J.—
Two pieces of coral from an elevation of 7,500 feet above Sulphur creek, Jasper park, B.C. Access. No. 252.

Cole, L. H.—
A specimen of Permian red clay with boring mollusks, Charlottetown, P. E. I., Access. No. 312.

Coulthard, G. M., and Ponton, G. M.—
Mesozoic fossils from the Smoky River district, Alberta. Access. No. 283.

Cross, W.—
A specimen of *Ogygites canadensis* from the Utica shale of Ottawa, also some fossils from the Leda clay deposits near Ottawa. Access. No. 262.

DeSchmid, H.—
A small collection of Carboniferous fossils from near Banff, Alberta. Access. No. 304.

Dick, W. R.—
(See Adams and Dick.)

Ells, S. C.—
A collection of Cretaceous fossils from near Ft. McMurray, Alberta. Access. No. 314.

Frechette, H.—
A collection of fossils from Montreal and vicinity and from the neighbourhood of St. Johns, Eastern Townships, Quebec. Access. No. 265.

Grant, Sir James.—
Utica fossils from near Government House, Ottawa, Ont. Access. No. 264.

Lenthal, R. E.—
A collection of fossils from 2 miles east of Gascons, Bonaventure county, Que. Access. No. 275.

MacKenzie, Dan.—
3 pieces of fossiliferous shale from a shale belt at the base of the limestone range flanking Crowsnest valley, Morrissey, B.C. Access. No. 255.

Narraway, J. E.—
A specimen of *Glossograptus? eucharis* Hall from near Cummings Bridge, Ottawa. Access. No. 276.

Phelps, Mrs. Chas. S.—
Two pieces of sandstone ripple-marks from St. Lawrence county, N.Y. Access. No. 269.

Piwonka, Thos.—
A collection of Onondaga fossils from the quarries at Marblehead, Ohio. Access. No. 284.

Ponton, G. M.—
(See Coulthard and Ponton.)

Shimmatsu, Ichikawa.—
One Palæozoic and two Cretaceous fossils from Japan. Access. No. 287.

Sims, F.—
Fossils from the Utica at Ottawa. Access. No. 272.

Sternberg, Geo.—
A collection of Mesozoic and Palæozoic fossils representing a small number of specimens from each of a considerable number of localities from South Dakota, Missouri, Kentucky, Ohio, Illinois, Indiana, North Carolina, Wyoming. Access No. 258B.

Williams, E. R.—
2 pieces of *Arthrophycus harlani* from the Medina sandstone between Thorold and Merritton, Ont. Access. No. 261.

Woods, J. E.—
Fossils from Pincher Creek, Alberta. Access. No. 253.

Acquired Through Exchange.

Hibbard, R. R.—
A collection of Hamilton fossils from sections along Eighteen Mile creek, Erie county, N.Y. Access. No. 279.
A collection of material from Eighteen Mile creek, N.Y. Access. No. 259.
A collection of graptolites from New York state. Access. No. 270.

Acquired by Purchase.

Kindle, E. M.—
A collection of about twenty trays of fossils including Devonian and Silurian fossils from Indiana and Devonian fossils from New York.

PALÆOBOTANY.

(*W. J. Wilson.*)

The year 1915 was occupied chiefly with the routine work of the office. The first part of the year was spent in studying, naming, and putting accession numbers on collections brought in from the field in 1914. These include collections made by C. H. Sternberg and George F. Sternberg from the Belly River formation, Red Deer river, and by D. D. Cairnes from Yukon Territory. Specimens from these collections were later sent to Dr. F. H. Knowlton of Washington, whose report is given below.

From the collections from the Belly River formation, Red Deer river, made by Mr. Sternberg during the past three summers, there have been identified the following plants, which are identical with forms described from the Judith River beds, Montana.

Dammara acicularis Knowlton.
Cunninghamites pulchellus Knowlton.
Populus cretacea Knowlton.
Castalia stantoni Knowlton.
Carpites judithæ Knowlton.

The Canadian specimens were sent to Dr. Knowlton, the author of the Montana species, who kindly named them or confirmed determinations already made. These five species are fairly abundant on Red Deer river, *Cunninghamites pulchellus* and *Castalia stantoni* being particularly so near Steveville.

The specimens brought in from the Belly River formation were picked up as opportunity offered while collecting vertebrate fossils, no systematic search being made for the plants. It is, therefore, probable that more exhaustive collecting and careful study will reveal other species the same as those that occur south of the International Boundary.

The finding of so many identical species in the Belly River and Judith River beds strengthens the conclusion, already arrived at, that they are one and the same formation.

During the summer a number of permanent, steel dustproof storage cases were supplied, and considerable time was spent in arranging in them named and catalogued collections which had been stored away in boxes. Now these specimens are for the first time readily accessible for comparison and study. Several collections remain stored away, which will be placed in the new cases as soon as time will permit.

The small collection of plants made by D. D. Cairnes in 1914 from Sheep creek and Granite creek, Kluane mining district, Yukon Territory, and a few specimens from the Belly River formation collected by Mr. Sternberg, were sent to Dr. Knowlton, who reported as follows:—

"I have at last found opportunity to look over the lots of fossil plants you recently sent me, and beg to inclose herewith the lists of determinations I have been able to make. As you of course know, most of the Alaskan material is very fragmentary, and hence almost impossible to identify satisfactorily.

The two lots from the Yukon Territory are clearly Tertiary and are probably to be regarded as referable to the Kenai formation; at least I see nothing in them that precludes this determination.

The three specimens of dicotyledons from the Belly River formation of the Red Deer River country represent two species. A and b are forms of the somewhat polymorphous *Populus cretacea* Knowlton, while the other is probably another species of Populus, but it is entirely without margin.

The fruits from the Belly River I should place as follows: Figures 1 and 2 are, apparently, a fine undescribed species of Carpites; figures 3 to 6 are referable to *Carpites judithæ* Knowlton; while figures 7 to 10 are probably a new species of Carpites."

List of Identifications.

From Sheep creek:
Salix sp.
Sequoia sp.
Sequoia langsdorfii Brgt. 9 specimens.
Populus balsamoides Heer ?
Fagus sp. ?
Juglans acuminata Heer ?
Taxodium distichum miocenum Heer.
Vitis crenata Heer ?
Corylus macQuarrii ?
Populus sp.
Taxodium sp.
Corylus sp. ?
Populus sp. ?

Populus sp.
Sequoia sp.
Juglans sp. ?
Populus richardsoni Heer ?
Fagus antipofii Abich. ?
Juglans sp.
Osmunda doroschkiana Göpp.
Corylus macQuarrii (Forbes) Heer.
Comptonia sp.

From Granite creek.
Sequoia ?
Corylus ?
Sequoia langsdorfii Brgt. ?
Rhamnus ? sp.
Carpinus sp.

During the present summer D. D. Cairnes sent in a small lot of fossil plants from Mt. Bush, Wheaton district, Yukon Territory, expressing the desire to have them determined at once in order that he could use the information they might afford in fixing the age of the rocks, a map of which he has nearly completed. Of these plants Dr. Knowlton to whom they were sent writes:—

"This lot contains only a few very fragmentary species, yet with a reasonable degree of certainty I am able to recognize the following forms:

Zamites arcticus Göpp.
Ginkgo lepida Heer ?
Dicksonia closipes Heer.
Thyrsopteris murrayana Heer.
Cladophlebis vaccensis Ward.
Pterophyllum nathorsti Schenk.
Ctenophyllum sp. ? nearest *C. angustifolium* Font.
Pagiophyllum sp. ?
Pinus nordenskiöldi Heer.

In my opinion this material is Jurassic in age. While two or three of the species have been found in—or at least reported from—the Kootenay, they have all been found in the upper Jurassic, and a majority are known only from the Jurassic."

Among the palæobotanical collections made during the present year that by Mr. C. H. Sternberg contains one very fine specimen of a palm, which has not yet been studied.

I wish to acknowledge the indebtedness of this branch to Dr. F. H. Knowlton, who has most willingly reported on collections sent to him.

Additions to the Palæobotanical Collections During the Year 1915.

Acquired Through Officers of the Survey.

Bell, W. A.—A very large collection of fossil plants from Cape Breton, N.S. Access. No. 116.

A collection of fossil plants from Pictou county, N.S. Access. No. 121.

Cairnes, D. D.—Specimens of fossil plants from the Tantalus conglomerate from Mt. Bush coal area, Wheaton district, Yukon. Access. No. 111.

Camsell, Chas.—A collection of fossil plants from a series of conglomerates, sandstones, shales, and volcanic rocks classed by McConnell (G.S.C. Vol. VII, p. 35C) as Cretaceous, north end of Takla lake, B.C. Access. No. 114.

Dowling, D. B.—Fossil wood from sec. 35, tp. 8, R. 10, W. 1st mer., Man. Access. No. 120

Dowling, D. B. and Slipper, S. E.—Two fossil plants from the Edmonton formation from the North Saskatchewan river, 28 miles west of Rocky Mountain House, Alberta. Access. No. 122.

Hayes, A. O.—A collection of fossil plants from the neighbourhood of St. John, N.B. Access. No. 123.

MacKenzie, J. D.—Three pieces of fossiliferous rock from the Hazelton-Aldermere area, B.C. Access. No. 113.

McKinnon, A. T.—Dendritic markings from Renfrew county, Ont. Access. No. 124.

McLennan, J. A.—A collection of fossil plants from Bankhead, Anthracite, and Roche Miette, Alberta. Access No. 115.

Slipper, S. E. —(See Dowling, D. B.)

Sternberg, Chas. H.—10 specimens of fossil plants from 2 miles above end of Bad Lands, north side of Red Deer river, Alberta. Access. No. 108.

41 specimens of fossil fruit from 3 miles above lower end of Bad Lands in Dead Lodge canyon, Red Deer river. Access. No. 109.

Fossil leaves, cone, etc., from the Belly River formation from Canal creek, Verdigris coulée, Sand creek, and from near Jenner, Alberta. Access. No. 117.

Sternberg, C. M.—Fossil seeds from the Belly River formation one mile above "Happy Jack Ferry," Red Deer river, 4 miles north of Denhart, Alberta. Access. No. 118.

Sternberg, Geo. F.—15 specimens of fossil plants, from Thompson creek, Ellsworth county, Kansas. Access. No. 105.

A collection of fossil leaves from the Edmonton formation 350 feet above the river, 3 miles north of Johnson ferry, east side of Red Deer river Alberta. Access. No. 119.

18 specimens of fossil plants from eastern edge of Ellsworth county, 6 miles northwest of Brockville, Kansas. Access. No. 106.

2 specimens of fossil Ginkgo from near Sauffer ranch, Red Deer river, Alberta. Access. No. 107.

A specimen of Redwood from Florissant, Cal. Access. No. 110.

Stewart, J. S.—50 specimens of fossil plants from the St. Mary River beds on the Crowsnest river about 1 mile east of Lundbreck, Alberta. Access. No. 125.

Acquired Through Presentation.

Benjamin, John, Ashcroft, B.C. (per C. W. Drysdale).—3 pieces of fossil wood from the glacial section 150 feet east of railway switch (west end) at Senelin Siding, on C.P.R., 5 miles east of Ashcroft, B.C. At a depth of 78 feet and in stratified clay silt. Access. No. 112.

MINERALOGY AND METEORITOLOGY.

(*Robt. A. A. Johnston.*)

Work Performed by Members of the Division.

Since writing the last summary report (1914) over three hundred specimens have been examined and reported upon by memorandum or by personal interview. The lack of suitable equipment for carrying on experimental work and research renders it constantly more difficult to discharge the demands made upon the division.

Mr. Eugene Poitevin has devoted himself with enthusiasm to the work entrusted to him. During such time as he could be spared from routine work he has paid particular attention to the study and classification of the large suite of specimens collected by him in Coleraine and Thetford, Megantic county, Quebec, in 1914. After spending a few days collecting at the mica mines near Pied des Monts and at the ilmenite mines at St. Urbain, Charlevoix county, Mr. Poitevin paid a further visit to the Coleraine and Thetford localities on September 4 and remained in the district until October 8. During this time he made large collections of new material and has added much to our information regarding the mineralogy of this interesting district.

Mr. A. T. McKinnon has faithfully and energetically discharged the duties assigned to him. The uniformly good quality of the educational collections sent out by the department attest to the interest which Mr. McKinnon takes in this phase of the activities of the division.

The clerical work of the division has been well and faithfully performed by Miss F. B. Richardson, and her services are becoming of increasing value in connexion with the recording of mineral occurrences.

"A List of Canadian Mineral Occurrences" was completed and published during the year. It is proposed to publish appendices to this list as circumstances demand.

Throughout the year much time has necessarily been given over to replies regarding occurrences of economic minerals in Canada. Many of these inquiries are directly traceable to conditions brought about by the present European war, while a few are no doubt due to recent industrial applications and progress. Prominent amongst the minerals and ores for which inquiries have been made are the following:

Magnesite and Hydromagnesite.—Carbonate and hydrous carbonate of magnesia respectively. Large quantities of magnesia are consumed in the manufacture of refractory furnace linings, wall boards, cements, medicines, etc.

For many years the demand for magnesia has been mainly met by supplies from the magnesite deposits of Hungary. As a result of the present blockade of German and Austro-Hungarian ports this source of supply is not available. Small quantities of magnesite have also been obtained from certain of the Grecian isles of the Aegean sea. The Grecian deposits seem to be pretty well exhausted and with the warlike conditions obtaining in that region supplies are not readily obtainable from them.

In Canada some small deposits of ferriferous magnesite have for long been known to occur in the townships of Bolton and Sutton, Brome county, Quebec. So far as our present information extends, however, little may be expected from these deposits.

In the township of Grenville, Argenteuil county, are to be found extensive deposits of super-magnesian dolomite. Numerous attempts have been made to utilize this material for commercial purposes. It is reasonable to suppose that the high percentage of magnesia may make this material valuable for some purposes, but the content of lime must interfere with its direct employment for refractory purposes.

In the province of British Columbia magnesite is known to occur in the vicinity of the town of Atlin and somewhat extensive beds of hydromagnesite also occur near the same place. Recently some small shipments of the latter have been made to Vancouver and it is hoped that a greater development in this trade will follow. Hydromagnesite is also known to occur near the Cariboo road in Clinton mining division, but at present transportation facilities are not of a character to make the exploitation of the deposits feasible.

In Yukon magnesite occurs extensively at several points, but lack of transportation facilities precludes commercial exploitation of the deposits.

Tungsten.—This metal is being employed to an increasing extent in the compounding of various steels intended for special purposes.

The principal ores are scheelite, a tungstate of lime, and the minerals of the wolframite-hubnerite group, tungstates of manganese and iron. Scheelite has been found in some abundance in connexion with auriferous quartz deposits in Halifax county, Nova Scotia, and another deposit has been noted in quartz veins in the township of Marlowe, Beauce county, Quebec. A deposit of wolframite near Burnthill brook, on the southwest Miramichi river, has attracted considerable attention of late and it is said that the property is now being developed for commercial purposes.

Molybdenum.—Molybdenum is used to a large extent in the preparation of special kinds of steel, and the employment of molybdenum steel in munitions of war has stimulated the demand for molybdenum ores.

The principal ore of molybdenum is the sulphide—molybdenite. Molybdenite has been found at a great many localities in Canada, but in only a few cases has any development work been carried on. The following are some of the best known localities—Burnthill brook, York county, N.B.; Egan township, Ottawa county, and Kewagama, Timiskaming county, Quebec; Brougham township, Renfrew county, and Harcourt township, Haliburton county, Ontario; Nelson and other mining divisions in the southern part of British Columbia.

Apatite.—Some twenty-five years ago a very considerable trade was carried on in Canadian fluorapatite obtained mostly in Ottawa county, Quebec, and in Leeds and Frontenac counties, Ontario. The discovery of thick beds of phosphate rock in Florida some years ago was followed by an almost complete discontinuance of trade in Canadian apatite even for domestic consumption, on account of the much lower price at which the Florida phosphate rock could be marketed.

It is reported, however, that some special application has recently been discovered for flourapatite and inquiries received during the past few months seem to encourage the hope for a revival in part at least of the former trade in this material.

Diopside.—Normal diopside is a calcium-magnesium pyroxene. Frequently, and it may be said generally, portions of these metals are replaced by iron. It is of common occurrence in the Archæan rocks of Canada.

It appears to be only recently that any commercial application has been found for this mineral. Under suitable treatment it has been found useful for the manufacture of certain kinds of porcelain, particularly where lightness combined with the necessary strength is required.

The market demands a material of very pure quality. Small admixture of other minerals precludes the employment of diopside in the way indicated.

Meteorites.—The Gay Gulch and Skookum meteorites, two siderites found in connexion with gold washing operations in the Klondike district, Yukon Territory, have been described in Museum Bulletin No. 15, published during the year.

On the basis of information coming to the office when these meteorites were obtained it was stated that they had been unearthed in the "White Channel" gravels. However, in a letter written subsequent to the bulletin in question, Mr. J. B. Tyrrell, the well known mining engineer of Toronto, informs the writer that the information is erroneous and that the specimens were found in McConnell's "Low Level" gravels also termed by Tyrrell the gravels of the Third Cycle of Erosion. These gravels are of much later age than the "White Channel" gravels and have in some instances been formed by the wearing away of the latter. They are of post-Tertiary age and hence it must be assumed that the meteorites are of similar age.

The writer wishes to acknowledge his indebtedness to Mr. Tyrrell for the information which enables him to correct the error into which he had fallen.

The following additions have been made to the collection of meteorites:

Sams valley	Jackson valley, Oregon	677 grammes siderite
Kendall valley	Texas	314 " "
Merceditas	Ten leagues north of Chanaral, northern Chile	267 " "
Mighei	South Russia	27 " "
Cowra	New South Wales	37·5 " "
Barrata	New South Wales	460 " "
Bacubirito	State of Sinaloa, Mexico	Cleavage piece showing crystalline structure.

Museum.

The Museum is still lacking the necessary exhibition cases in which to display the large collections of minerals possessed by the Geological Survey. The collections formerly displayed in the old Museum building on Sussex street still remain in the packing cases in which they were moved to the Victoria Memorial Museum building five years ago. To these collections large additions have been made in the intervening period and for lack of proper equipment it has been necessary to place these in storage also. Under these conditions the usefulness of the collections is to a very great extent lost.

The services of a lapidary are very much needed in connexion with the Museum to make proper preparation of large numbers of specimens for study and exhibition purposes.

Additions to the Mineral Collections.

The following additions have been made to the mineral collections since the Summary Report for 1914 was written:—

Donations.

Mr. Ivan A. Bayley, North Sydney, N. S., per O. E. LeRoy.—Manganese ore from Conception bay, Newfoundland.

Julius R. Campbell, Pas, Man.—Gold ore from Herb lake, Man.

Mr. W. R. Dick, Commission of Conservation.—Phosphatic rock from Banff, Alberta.

Mr. J. Galletly, Pas, Man.—Staurolite from Grassy river, Man.

Mr. Charles Keddy, New Ross, N. S.:—Eosphorite from New Ross, Lunenburg county, N.S.

Mr. Wm. Fleet Robertson, Victoria, B.C.—Infusorial earth from Deadman river, Lillooet district, B.C.: native mercury from an island in Sechart channel, Barkley sound, Vancouver island, B.C.: infusorial earth from a point near Spokane, Washington, U. S. A.

Mr. Shimmatsu Ichikawâ, Kitashinjo-mura, Imatate-gun, Fukui-ken, Japan.—Left handed rock crystal, right handed rock crystal, quartz twins, molybdenite crystal, reinite, and ferberite from Mount Kinbuzan, Kai province: rock crystal with tourmaline and chlorite and quartz ball from Takemori, Tamamiaja-mura, Hi gashi yamanshi-gun, Kai province: complex twin of chalcopyrite from Yuseri mine, Nomi-gun, Kaga province: gypsum crystal from Udo mine, Hikana-gun, Iduno province: fluorite crystals and native bismuth from Ikuno mine, Asako-gun, Tajima province: epidote crystals from Buseki-mura, Chiisagata-gun, Shinano province: magnetite crystal from Kamaishi mine, Rikuchu province: hyalite from Shin-yu on Mount Tateyama, Etchu province, Japan.

Mr. Stewart, Victoria, B. C.—Molybdenite from Portland canal, B. C.

Collected by Officers of the Department.

C. W. Drysdale.—Chromite from Eldorado creek, Lillooet district, B.C.

A. T. McKinnon.—Suite of specimens from Lyndoch township, Ontario, embracing columbite, samarskite, beryl, etc.; garnets in schist from Kaladar, Ont.; molybdenite, wolframite, and topaz from the vicinity of Burnthill brook, southwest Miramichi river, York county, N.B.

Exchange.

Dr. Charles Palache, Harvard University museum, Cambridge, Mass., U. S. A.—Thirty-seven specimens from Franklin Furnace, N. J., U. S. A., embracing arsenopyrite, tourmaline, pyrrhotite, willemite, franklinite, zinc spinel, rhodonite, native copper, barite, hodgkinsonite, phlogopite, fluorite, garnet, jeffersonite, magnetite, chalcocite, hematite, zincite, chondrodite, titanite, rhodocrosite, bementite, apatite, baucockite, schefferite, hardystonite, tephroite.

Purchases.

Awaruite from Smith river, California, U. S. A.

Large surface specimen of silver ore from the Hudson Bay mine, Coleman township, Timiskaming district, Ontario.

Betafite from Betafe, Madagascar.

Ampangabeite and euxenite from Antsirabe, Madagascar.

Autunite from Easton, Pa., U. S. A.

Colemanite from Death valley, California, U. S. A.

Ferberite from Cornwall, England.

Metahewettite from Colorado.

Bauxite from Georgia.

Educational Collections.

The system of furnishing collections of minerals to educational institutions in Canada has been continued throughout the year and has continued to meet with general favour.

For several years closed oak cabinets have been provided for the safekeeping of these collections. It has been found, however, that there is a great disadvantage in the employment of closed cabinets inasmuch as it necessarily limits the use of the collections so far as pupils are concerned to class hours. It is felt that the value of the collections from an educational point of view would be greatly increased could they be made available to pupils at other than class hours. This matter is receiving attention with a view to designing an inexpensive glass topped exhibition case suitable for school purposes.

During the year collections have been distributed as follows:—

Province	Standard	Grade 2	Miscellaneous	Mineral chips	Prospector's
Yukon					
British Columbia	4		1	1	
Alberta	1	2	2		1
Saskatchewan		1			
Manitoba	1	1			
Ontario	10	4	2		1
Quebec	9	8		1	1
New Brunswick	2	2		1	
Nova Scotia	1	1			
Prince Edward Island		1			
Foreign	2		5		
Total........66	30	20	10	3	3

As a result of Mr. McKinnon's activities during the year nearly fifteen tons of materials in the rough have been assembled for educational purposes. These are being trimmed into specimens of suitable sizes to suit different requirements.

Special thanks are due to the following gentlemen for assistance in securing materials during the year: Mr. Alexander Parks, Eganville, Ont.; Mr. Donald Henderson, Mr. Donald McKinnon, Madoc, Ont.; Mr. R. H. James, Cobalt, Ont.; Mr. Bush Winning, Ottawa, Ont.; Mr. Samuel Freeze, Doaktown, N. B.; Capt. H. C. Heise, Mr. C. W. Walker, Mr. E. J. Thibault, Notre Dame des Anges, Que.

WATER AND BORINGS DIVISION.

(*Elfric Drew Ingall.*)

During the year ending December 31, 1915, the work of this division was continued along the lines set forth in former reports.

The work of collecting and studying the data obtainable as a result of the numerous deep borings made in the western parts of the northwest provinces was attended to by D. B. Dowling assisted by S. E. Slipper, as part of their geological investigations of those regions. Similarly, in other parts of Canada where members of the field geologists staff are making investigations, the additional geological data rendered available by boring operations are included in their investigations. The division aims to follow a continuous policy of collecting records of borings in all parts of the Dominion in this way as well as by direct communication with the drillers.

Apart from the important boring operations reported upon elsewhere in the Summary Report by Dowling and Slipper, in Alberta and adjacent districts, the borings division was enabled through correspondence and personal application to obtain returns from a number of places in Manitoba, Saskatchewan, and parts of Alberta, as well as in eastern Canada, particulars of which are given on following pages.

A copy of the circular used for making inquiry regarding shallow wells put down in search of water for private and local use, follows:

Department of Mines,
Geological Survey of Canada,
Water and Borings Division,
Ottawa, Ont.

M.. ...., 19....

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SIR:

In its study of the water resources of Canada, which this Survey is making with the view of publishing the results for the benefit of the people, an attempt is being made to obtain important facts relating to wells, whether flowing or not. As it is impracticable, on account of expense, to visit all places, the endeavour is made to extend and complete the information by correspondence. If you will aid in this work by furnishing the data requested in the following list of questions your assistance will be much appreciated. If you cannot supply all the data, kindly answer such of the questions as you can, *a partial report being much better than none.*

Very respectfully,
R. G. McCONNELL, *Deputy Minister.*

Send reply in accompanying envelope, which requires no postage, to....................

....

1. Owner.. Address..
2. Driller.. Address..
3. Situation of well...............Elevation is..........feet............the level of..................
   (Hill, slope, plain, valley.) (Above or below.) (See, railroad station, lake, river.)
4. Type of well..Year completed..................
   (Dug, driven, bored, or drilled.)
5. Depth of well.......................... Does it enter rock?.............. If so, at what depth?.........
6. Depth to principal waterbed.............. Character of waterbed..................................
   (Gravel, sand, clay, rock, etc. If rock, state kind.)
7. Were any other waterbeds or seams found?..............If so, give depth of each..........................
8. Give sizes and lengths of casing.. Length of strainer.................
9. Does water flow at surface without pumping?........... If so, at what height does it now flow?...............

   Has it been tested to see how high it will rise?........If so, to what height?.........What is its pressure?......

   If not flowing, how near surface does it stand when highest?..................When lowest?...............
10. Is well pumped?............If so, by what?..
    (Suction, deep well, or force pump, steam, gasoline, air-lift, or windmill.)
11. Temperature of water at well mouth..............Month taken..............Temperature at bottom...........
12. Natural yield, if flowing........Maximum yield by pumping..........Water is lowered........feet by pumping
    (Gals. per min.) (Gals. per min.) State number.)
13. Has supply decreased or increased?...................................To what due?.....................
14. Quality of water—hard, soft, salty, alkaline, iron, or sulphur bearing...................Cost of well.........
15. Is water used for drinking?........Washing?........Cooking?........Stock?........Irrigation?........

    If for irrigation, give crops..

    Is it sold?........If so, for what purposes?..

    If used for purposes not mentioned, please name..
16. Describe interesting peculiarities of well, if any, on back of this sheet..............................
17. Give *record* of beds passed through, *analysis* of water, names of other *well owners* or *drillers* on back.

....

....
Name of person filling out blank..................................

NOTE.—Please mark location of above described well on the attached township form.

The importance of accumulating as much of this information as possible is evident; but it has been found very difficult to obtain and maintain the interest of the thousands of owners of portable, shallow boring rigs scattered throughout the country. Where sufficient data can be obtained for a given locality, important information as to the geological conditions governing the occurrence of water in the surface deposits and of its fitness for use can be deduced.

With this end in view, wherever knowledge of such operations was obtained through the newspapers, or from other sources, circulars sent out were distributed as follows: Quebec 4, Ontario 83, Manitoba 35, Saskatchewan 55, Alberta 51, British Columbia 14.

As in past years, a considerable proportion of the time of the staff of the division has been occupied in answering inquirers and in supplying operators at various points in Canada, with geological information necessary to the intelligent prosecution of boring operations whether for water, oil, or gas.

In the northwest provinces, as before stated, such assistance was given directly to the operators by the field officers of the department engaged in investigating those parts of the Dominion.

In the eastern part of the country the borings division has, during the year, had a special opportunity of keeping in close touch with the operations in the St. Hyacinthe district of Quebec, and in the district between Ottawa and Montreal.

In the former the geological questions involved in the testing of the district for gas or oil have been continually under consideration by the division, in co-operation with Mr. Edmond Coté, the drilling contractor of the Canadian Natural Gas Company, as well as with the officials of the National Gas Company of Ottawa. The former company in 1915 put down a boring to a depth of over 3,400 feet at a point about 2 miles in an easterly direction from their previous borings in the St. Amable range. Whilst the geological data in the region are very meagre, as far as surface outcroppings of the strata are concerned, it was believed that there was probably an anticline in the vicinity of the latter boring and that conditions here might be considered more favourable to the accumulation of gas than in the neighbourhood of the borings made in former years. The anticipations as to the geological structure were in general confirmed in this boring, as the upper red beds were found to be absent; while in the previous more westerly borings, they proved to be about 1,000 feet thick showing that they were in a syncline along the range of country in which the first holes were situated. Looking to the possibility of the occurrence of another anticline on the other, or westerly, side of this syncline, another boring was started by the Canadian Natural Gas Company, at a point near the village of St. Jude. This hole had attained a depth of nearly 2,500 feet at the end of the year and was still in progress.

From all of these wells full sets of samples have been obtained and the results of the study of these samples have been placed at the disposal of the operators.

Further boring tests in this district and in other parts of the Eastern Townships of Quebec are contemplated; and thanks to the courtesy of Mr. Coté the borings division is promised samples, and the co-operation of the past will be continued in the coming year.

From information given by the operators, natural gas under high pressure has been a constant feature in all borings made in this district, leading to the hope that, by persistent effort on the part of the pioneers, as in other districts on the continent, points may be located where heavy and continuous flows may be encountered.

Owing to the great thickness of the Richmond and Lorraine group of sandy shales, etc., in this district (possibly 2,500 to 3,000 feet) the Collingwood horizon, which is known to be gaseous in the Ottawa section, farther west, has probably never been approached and these deeper strata can only be reached at much greater depths than those so far attained. The successful solution of the problem of testing the deeper horizons will depend on locating points for borings on the crests of anticlinals where the lower portions of the series are brought near the surface and where the expense of piercing so great a thickness of the upper portion can be avoided.

In the eastern Ontario district lying between Ottawa and Montreal, the widespread occurrence of natural gas in shallow wells, and in many of the deeper borings made at various points, has led to the formation of the Russell Natural Gas and Oil Company, for the further exploration of this field. The company has taken over the territory near Bourget on the Canadian Pacific short line, for which leases were secured by Mr. O. A. Lett of Ottawa during 1913 and 1914. A number of short borings having demonstrated the widespread occurrence of natural gas in the drift formations where they overlie the Palæozoic strata, arrangements have been made for further tests by deep boring and the first hole has been started at a point about 2 miles in a southeasterly direction from the village of Bourget.

The Collingwood strata, lying between the dark bituminous Utica shales and the limestones of the upper Trenton, outcrop below the surface deposits of the area and the Collingwood shows indications of gas throughout an extended range of country. The deep borings contemplated by this company will not only further test the Collingwood horizon but also the underlying beds of the Trenton group, the Chazy, and Beekmantown as well as proving the possibilities of the Potsdam sandstone, should the latter prove to be more porous in this district than where pierced by the deep boring at Ottawa.

From the Maritime Provinces a number of logs of bore-holes in the Sydney coal field were received, and notes of borings from the Acadia Coal Company, but the particulars of the operations of the government drills during 1915 are not yet available. The Annual Report of the Department of Public Works and Mines for 1914, issued since the last summary report of the borings division, gives interesting details of their operations. In this publication it is stated that the total distance bored was 3,931 feet, 10 inches; 3,372 feet bored by diamond drills and 559 feet, 10 inches, bored by calyx drills. The expenditure of the Nova Scotia government for boring in 1914 is stated to have been $7,261.26, which includes $1,100 for the purchase of a diamond drill with a capacity of 1,000 feet and producing a core $1\frac{1}{8}$ inch diameter.

Summary of Government Drill Operations in Nova Scotia.

Locality.	Depth. Feet.	Depth. Inches.	Max. progress, feet per hour.	Drill.	Cost per foot.	Material penetrated.
Rear Boisdale, C.B.	301	4	5	Diamond 2 in.	$ 1.00	Mostly limestone, some slate, etc.
Steels Lake........	227	3	....	" "	2.36	Limestone with serpentine and quartzite.
Thibeauville, Richmond....	40	4	3	" "	3.08	Mostly grey shale and top clay.
" "	828	2	$4\frac{1}{6}$	" "	0.95	Mostly sandstone and shale
Avondale, Hants..	107	......	....	Diamond $1\frac{1}{8}$ in.	1.21	Mostly clay and gypsum.
" " ..	90	......	....	" "	1.15	Sand, clay, and gypsum.
" " ..	108	......	....	" "	0.54	Clay, gypsum, and some limestone.
" " ..	24	7	....	" "	1.63	Clay and gypsum.
" " ..	70	......	....	" "	0.59	Gypsum and clay.
" " ..	56	3	....	" "	0.66	Limestone.
" " ..	156	......	....	" "	0.89	Mostly limestone and gypsum, little clay and shale.
" " ..	133	......	....	" "	0.90	Gypsum and limestone.
Wentworth, " ..	140	......	....	" "	0.83	Gypsum.
" " ..	133	......	....	" "	0.86	"
" " ..	74	......	....	" "	1.11	"
" " ..	60	3	....	" "	1.03	"
" " ..	45	......	....	" "	1.56	"
" " ..	30	......	....	" "	3.53	" sand and gravel.
" " ..	111	......	....	" "	1.73	Gypsum.
" " ..	110	......	....	" "	1.08	"
" " ..	101	11	....	" "	1.01	"
" " ..	113	3	....	" "	0.94	"
" " ..	125	4	....	" "	0.78	"
" " ..	110	2	....	" "	0.77	"
" " ..	30	......	....	" "	2.06	"
" " ..	96	......	....	" "	1.82	Sand and stone.
" " ..	60	1	....	" "	2.09	Clay and boulders.
" " ..	43	......	....	" "	2.72	Sand and boulders.
" " ..	40	8	....	" "	1.67	Gypsum (mostly).
" " ..	23	......	....	" "	1.22	Gypsum.
Acadian mine, Pictou	278	10	....	Calyx 6 in.	....	....
Fraser's mine, Pictou	180	......	....	" $1\frac{5}{8}$ "	1.57	Clay, shales, limestone, and some conglomerate.
Nappan, Cumberland..........	101	......	....	" 6 in.	3.92	Sand and clay mostly.

The average cost per foot of boring was $1.51. The greatest cost with diamond drills was $3.53 and the lowest $54\frac{1}{3}$ cents per foot. With the calyx drill the highest and lowest charges per foot were $3.92 and $1.57 respectively.

Particulars are given in the report of thirty-three holes, most of them under 300 feet in depth, one reaching a depth of 828 feet.

The average carbon cost per foot with the diamond drill is given at 5·6 cents and for shot with the calyx drill at 0·89 cents per foot.

From Nova Scotia also a report comes to hand of an important discovery made with the diamond drill in the Acadia Coal Company's mine. The presence of a 21-foot coal seam was revealed, whose existence had for long been surmised by the management. The test was made by boring a hole through the 212 feet of strata separating the workings on the McGregor and Stellar seams. As a result the above-mentioned 21-foot seam was located and another seam 3½ feet thick was found about 15 feet below.

No reports of deep boring operations of any extent were received by the division from New Brunswick or Prince Edward Island. In Quebec, apart from the activities in the St. Hyacinthe district already alluded to, no deep borings were reported. Inquiries were, however, answered regarding geological matters having a bearing on questions of the occurrence of gas and oil at various points in the province.

In the eastern Ontario Palæozoic field the activities of the Russell Natural Gas Company have been already alluded to. Flows of gas obtained from the bottom of the surface deposits in the same vicinity have been reported as a result of further boring of a large number of shallow holes by the Messrs. Beaudette.

Sets of samples from two deep wells in Ottawa city were obtained through the courtesy of the Wallace Bell Company, boring contractors, of 1146 Clarke street, Montreal, Que. Both of these holes were put down for the purpose of obtaining water. One for the Brading Brewery Company on Wellington street, starting in the upper beds of the Trenton, was continued to a depth of 1,000 feet, ending in the lower sandy beds of the Beekmantown just above the Potsdam sandstone. The other well was bored for the Ottawa Dairy Company on Somerset street near Bank street. Starting in the top beds of the Trenton this well attained a depth of 1,200 feet, reaching much the same horizon as the Brading well, although starting some 100 feet higher up in the series.

A number of inquiries were sent in regard to operations in western Ontario and replies were received giving information relating to a number of shallow wells at various points, as well as logs and samples from deep borings in the township of Adelaide, Middlesex county, by the Union Gas Company, of Chatham; from the boring of the Delaware Development Company in the same county. In Wellington county the borings division was in frequent correspondence with the Preston Oil and Gas Company to whom geological information was sent and who supplied a set of samples from their deep boring in Puslinch township. This boring attained a depth of 2,428 feet, passing through the overlying sedimentary strata into the Archæan rocks below.

Thanks are due to Mr. Arthur Embley, drilling contractor of Sault Ste. Marie, Ont., for very full and interesting particulars of a number of shallow wells bored by him for water in that district.

In the northwestern provinces, in reply to circulars sent out, a number of logs were received of shallow wells bored for water. Samples and data regarding deep borings were received from the Liberal Oils Company of Medicine Hat; from the Grand Trunk Pacific Development, at Coutts, Alberta; and from the Alexandra Oils Company, Limited, at Ballantine, Alberta.

Most of the samples and logs illustrating the great activity in boring for the past two years, collected by S. E. Slipper in the course of his studies of the oil and gas fields of Alberta, are still in Calgary. The results will appear in the reports of Mr. Dowling and Mr. Slipper.

In British Columbia the division has continued its relationship with Mr. C. D. McRae, through whose courtesy samples and information have been received during 1915 illustrative of the continuation of the deep borings at Port Haney and Pitt Meadows in the estuarine deposits of the Fraser River valley near Vancouver.

In all the work of the division effective assistance has been rendered by J. A. Robert, and by H. N. McAdam. The latter severed his connexion with the Survey on November 4, 1915. The files of the branch were gone over and put in good order. A large mass of papers pertaining to borings in past years and accumulated by H. M. Ami, formerly an officer of the Geological Survey, were gone over and copies of all data of use to the division made for the files.

The table below gives information received in reply to circular sent out to various operators.

Returns in Answer to Well Schedule H, 1915.

Locality.	Sec.	Tp.	R.	West of meridian	No. of wells.	Depth feet.	Remarks.
Saskatchewan:							
Glen Ewan........	36	1	I	2	1	298	No rock.
Midale........	14	4	XI	2	1	224	"
Osage........	28	12	XII	2	1	70	"
Laura........	19	33	IX	3	Several	34 to 241	Notes, etc.
Biggar........	1	36	XIV	3	1	170	No rock.
Red Pheasant....	33	40	XVII	3	1	22	" also location 22 wells.
Alberta:							
Drowning Ford Ranch........	21	15	V	4	1	668	Gas and water.
Lucky Strike....	9 and 10	3	XII	4	6	7 to 16	No rock.
Govt. well........	27	3	XII	4	1	225	
Burdett........	33	10	XII	4	2	95	
"	2	11	XII	4	3	42	No rock.
"	10	11	XII	4	1	28	"
"	11	11	XII	4	1	36	"
Taber........	7	11	XIV	4	1	140	No water.
Warner........	31	5	XV	4	1	196	Water.
"	6	5	XV	4	1	126	Stops at rock.
Purple Springs....	28	10	XV	4	1	140	Water.
" "	33	10	XV	4	1	120	No rock, water.
" " ..	2	11	XV	4	1	8	Water.
" " ..	12	11	XV	4	1	30	"
Coaldale........	3, 5, 7, 9, 13, 16, 14, 18, 24, 28	10	XIX	4	14	......	
"	8	10	XIX	4	1	290	Water.
Picture Butte....	30, 31, 32, 33, 34, 35	10	XX	4	22	23 to 270	
" "	31, 32, 33, 34	10	XX	4	9		
Albion Ridge....	2	12	XXII	4	1	228	
" "	26, 27, 34, 35	11	XXII	4	5	60 to 180	
" "	24, 25, 26, 27, 33, 34, 35	11	XXII	4	10	20 to 150	
British Columbia:							
Royal Oak........	....	....	....	....	1	75	
Prince Rupert (vicinity Kwinitsa)........	....	....	....	....	1	....	Notes and correspondence.
Ontario:							
Meaford........	....	....	....	....	1	104	Rock at 18 feet, water.
Hespeler........	....	....	....	....	1	100	Rock at 99 feet, water.
Aylmer........	....	....	....	....	1	235	Rock at 234 feet, water.

CANADIAN ARCTIC EXPEDITION 1915.

(*R. M. Anderson.*)

Written at Bernard Harbour, Dolphin and Union Strait, January 22, 1915.

Since my last report to the Government, dated September 12, 1914, at Herschell island, the work of the expedition has proceeded as follows:

After loading the *Alaska* with coal, distillate, gasoline, coal-oil, and some additional provisions, we sailed from Herschell island eastward at 5 a.m., September 13, 1914. The Hudson's Bay Company's ship *Ruby* which was supposed to be due at Herschell island, carrying some additional supplies for the expedition, had not arrived, and we have not yet heard what happened to her. We were also disappointed in not getting the mail which went by way of Barrow. The *Herman*, Capt. C. T. Pederson, was the only ship which came in to Herschell island from the west and she left Barrow before the mail had arrived.

The geological, zoological, and ethnological specimens collected by the expedition last year I had left stored at Herschell island, in care of the Royal Northwest Mounted Police, and as the *Ruby* did not arrive, Inspector Phillips shipped them out on the *Herman*. I trust that they arrived at Ottawa safely. I enclose a list of the zoological specimens which I have collected, up to November, 1914. The specimens collected at this point during the autumn and winter have not been listed yet.

The *Alaska* came back to Baillie island on the night of September 15, in the midst of a northwest gale, with frequent snow squalls, and spray freezing on the decks and rigging. The storm kept rising for the next two days, the worst storm of the season, and did not abate until noon of September 19. There was a very high storm tide, rising about 4 or 5 feet at Baillie island, the waters of Liverpool bay seeming to have been piled up by the northwest gale and forced out between Baillie islands and the mainland. The distillate drums and coal sacks which had been landed on the beach in the summer were half buried by the sand washed up and we had to dig them out.

Considerable quantities of large ice had come in close to Cape Bathurst during the prolonged storm, but as the weather was calm on the morning of September 20, we tried to go out of Cape Bathurst harbour, hoping to get through to Cape Parry at least. We had barely room to turn around in our anchorage and ran the bow slightly around in the mud. We kept trying all day to kedge the schooner off, but with the falling of the westerly wind, the tide fell very rapidly and we were unable to move her an inch. As the high storm tide kept on falling very rapidly, the schooner settled on the ground for most of her length and listed over heavily. The only thing to do was to discharge the cargo on the beach, including 99 sacks of coal, 24 cases of coal-oil, 2 drums of coal-oil, and 5 drums of gasoline. The *Alaska* finally floated free on the evening of September 24.

As we had unloaded all of our cargo, in order to get the schooner afloat, it was evident that short-handed as we were, we should have to spend about three days reloading before we could sail out again. As the nights were very dark at this season of the year with the moon gone, and considerable heavy ice was coming in from the northward with young ice forming thick and slushy at times, it was a precarious matter to sail at night in a small vessel. In the summer time, with daylight all night, a vessel can tie up to the ice, but it is a different matter in the autumn when the ice is moving in the dark. From the outlook here (at Baillie island) it seemed doubtful whether we would get east of Cape Parry, or possibly Pierce point, and there is no harbour beyond that for a long distance. As we did not have very much to bring back to the base camp in Dolphin and Union strait, and nothing that was absolutely necessary, the advantage in getting back there with the *Alaska* did not seem commensurate with the risk involved to the vessel, so I decided to put the boat into winter quarters at Baillie island, or rather in the harbour behind the end of the Cape Bathurst sandspit. The *Alaska* has to go to Herschell island next summer (1915) anyhow for supplies and mail, and has a better chance of getting out early from Baillie island than from farther east. The scientific staff, with all their equipment and supplies, and the schooner *North Star* were already favourably located at their desired base, and I knew that I could join them by sledge as soon as ice travelling was good.

We had enough supplies on the *Alaska* for the men who were to remain with the schooner as "ship-keepers" during the winter. Two fresh whale carcasses on the beach near the ship provided an abundance of dog food and also attracted a number of polar bears to the vicinity. Fifteen polar bears were killed by the men on the *Alaska* before I started east on November 20. The skins and meat were preserved, so that there is plenty of fresh meat at Baillie island for the men there. A few seals and ducks were killed in the autumn and some zoological specimens preserved.

On November 20, 1914, I started to go from the *Alaska* at Cape Bathurst to the winter base in Dolphin and Union strait—an estimated distance of about 400 miles—accompanied by Aarnout Castel (sailing master of the *North Star*), James Sullivan (cook of the *Alaska*), and Ikey Angatitsiak (Point Hope Eskimo). We took one Nome sled and seven dogs and followed the west side of Franklin bay 90 miles to Langton bay, where we arrived November 24. The only inhabitants on the shores of Franklin bay this winter are a small group of Eskimos who took a small schooner belonging to the Hudson's Bay Company from Herschell island to the mouth of Horton river where they are wintering. The schooner was well fitted with provisions and trade goods, and the Eskimo in charge told me that Mr. Phillips, the company's agent at Kittigazuit, Mackenzie delta, had instructed him to let the expedition have what supplies or other accomodation he could furnish in case he should meet any of the parties. We needed nothing, however, but it is possible that one of the western parties in the spring may go that far. The *Argo* in the southwest corner of Darnley bay, and the *Rosie H.* at Booth island (Cape Parry) may possibly be of some assistance to the western survey parties. I made arrangements with Capt. Klengenberg, who is living just south of Cape Lyon, to try and get some seals ahead so that the survey parties can get plenty of dog food, and also to ask the natives there to do the same. As Darnley bay is a good sealing place in the spring there should be no difficulty. We also have some provisions cached at Pierce point, and at several points east of there.

On the way east, instead of going around Cape Parry, we went east from Langton bay across the base of the Parry peninsula to the foot of Darnley bay. There were no people at the *Argo* quarters. Continuing around the south and east sides of Darnley bay, we passed the only two dwellings on the east side of the bay—a family of Alaskan Eskimos who came in with the *Argo* party, and a scow schooner belonging to Capt. Christian Klengenberg, who came to this region two years before, after spending one year at Booth island, and the previous winter in Liverpool bay. I got considerable information about the topography and general conditions of the region on the east side of Darnley bay from Capt. Klengenberg. We were delayed three days by a blizzard on Darnley bay and one day at Klengenberg's and reached the cache made at Pierce point on December 6. We found the cache in good shape and took on some additional stores here, of flour, biscuit, sugar, and coal-oil. We did not know whether we should be able to find driftwood enough for fuel at all points along the coast on the 200 miles left for us to travel between Pierce point and the winter quarters, and had expected to be obliged to use a "Primus" coal-oil stove part of the time. However, we found enough driftwood for fuel at every camp site along the coast, and put up piles of wood at various points so that there will be no danger of having the wood covered by heavy snow when we pass along the coast again in the spring.

We started east from Pierce point on December 8, but did not make very good progress on this day nor the next, on account of rough ice along the coast and the thick, stormy weather. On December 10, behind Keats point, we met a sledge driven by Kenneth G. Chipman and J. J. O'Neill. They had started west from the winter quarters on November 19, to make a topographical and geological reconnaissance along the coast as far as Pierce point, in preparation for the coming spring's work, as well as to look for the whereabouts of the *Alaska*. They had made several small caches of supplies along the coast to the eastward. Their progress had necessarily been slow on account of the short days and they had been stopped six days at Keats point by almost continuous blizzard and wind dead ahead of them. They turned back here and accompanied us eastward. Everything had been going well with the party at the base camp up to the time they had gone away. We found open water pretty close to the shore all along from Cape Lyon to Point Clifton, and at one place, Point Dease Thompson, the ice had recently broken away from the cliffs and we had to make a detour around on the land. We were delayed two days by a blizzard near Wise point, and reached the winter quarters of the main party about noon December 25. Travel had been rather slow, principally on account of the shortness of the days at that time of the year. It was barely light enough to see a trail at 9 a.m. and it was dark about 3 p.m. on clear days; while the daylight was considerably shorter on cloudy and foggy days. The temperature in general was warmer than usual at that season, not going below zero at any time of observation during the first two weeks of December, and on one occasion rising to 25 degrees above zero Fahrenheit. Before leaving Baillie island we had one cold snap, the thermometer reaching 31 degrees below zero on November 7. Coming east from Cape Lyon the prevailing wind was favourable, from the northwest.

We found everything in good shape at Bernard harbour, the winter quarters of the party. The men had built a comfortable frame house covered with sod, and had picked up enough wood in the autumn to use for fuel up to Christmas, which with the coal remaining, is estimated to be enough for heating the house and for cooking purposes during the remainder of the winter. After the arrival of the party from the west, an addition was made to the house for gallery and mess room as well as for extra bunks.

About thirty seals had been killed in the autumn, but only four caribou. The great herds of caribou which usually cross the strait near this point from Victoria island to the mainland, did not pass near here this autumn. The Victoria Island Eskimos, who have been here since, say that the reason the caribou did not cross here this autumn was on account of the lateness of the freezing of Dolphin and Union strait. The caribou came down in large numbers to the south coast of Victoria island north of here, and as the strait was not frozen so that they could cross over, they moved east along the south coast of Victoria island and crossed Coronation gulf some distance to the eastward. The Eskimos on the Victoria Island side north of here got plenty of caribou in the autumn, while those to the westward of them got very few. The Eskimos a little farther east, around Simpson bay, killed large numbers. Many of these Eskimos had large caches of frozen caribou meat, and some of them still have some left. As they live largely on seal in the winter time, and can not cook caribou meat on the ice, they seem quite willing to sell their surplus. D. Jenness, on his various trips to Liston and Sutton islands, and to the Victoria Island side, to visit the Puiblirmiut, Haneragmiut, and Akuliakattagmiut Eskimos, has purchased quite a quantity of caribou meat and a few seals from the Eskimos, and some of them have brought meat over to sell, so we have had no difficulty in getting as much fresh meat as we needed at a very reasonable price.

Mr. Jenness has also succeeded in getting a large collection of ethnological specimens from the natives, clothing, weapons (bows and arrows, spears, and knives of iron and copper), implements of all kinds, stone lamps, pots, etc. A small number of zoological specimens have also been taken. Meteorological observations have been kept up since the vessels landed here.

I shall start from here within a few days to go to Fort Norman with the mail. Mr. Aarnout Castel is going through with me to Fort Norman. Another sled will go along at least as far as the mouth of the Coppermine to make a small cache of supplies for the trip back. The distance from here to Fort Norman is approximately 500 miles, so that we shall probably not get back before the latter part of March. As we were not in a position to start before the sun disappeared, we think that we can travel to better advantage when the days are a little longer, although that is the coldest part of the winter.

The topographical and geological surveying parties, at least the party going west to Cape Parry, will try to get away from here by March 10. Mr. Chipman and Mr. O'Neill, who have already looked over part of this ground, with one of the Eskimos will probably constitute this party. Starting early in March will give them time enough to get west at as early a time as work can be started with any advantage. Work will be started near Cape Parry and continued around Darnley bay, coming east as the spring advances. John R. Cox at the same time will do what he can in mapping the coast from here around Cape Krusenstern to the mouth of Coppermine river and up Richardson river or Rae river, or both, including the large lake called Akuliakattak by the Eskimos. He will attempt to make a topographic traverse of this region, so that Mr. O'Neill can do the geological work on the more interesting spots in detail after his return from the west, either in the early summer or in the autumn. After the ice breaks up, probably in the latter part of July, the *North Star* with the gasoline launch will most probably operate eastward for a time, doing topographic work on the coast and islands, and establishing further bases for the next winter's and spring's work, presumably as far as Bathurst inlet, although the extent of territory covered will depend upon circumstances. If important formations are discovered of course more intensive work will be done at those points. The two topographers will work separately as far as possible, but as the one geologist can not accompany both parties, the survey of several hundred miles of coast, to say nothing of the hinterland at very many points, is necessarily a long job.

As soon as I return from Fort Norman, my intention is to proceed west at once to assist the western survey party, and to haul some auxiliary supplies. Whether I am obliged to go to Herschell island next summer with the *Alaska* will depend upon circumstances. It is rather a difficult matter to arrange for the extensive programme which we have to carry out, short-handed as we are. At this place we have only one white man (Mr. Aarnout Castel, a professional sailor and a very efficient man both on water and on land), two Eskimo boys, and a cook, outside of the scientific staff; while at Baillie island, on the *Alaska* we have only two white men, the sailing master, the engineer, and an Eskimo assistant engineer. The local Eskimos are not able to render any efficient assistance, and furthermore, do not seem to be very reliable or trustworthy. I tried very hard to get some more Eskimo assistants at Herschell island last summer, but was unable to get any suitable men at that time. With the staff on hand we have to carry on the surveys in the field, get the two vessels out next summer, and send one vessel, the *Alaska*, to Herschell island, while the *North Star* explores the coast and islands of Cornation gulf. We also have to provide for a guard or garrison here at the base camp during the spring and summer, while most of the men are away, on account of the natives, who, while very friendly, are inveterate beggars, and more or less thievish. Mr. Johansen or Mr. Jenness will probably stay here in the spring.

The winter began very late here in the harbour; young ice formed on October 14 and the harbour froze over on the night of October 16. On October 17 the anchor of the *North Star* was hauled up and the men walked all over the harbour on the ice. The straits were partly open at that time. On October 22, there was ice eastward about halfway to Liston island, but the sea was open westward. On October 28 there was still open water west of Liston island and travel along the coast was not yet feasible. On November 3, Mr. Cox and Mr. Jenness went west with a sled, but found open water close up to the beach about 5 miles east of Cape Bexley, and as they could proceed no farther they made a small cache of provisions and returned to the winter quarters.

There has been no sickness nor ill health among the members of the expedition during the past summer, autumn, or winter, and all are in good spirits. The sun was visible here for the first time on January 15, although it was seen from the islands several days ago. Yesterday the sun was above the horizon for over two hours and the days are getting appreciably longer.

Messrs. Chipman, Cox, McNeill, and Jenness are sending in partial reports of their work by this mail, so I think it will not be necessary for me to touch upon their work further at this time.

Written at Bernard Harbour, Dolphin and Union Strait, April 20, 1915.

Since my last report, dated at this place, January 22, 1915, the work of the expedition has proceeded as follows:

I spent the latter part of January in completing preparations for a sledge trip to Fort Norman with the winter's mail from the expedition. Mr. Aarnout Castel, sailing master of the *North Star*, was to accompany me all the way through, while Mr. Jenness, Mr. Johansen, and the Eskimo Palaiyak were to go along up the Coppermine river, at least as far as the northern limit of spruce trees, to help us haul auxiliary supplies to establish caches of provisions for our return trip. The distance from here to Fort Norman is something over 500 miles through a rough and uninhabited country, and it is practically impossible to haul enough supplies for the entire trip on one toboggan. We hoped to find some game on the road, but could not depend upon it, while any extensive hunting operations would consume too much time, as it was necessary for me to come back as soon as possible in order to assist in the surveying operations to the westward and if possible to go to Baillie island. D. Jenness volunteered to go along, as he wished to make a reconnaissance in that direction, hoping to get in touch on his return trip with Eskimos who might be encamped near the mouth of the Coppermine river or near Cape Krusenstern; while F. Johansen went along in the hope of making some investigations in regard to forest insects and the flora at or near the limits of trees.

We started out from the winter quarters on February 2 with two toboggans and one sled, loaded altogether with a little over 1,500 pounds, including provisions (man and dog food), two tents and sets of camp gear, rifles and ammunition, and a little trade stuff with which Mr. Jenness hoped to purchase some more sledge dogs from the Eskimos on his way back. Owing to his linguistic abilities and acquaintance with the Eskimo character, Mr. Jenness has been the official purchasing agent for the expedition in practically all business transactions with the local natives, including the purchase of meat, fish, and clothing, as well as ethnological collections.

The country east of here proved to be too rough and stony to portage with our heavy loads, so we went east around Cape Krusenstern and then southwest on Coronation gulf to the mouth of the Coppermine river which we entered on February 9. We saw quite a number of caribou on the ice and on the land around the mouth of the river, and killed three on February 8. This enabled us to add a little to our provisions and to make a good cache here for the use of the support party on their return trip. These caribou, and three more which the Eskimo shot on February 11, just above Bloody fall, and two more on the 13th a little south of the tree-line, enabled Mr. Johansen and Mr. Jenness to pursue their investigations on the river longer than they would have been able to do otherwise, and enabled us to make more caches for our return trip.

On the morning of February 10, a large female white wolf came up among the dogs at our camp just below Bloody fall, and in the mêlée which ensued Mr. Jenness was quite severely bitten on the left forearm. As several muscle fibres were severed and protruded and the wound bled quite profusely, we were obliged to stop over for that day. Although, Mr. Jenness' arm was rather badly crippled for several days, no serious results followed, and he speedily recovered the perfect use of his arm. On account of the extreme roughness of the ice, we left the river bed a few miles above Bloody fall, and followed the upland benches, striking the river again a little above the Muskox rapid, on the east side a little above Burnt creek. We made another small cache of provisions just before going on the river again at this point. We had made our first permanent cache a little below Bloody fall, far enough inside the river to avoid the cache being discovered by the Eskimos, who are all on the coast or on the ice in winter. We were obliged to double-trip in order to get our toboggan load across the small range of steep, hummocky hills which skirt the east bank of the Coppermine river near the Muskox rapid.

We entered upon river travel again on February 16 and found that our troubles were just beginning. Between this place and the mouth of Melville creek, a distance of from 10 to 12 miles, the river ice was exceedingly rough all the way across, 400 or 500 yards wide, so rough that in hardly any place could a toboggan have been taken across the river without stoving the bottom on the sharp, jagged ice ridges. However, one side of the river was apparently neither better nor worse than the other, and the banks were so steep and rugged as to be impassable with sled or toboggan. We were obliged to follow closely along the base of the steep boulder bank of the river on the east side, just inside the rougher ice, which was crowded up against the boulder bank in some places. In a great many places the base of the boulder bank, which we had to follow closely, was a rough mixture of boulders with jagged ice cakes jumbled up amongst them. The snow was very soft, and hip deep or more among the loose boulders and ice-cakes, so that we were unable to make a good trail even with snowshoes. Part of the trail needed packing for perhaps a few yards with tracking snowshoes, then it would be necessary to use the axe to smooth a road through rough ice. The dogs refused to pull very hard as they kept continually losing their footholds and stumbling into holes. Snowshoeing is very difficult in such stuff and without snowshoes a man is continually falling into holes and broad ice-cracks concealed by the soft snow, at considerable risk to joints and limbs. Whenever the sledge stopped it was always necessary to jerk it out of the hole and start it forward by man power alone before the dogs could even be induced to move forward. After working ahead about half a mile, we were obliged to drop half our load, and bring it ahead by a second trip. By a hard day's work we advanced our toboggan and load about 2 miles up the river on February 17, getting a little past the mouth of Burnt creek.

Next day the boulder banks were rougher and we had to work out into the ice in places, making two trips with half loads the same as the day before, advancing about 4 miles. For some distance we passed along the side of perfectly smooth planed ice walls, at the base of the upper and outermost ice terrace line which was from 12 to 15 feet above the second ice terrace line. The river apparently had had at least two large ice jams and subsequent fall of water after the freeze-up. The uppermost heaped-up ice cakes were at least 30 feet above the lowest level of ice in the middle of the river. We had to chop and grade up a road through the rough ice during most of the day. The ice in many places was as rough as any sea-ice pressure-ridges I have seen anywhere. The next day we found the ice somewhat smoother and crossed to the west side of the river a little below the mouth of Melville creek. We made two trips, advancing about 5 miles to a small creek about 3 miles above the mouth of Melville creek.

Travel on this stretch of the Coppermine river was many times more difficult than I have found it before. The ice apparently does not jam at the same place every season, and probably the height to which it becomes piled depends upon the stage of water at the time of the freeze-up. Another factor which made an enormous difference was the deep snow, which had not drifted very much. Apparently there had been no heavy winds in that region this winter. Later, a strong gale drifted the snow and packed it very hard, smoothing over many spots which were rough and difficult before, so that on our return trip we slipped over hard snowdrifts packed several feet deep in places over our old trail. In one day going down the river at this point we passed three of our up-river camping sites. On this trip up the river in February, we were obliged to work hard for four days to cover the ground over which two of us had taken two toboggans in about half a day's travel while hauling specimens to Dease river in April, 1911.

Going around the big bend of the Coppermine river, we found the ice not nearly so rough and the banks lower, so that travelling was better along the side of the river. We reached the mouth of Tepee creek on February 22, and spent one day building a substantial log cache which we hoped to make wolverine-proof, to store a small amount of provisions for our return. The whole country from Coronation gulf to Great Bear lake is so infested with wolverines in the winter that unless a mass of large loose rocks is available, hours must be spent in constructing a cache which is reasonably secure for even a single night. Another female wolf (yellow), which came up among the dogs at our camp, was killed at the mouth of Tepee creek.

A wolverine ultimately got in before our return, through a weak log on this cache, but the only thing which he was able to drag out was the skin and skull of a wolf which we had killed. Leaving here, we had to make three trips to get to the top of the bench land, to make the portage across to Dismal lake. We reached the west end of Dismal lake on February 27, having killed two caribou out of a herd of nine, on the lake the same day. Large herds of caribou were seen on the east bank of the Coppermine opposite the mouth of Kendall river. Two Arctic hares killed on the Coppermine comprise all the other game killed up to March 1. It is interesting to note that in the winter of 1910-11 we saw no "coloured" foxes around the east end of Great Bear lake, Dease river, Coppermine river, or Coronation gulf, and Messrs. Hodgson, Melville, and Hornby, who were wintering on Dease river, got no skins from the Indians, who said the "coloured" foxes were rarely if ever taken on Dease river or Coppermine river. In February and March we saw several cross foxes, two or three red foxes, and one black or very dark silver grey, along the lower Coppermine, and cross foxes at the mouth of the Coppermine and on Dismal lake and Dease river, while we saw only one white fox on the whole trip. Arctic hare tracks were numerous everywhere, but none of the smaller varying hares ("bush rabbits").

The only birds seen were ravens, rock ptarmigan, willow ptarmigan, snowy owl, Canada jays, and redpolls.

On March 1, we crossed the divide between the west end of Dismal lake and the Dease river, and camped near the head of Sandy creek. The next day we camped near the junction of the northern and middle branches of the Dease river, about half a mile from "Hanbury's Kopje," and on March 3 started down the Dease river, finding the snow deep on the river, but level, and an improvement over the rolling tundra which we had just crossed. Large herds of caribou were seen both days on the open country, but none after we entered the woods on the river, although numerous tracks were seen on the river. There were no signs of human beings having been in the region during the present winter. The river was exceedingly crooked in this part of its course, so that we had to travel probably 5 miles to make 1 mile in a straight line. To cut across the bends was impossible as we could barely keep moving through the lighter snow on the river ice. On March 4 we passed through a narrow rock gorge where the river breaks through a rugged chain of hills. The snow kept getting deeper and softer as the spruce timber became denser and the toboggan sank deeply into it. On March 5 the dogs balked utterly in the afternoon, and no variety of persuasion could make them budge a step farther, not even up to the bank, so that we were obliged to unload in midstream and pack our camp gear about 75 yards over to the bank where there was wood for camping. The next day the dogs refused to pull at all when hitched up and after dragging the toboggan a short distance by hand with considerable effort, we finally had to unload and pitch camp again in the same place. The dogs appeared to be in good condition, not very thin, having received the same ration as they had been accustomed to, and had had several days' rests en route and extra feeds when we had killed deer, so their refusal to work was rather unexpected. They seemed dead, hopelessly inert, apparently utterly helpless and discouraged in the deep snow. The team was composed of seven large, strong Arctic coast dogs, and was considered one of the best teams on the coast, but the heavy-boned dogs seem to make harder work in soft snow than do the lighter breeds of Indian dogs.

We stayed at this camp for two days, made a log cache for our goods, cut off about 3 feet from the end of our toboggan, a rather heavy Hudson Bay freight toboggan, and repaired fractured and cracked boards in its bottom. On March 9 we started out again, having cached everything but the barest essentials and four days' provisions, hoping to reach the mouth of Dease river, the site of old Fort Confidence. We hoped that we might find some Indians at the mouth of the river from whom we could obtain provisions and go on to Fort Norman, or else get some of the Indians to carry the mail on to Fort Norman for us. We had double snowshoed a trail ahead for some distance through the deep snow, but after advancing for about three-quarters of a mile in about three hours' time, with many exasperating halts, the dogs went on a passive strike again. I thought of going ahead alone to Fort Confidence, packing a blanket and axe, but that would probably have taken three or four days more, and if there had been no people there, we should have been out of food, and 250 miles from either Fort Norman or our quarters on the coast. With an Eskimo or Indian companion who was used to and willing to try to live on the country, it would doubtless have been possible to stop and hunt long enough to dry meat for the long trip down Great Bear lake, and reach Fort Norman by spring, but it would have been impossible to get back to the coast again before spring. It accordingly seemed best to turn back, and at least get up into better caribou ground before our provisions were entirely exhausted, as in the heavy timber farther down the river the chances of getting game are rather small. Going back the dogs did not pull much better, in fact would not pull at all unless one man was pulling ahead of them in harness, and the other man pulling alongside of the sled. As we were travelling lighter going back, we managed in most cases to make the same time as going down, and in some cases better time, but it was a steady pull in harness with the dogs every day for both of us until we came nearly to Cape Krusenstern and met Mr. Cox and Mr. Jenness surveying, on March 30. We found that wolverines had broken into two of our strongest caches en route and stolen some provisions, but not enough to inconvenience us. We killed two caribou near the northern limit of trees on March 23 and could have killed more later, farther down the river, if we had needed meat.

Mr. Cox and Mr. Jenness had been out on a surveying trip for several days and Mr. Cox had surveyed the coast from the winter base around to Cape Krusenstern and Point Lockyer in Coronation gulf. As Mr. Jenness was only acting as temporary aid to Mr. Cox until Mr. Castel should return, and as they were getting short of provisions, they returned with us, and we reached the expedition quarters on the evening of April 1, having been fifty-nine days on the trail.

Affairs at the base camp had progressed about as planned. Mr. Jenness and Mr. Johansen had returned there on the first of March as agreed. They had found Eskimos and purchased a few new dogs, together with some ethnological specimens. A large number of Eskimos from Coronation gulf, Coppermine river, as well as from the settlements in Dolphin and Union strait, had visited the station, and brought in nineteen seals.

K. G. Chipman and J. J. O'Neill, with the Eskimo, Ikey Bolt, for an assistant, had started westward on March 17 to begin their survey work in the Darnley Bay region.

Mr. D. Jenness, ethnologist, had succeeded in perfecting his plan for spending a summer with the Prince Albert Sound Eskimos, by making an arrangement with an Eskimo family from the Dolphin and Union Strait group, who had hunted in Victoria island before, to accompany them in their migration north in the spring as soon as the caribou should begin to go across the strait. They intend to cross the Wollaston peninsula by sled to the foot of Prince Albert sound, and thence to proceed up to a large lake in the central part of Victoria island, where these Eskimos fish and hunt caribou in summer. Mr. Jenness expects to live with these Eskimos all the coming summer, to return to the south side of Victoria island following the caribou in the autumn, and to cross over here again as soon as the ice is strong enough in the strait. He has made a provision cache on the south side of Victoria island to fall back upon in the autumn while waiting for the freeze-up. He hopes to gather much new and interesting ethnological data during his stay there. Mr. Jenness made his final start for Victoria island on April 13, with his Eskimo companion, a middle-aged man named Ikpukkuaq. The said Ikpukkuaq was supplied with a Winchester 44 rifle and some cartridges, and was promised that if he did well by Mr. Jenness during the summer he was to keep the rifle on his return and receive a certain number of cartridges. Quite a number of these people have received guns during the last four or five years, either from the schooner *Teddy Bear* or from the Great Bear Lake traders and Indians.

As the schooner *North Star* was found to be leaking, it was found necessary to have Mr. Castel remain here to look after her instead of accompanying Mr. Cox on his survey work around the western end of Coronation gulf. Mr. Cox started out again April 16, taking James Sullivan as cook and general assistant. Mr. Cox hopes to complete his survey down around Backs inlet, and up the Rea river, probably making a traverse across from the head of Rae river to the home camp just before the spring break-up.

I expect to start west tomorrow, with the Eskimo Palaiyak, to join the western survey party (Chipman and O'Neill), to bring them some auxiliary supplies, and probably assist them in their spring work. Palaiyak will go on to Baillie island with the mail and help on the *Alaska* to Herschell island. I may have to send the other Eskimo with him also or go through myself. It will hardly be possible to go all the way to Baillie island and return here again, and there are so many things demanding attention here, where the main work of the party is being carried on, that I do not see how I can afford the time to go to Herschell island in the *Alaska*. The *Alaska* has merely to get more coal and provisions, if any come in, and get the summer mail, and I think that Mr. Sweeney can attend to that. My team of dogs was pretty well played out when I returned here April 1, but as the weather has been mild and they have been well fed, they have picked up remarkably well and are in good shape for another long trip westward.

The only men remaining here at the base camp will be Mr. Johansen and Mr. Castel, until Mr. Cox returns in the spring, or the party returns from the west, probably not until the first of June. At present there are no Eskimos here, but until a few days ago they have been more or less of a nuisance all the time, crowding into the house under every pretext, and having to be put out very frequently, as their continual begging and meddling with things becomes tiresome and interferes with work a good deal. Some of them are thievish also, and a few small articles were stolen during the winter. The morning Mr. Cox left, a native from the eastward came in and told us that two Coppermine River Eskimos, whom he named, had taken all the provisions which Mr. Cox had cached near Point Lockyer, south of Cape Krusenstern, for use in his next month's survey work—about 75 pounds of pemmican and rice—and had gone east with it. Whether Mr. Cox meets with them later and succeeds in getting it back or restitution for the same, is very doubtful. It becomes a serious matter when the thievish natives rob depots of provisions, as one can then never be sure of more provisions on a trip than he can carry on his own sled at the time.

Written at Bernard Harbour, Dolphin and Union Strait, July 29, 1915.

Since my last report the work of the southern party of the Canadian Arctic expedition has proceeded as follows:

After making an unsuccessful attempt to get down to Fort Norman on the Mackenzie river, with the winter mail, via Great Bear lake, on account of very rough ice on the Coppermine river and heavy snows on the Dease river, I returned to the winter quarters of the party, with Mr. A. Castel, on April 1, 1915, having been fifty-one days on this trip. The mail was later sent out to Herschell island by the *Alaska* from Baillie island.

John R. Cox, topographer, and D. Jenness, ethnologist, were met by us March 30 on the northwest end of Coronation gulf. Mr Cox had surveyed the coast in detail from the winter base west of Chantry island, eastward along the south side of the strait to Cape Krusenstern, and as far south as Point Lockyer. On meeting us they cached what provisions they had left together with the little we had left, and returned with us to the station for more supplies, and to relieve Mr. Jenness, who was acting only as temporary aide to Mr. Cox until another assistant could be secured. The cache of provisions left at this point, about 75 pounds of pemmican and rice, was entirely carried off by a party of thievish Eskimos en route to the Coppermine river, before Mr. Cox came back about two weeks later. Information was given by other Eskimos shortly after the theft was committed, so that Mr. Cox was not depending on the cache for provisions. The Eskimos here make themselves very much of a nuisance to the expedition, except from an ethnological standpoint, as a few of them are around the station most of the time, and they have a propensity for pilfering anything they can slip up their sleeves, under their coats, or down their boots, as well as more bulky articles that they can pack away when unobserved. This is not such a serious matter as the robbing of caches, as we can usually watch things around the station.

It seems that the only apparent security of caches for travelling parties, is in a number of small caches, well concealed, in the hope that the natives may not run across all of them. The natives have never shown a hostile or unfriendly attitude in any way, even when one or two men are alone with a large party. They do not seem to be ashamed or embarrassed when accused and convicted of stealing, except perhaps of maladroitness in being detected.

Ethnologically, D. Jenness has been able to accomplish a great deal of work among the hitherto little known groups of Eskimos in this region, including numbers of Akuliakattagmiut, Haneragmiut, Uallirmiut, Puiblirmiut, Pallirmiut, and Kogluktogmiut. He finds that these groups are not as definite as was formerly supposed, in fact the groups are pretty thoroughly mixed, both by intermarriages and by families shifting from one group to another, nearly every group containing individuals from other groups more or less remote. He has made good progress in linguistic work and vocabularies, made fifty or more gramophone records of various Eskimo songs and spoken words which he has had repeatedly reproduced before the natives so that he could get the text letter-perfect and translated for comparison with other Eskimo dialects. A considerable number of photographs of Eskimo people with their life and customs, have also been made by Mr. Jenness and other members of the party. Mr. Jenness' facility in learning the Eskimo dialects and the customs of the people has been of great service to the expedition in many ways. He made many trips in the winter, to the islands in the strait and to Victoria island, and in addition to his ethnographical work, usually obtained and brought home to the station on each trip, a quantity of fish, caribou, or seal meat as well as engaging with natives to bring more meat over. While at the station Mr. Jenness acted practically all the time as interpreter and purchasing agent of the party in trading with the natives for fresh and dried meat, fish, skins, and clothing. In doing this work he collected a large number of specimens of Eskimo tools, weapons, and other implements, clothing of all kinds, stone lamps, and pots, a collection which is very complete for this region, and a large series of duplicates of many things.

In the early spring, arrangements were made for Mr. Jenness to spend the summer with the Eskimos in the heart of Victoria island. He had a good quantity of provisions hauled across Dolphin and Union strait in early April and cached on the south side of Victoria island for his use if necessary in the autumn. He engaged a middle-aged Eskimo named Ikpukkuaq (who had been in that part of Victoria island before) together with his family, to accompany him and help him during the summer, Mr. Jenness supplying the man with a rifle and ammunition, which together with a tent and other things are to be given him if he serves Mr. Jenness faithfully and returns with him in the autumn. Mr. Jenness started on April 13, 1915, for Victoria island, with this family of Eskimos, and a few others who were thinking more or less seriously of joining the party. They started about the time the barren ground caribou began to migrate across to Victoria island in numbers, planning to follow the caribou migration north across the Wollaston peninsula, then go up to the head of Prince Albert sound, and ascend a large river to a large lake called Tahieryuak, in the interior or west central part of Victoria island. When the snow disappeared they intended to cache their sleds, either at the head of Prince Albert sound or at the lake, and continue their journeys during the summer with pack dogs. That region is the summer hunting and fishing ground of a large number of the Kanghirmiut (Eskimo of Prince Albert sound) and Mr. Jenness hopes to gather much new and valuable ethnographical material concerning this hitherto little known group of Eskimos. Mr. Jenness expects to live with these Eskimos all the coming summer, and return to the south side of Victoria island in the autumn, following the caribou to the southward again, and returning to the station at Bernard harbour as soon as the ice is strong enough to cross Dolphin and Union strait in the autumn.

Kenneth G. Chipman, chief topographer of the party, and J. J. O'Neill, geologist, started on the western survey from Bernard harbour, on March 17, 1915, taking one sled and the Eskimo, Ikey Angatitsiak, as camp assistant. It had been decided that Mr. Chipman should work with Mr. O'Neill in covering this region in the spring because they had already made a preliminary reconnaissance by sled from the station as far west as Keats point in November and December, 1914, and were familiar with the general features of the problems to be encountered in that region. They went west as far as the southwest portion of Darnley bay, in order to connect with the previous surveys on the Cape Parry peninsula. The survey was carried eastward from this point during the month of April with favourable weather conditions, the season being apparently much further advanced than it was farther east at the same season. As there are no rock exposures near the coast on the south side of Darnley bay, Mr. O'Neill was able to remain on the east side of the bay for some time to conduct geological investigations there. One of the larger unnamed rivers flowing into the east side of Darnley bay was ascended for some distance inland. Considerable assistance was obtained here through the friendly aid of Captain C. Klengenberg, an ex-whaler and trapper, and from a family of Alaskan Eskimos who are temporarily located on the east side of Darnley bay, about 150 miles east of the usual range of the western Eskimos. Captain Klengenberg's young son, Patsy, accompanied the party to the eastward to assist as interpreter and hunter during the coming year. This was a very advantageous arrangement as we had no native assistants and consequently no reliable interpreter at the station, the two Eskimos who were attached to the southern party being obliged to go on to Baillie island to help with the *Alaska* during the summer.

The rock exposures along the coast are pretty continuous from the south of Cape Lyon around to the east of DeWitt Clinton point, and Mr. O'Neill was able to follow them up and make a practically continuous section, including one or two important contacts of the diabase with the prevailing dolomitic and conglomerate rocks of that section of the coast. A good series of geological specimens was collected by Mr. O'Neill at all points touched, including certain fossils from the superficial formations around Darnley bay. Mr. O'Neill forwarded a brief report of his work in the spring.

I started west from Bernard harbour with the Eskimo Palaiyak, one sled, and seven dogs, on April 21, and met Messrs. Chipman and O'Neill coming east, with Ikey Angatitsiak and Patsy Klengenberg, near Dease Thompson point, on Amundsen gulf. The Eskimos Ikey and Palaiyak were sent on to Baillie island with the mail and to help on the *Alaska*, while I returned to the eastward with the survey party.

Mr. Chipman reports as follows: The coast has a regular and well defined shore-line of rock, or boulders and gravel. None of the rivers coming to the coast east of Darnley bay seem to extend any great distance inland, for their valleys are small and both valleys and beds indicate a heavy run-off in a short time. The Croker is the largest river. Its delta is built out a short distance from the coast, and is 4 miles wide and extends inland for 3 or 4 miles. The river spreads out over this delta and none of its channels are very definite. The beds of Croker river and the other rivers are composed of heavy boulders, and the quick run-off is further evidenced by the continuous sandbars built across their mouths when the water is low in summer and autumn. At the head of Darnley bay two fairly large rivers come to the coast.

The survey of this entire stretch of coast-line was completed eastward nearly to the base station to connect with the surveys made by Mr. Cox. The coast-line as traversed from Cape Lyon eastward is seen to be somewhat straighter than the former charts give it, but this was apparently due to the practical impossibility of sketching a coast-line from a boat in a hurried passage some distance off shore. This method has given the result that many of the so-called points on this coast are not salient projections, but more often high land or rock cliffs with low land on either side giving the higher places the appearance of points or capes when viewed from a distance. Our method of locating control points at frequent intervals by latitude, longitude, and azimuth observations, and traversing between these points by frequent compass sights and pacing most of the shore-line, will undoubtedly give a more accurate map, although the former maps of this portion of the coast are really very good considering the conditions under which they were made.

Messrs. Chipman, O'Neill, and myself reached the station at Bernard harbour on May 24, one week ahead of our scheduled time. We had decided upon the date June 1 as the time when the spring sledge-survey parties should be back at the station, to avoid being troubled by the breaking out of the rivers. The unusually mild weather during the month of May facilitated our work very much. The skies were usually clear and conditions good for travelling and taking observations. The weather was very warm and the snow thawing fast around Croker river May 16, but east of that point the season was more backward, and at the station the ground was completely snow-covered until after the first of June.

John R. Cox, with James Sullivan as camp assistant, started from Bernard harbour on April 16, to take up the survey where he had left off at Point Lockyer, Coronation gulf. He continued the survey around Basil Hall bay, Cape Hearne, Cape Kendall, up into Backs inlet, and up Rae river by sled. He ascended and surveyed Rae river for about 70 miles, until it forked into two small creeks. Mr. Cox found rather large willows at rather frequent intervals on Rae river after getting some way from the coast, but no spruce nor other timber. After reaching the head of Rae river, Mr. Cox made a six-day portage across country with his sled, striking the Arctic coast on the south side of Stapylton bay. He then surveyed a section of the coast from Young point (the western end of Stapylton bay) east to the home station, reaching Bernard harbour on May 25. He found that South bay (southwest of Cape Bexley) was somewhat deeper than he expected, and Stapylton bay not so deep as the existing charts make it appear. The maps of these surveys are, of course, not yet computed and plotted.

Mr. Fritz Johansen, marine biologist, botanist, and entomologist, has carried on extensive work throughout the year. He has collected and preserved considerable marine and freshwater biological material from the harbour and from the neighbouring lakes, ponds, and streams. A practically complete collection of the local flora in large series has been preserved and the large collections made at Collinson point, Alaska, and Herschell island, Yukon Territory, arranged. A considerable number of interesting entomological specimens have been obtained here, and he has also succeeded in raising larvæ collected the previous season at Collinson point, and working out some hitherto unknown points in the life history of various forms of Arctic insects. Some work was also done on forest insects at the northern limit of trees (spruce) during a short trip up the Coppermine river in February.

In the line of mammals and birds I have collected about five hundred specimens, besides a number of sets of eggs with nests, and have made a number of notes on the vertebrate fauna. A considerable number of the nests of Arctic birds have been photographed *in situ*. The present station, where we are perforce confined during the most interesting and fruitful part of the year for field collecting, *i.e.*, the early part of the summer, on account of being unable to move either by sled or by boat, is a very unfavourable place for land animal and bird life, as the land for many miles back from the coast is very stony, rocky, and barren, affording little sustenance for most of the species. I hope to obtain more specimens in the latter part of the summer, while with the boat survey along the southern portion of Coronation gulf. I have obtained a number of photographs of birds and animals in life, and Mr. George Wilkins, who has been with us since the latter part of May, has also made for me a series of photographic studies of the living forms that have been available around the station.

On June 9, 1915, John R. Cox, topographer, and J. J. O'Neill, geologist, started from Bernard harbour eastward, with a large skin boat or umiak (a large whaling umiak from the Point Barrow whaling station) on a low boat sled. The umiak is over 28 feet long and about 6 feet beam. They also took another sled load of provisions and supplies. They had as assistant an intelligent Alaskan Eskimo, Billy Natkusiak, who had been in the region with me several years before, and a family of Coppermine Eskimos (a man named Mupfi, with a wife and child). Billy Natkusiak was to help Messrs. Cox and O'Neill with the survey through the summer, and Mupfi was engaged to hunt, fish, and look after their dogs after the ice had broken up and they had to leave the sleds. The party was to proceed by sled if possible to Tree river, or the Unialik, or one of the other small rivers on the south side of Coronation gulf east of the Coppermine river; during the early summer to work geologically up some of these rivers and creeks as far as Mr. O'Neill should think desirable; and to work gradually eastward along the coast as far as Cape Barrow (at the western extremity of Bathurst inlet). Mr. Chipman and I were to come in on the *North Star*, bringing in the gasoline launch with additional supplies and gasoline, planning to meet them around Cape Barrow about the first of August if possible. The *North Star* would put in caches of provisions and gasoline at designated points for the return along the coast and for possible work later in the autumn or the coming spring, and would then be free to go westward again.

At Cape Barrow, the circumstances of the season and the condition in which we found the party and the boats, would determine the extent of the survey which we could make of Bathurst inlet during the latter part of the summer. It was planned to finish up as much as possible of the eastern end of our assigned territory during the present summer, leaving the region nearer home (near the mouth of the Coppermine river) for the early autumn or coming spring, where the unfinished ends can be worked to better advantage from the base station.

I consider that Messrs. Cox and O'Neill had a very practicable outfit for spring and summer coast work as well as for going inland for some distance. The Umiak is a large sea-going boat capable of carrying about 2 tons in reasonably smooth water; is light draft (about 18 inches when heavily loaded), and is light enough for two men to drag out of the water on any beach, and can be hauled anywhere over fairly smooth ice by four or five dogs. On a former expedition we took a similar boat from Point Barrow, Alaska, to Herschell island, Yukon Territory, one summer, hauling it on a sled part of the way, and when the ice broke loaded our goods, dogs, and two sleds into the boat and sailed, paddled, and tracked along the coast, including a trip through 50 or 60 miles of the Colville River delta.

For the Coronation Gulf survey party we strengthened the stern part of the canoe frame, and adjusted an Evinrude detachable gasoline motor, which should prove a valuable auxiliary. We found the Evinrude very valuable last year—one used by Mr. Chipman on various boats in the Mackenzie delta, and one on a heavy ship's dinghy on the *Alaska* last autumn. The Evinrude burns little gasoline and the party hauled enough on their sleds for their estimated use up to the first of August. The umiak is a very good sailing boat, and will about keep up with a whaleboat in a fair wind, although the flat bottom makes it unsuitable for, beating against a wind. It was equipped with a mast and sail in addition to paddles and motor. The greatest advantage of the umiak in coast work, however, is the fact that it can be safely and easily beached almost anywhere, as it is of light draft, and the elastic frame and tough covering of Bearded Seal skin are not at all easily stove in by ice or rocks, while if navigation is stopped by a strip of ice, the boat can easily be put on the low boat sled, pushed or hauled over the ice, and launched quickly on the other side.

For inland work up the streams or elsewhere, recourse must be had to packing in the summer, as the streams are too small to be navigable. The party was supplied with condensed rations, and had dog pack-saddles for their largest and strongest dogs and an experienced packer. Three or four dogs can pack all the necessaries for a small party for several days.

On May 21, 1915, George H. Wilkins arrived at Bernard harbour with a sled, accompanied by James R. Crawford, engineer of the northern party's schooner *Mary Sachs*, and one Eskimo. They had come from the winter quarters of the *Mary Sachs* near Cape Kellett, Banks island, making the trip in about twenty-five days, across the southern end of Banks island, Prince of Wales strait, Prince Albert sound, and Dolphin and Union strait. Mr. Wilkins had found the Stefansson party on Banks island last summer, and Mr. Stefansson had sent Mr. Wilkins down to see if arrangements could be made to send the *North Star* to Banks island or Prince Patrick island as an auxiliary or advance party for the proposed further northern work which Mr. Stefansson has projected for the northern party. Mr. Stefansson is announced to have extended the plans for the northern party for one or more years longer than was expected and that he was keeping the *Mary Sachs* in reserve, while he wished to send the *North Star* still farther north, so that he could take longer chances if he had another ship to fall back upon in case the *North Star* also were to be lost.

It was, of course, impossible to send the *North Star* away at once without practically rendering ineffective the work of the southern party for the present season, at least in the geological and topographical sections, as the *North Star* is the only vessel here, the *Alaska* being at Baillie island, and bound to go to Herschell island before coming in here again. The plans for the southern party's summer work had been based on the certainty of having the *North Star* for the summer work in Coronation gulf. With no large vessel the boat parties could not be properly outfitted with provision depots; caches could not be made for future work and the gasoline launch could not be brought to any place where it could be used to any advantage this year. However, it was arranged that the *North Star* should take the launch east and lay down some provision caches as far east as Cape Barrow, and that Mr. Wilkins should then go west to Herschell island with the *North Star*, and later to Banks island.

Mr. Wilkins brought a cinematograph outfit with him from the northern party's base on Banks island, and exposed about 2,000 feet of cinematograph film, principally views of the local Eskimos. He also obtained a small collection of Eskimo clothing, weapons, and instruments to send out for advertising purposes. Mr. Wilkins has made a very good series of portrait studies of most of the local Eskimos, men, women, and children, in full view and in profile, for Mr. Jenness' ethnographical work. He has also made good photographs of growing plants, flowers, insects, etc., for the botanist and entomologist, and many photographs of birds, mammals, etc., which are of great scientific as well as artistic value.

The present summer seems to be very cold and late. The ice melted very slowly. Bernard harbour was free of ice July 20, but outside Dolphin and Union strait was full of ice. Broad leads opened up outside for a little, but the ice seemed pretty solid to the eastward. A steady, strong northwest wind, for a week, practically a gale for three or four days, kept driving the ice down into and blocking up the strait until the present date. Now to the northward, between here and the Liston and Sutton islands, the strait is packed full of rough, heaped-up blocks of ice, where we had only smooth bay ice all winter.

The *North Star* is loaded for her trip east, which should not take more than a week if Coronation gulf is free of ice, and is also provisioned with enough for the three men who will go west, in case the vessel is caught between here and Herschell island. The gasoline launch has been overhauled and put in good shape this spring, and the new 7 horse-power Gray motor installed. It should be of good service in the eastern work if we can get her in there pretty soon. Some dredging and trawling has been done for Mr. Johansen with the launch in the harbour and also a little outside.

I am sending four cases of bird and mammal skins out to Herschell island by the *North Star*, all that are in condition for packing and shipment. I am leaving Mr. Jenness' large ethnological collection until he comes back from Victoria island, as he may perhaps want to assort the material and label it more fully.

Cape Barrow, Coronation Gulf, West Side of Bathurst Inlet, August 12, 1915.

After being held for nearly two weeks by heavy ice packed into Dolphin and Union strait by continued westerly winds, a spell of easterly wind started the ice moving westward again, and we worked the *North Star* out through ice east of Chantry island August 9, then to the north side of Lambert island and around Cape Krusenstern August 10. We passed through the Duke of York archipelago in the night, found very little ice after passing Cape Krusenstern, and found Coronation gulf entirely free of ice to the east. We reached Epworth point (Tree river), in the forenoon of August 11, and found a beacon and cache with a note signed by J. J. O'Neill and John R. Cox stating that they had been working in that region until July 30, when the ice moved off the coast allowing them to proceed eastward. They had gone east to Cape Barrow, where we found their beacon stating that they had reached this point August 2. We put down a cache of provisions (100 lbs. flour, 50 lbs. rice, 50 lbs. pemmican, 24 lbs. sugar, 6 cases gasoline) at Epworth point, and another cache here for our present work and the possibility of sledge work next spring. We shall carry on the survey at present with gasoline launch and skin boat.

The *North Star* is to start back for Herschell island at once with Geo. H. Wilkins, A. Castel, Jas. P. Crawford, and Billy Natkusiak. The party remaining for work here consists of four men: K. G. Chipman, J. R. Cox, J. J. O'Neill, and myself. Whether we get back to Bernard harbour this autumn, depends upon circumstances, principally upon the date of the freeze-up. We have two sleds cached at Epworth point.

It is very regrettable that we have not the *North Star* to stay and carry out our plans as originally made, now that we have a good staff in this field. We had planned to have the *North Star* for the whole season, but under the circumstances we were placed last spring, I thought we might do as much in the long run by an arrangement with Mr. Wilkins and Mr. Crawford to put the *North Star* engines in good running trim. This arrangement allowed me to put Mr. Cox and Mr. O'Neill in the field east of the Coppermine river at once. Otherwise Mr. Cox would have been obliged to stay at the station to work on the engines of the *North Star* and the launch, perhaps for some time, and Mr. O'Neill would have been obliged to work nearer home (*i.e.* on Rae river or mouth of Coppermine) early in the season. It seemed that what we would gain in the field work in the early season would compensate for a little less extended work (*i.e.* on the *North Star*) later in the season. The extremely late date at which we were able to get the *North Star* out of the harbour, makes our eastward season very short, unless we have a late autumn. We shall, however, accomplish considerable work, unless weather conditions are extremely unfavourable, and if necessary, can do some finishing work here next spring by sledge.

Geological Reports, Canadian Arctic Expedition 1915.

(*J. J. O'Neill.*)

Reconnaissance on Herschell Island, Yukon Territory.

Herschell island is situated in the Beaufort sea, in latitude 69° 3′ 35″ north, and longitude 139° 05′ 55″ west, about halfway between the International Boundary line, at Demarcation point, and Shingle point, the western edge of the Mackenzie River delta.

The island is about 9 miles east and west, by 5 miles north and south at its broadest. There are three prominent sandspits. The southwest sandspit extends nearly to the mainland and is separated from it by a gap of less than half a mile in width, which is passable only for whale boats and shallow draught schooners. From Flanders point, at the south end of the island, a spit extends towards the mainland for about half a mile. The third sandspit is at the east end of the island, and comes out in a hook towards the southwest, forming Pauline cove, which is a good winter harbour for whalers.

Around the whole of the island, either rising from the sandspits or directly from the water, there are cliffs of muddy sand, or sandy mud, with sometimes considerable black loamy mud. There is a little gravel in places, an occasional boulder, and at least one log has been observed protruding from the mud. Indistinct stratification may be seen in places. The cliffs range up to 40 and 50 feet in height, and from the tops of them the island slopes upward to a maximum height of about 500 feet.

The top of the island is rolling and is traversed by broad valleys in the middle of which small gorges are sometimes developed. Many small lakes and ponds occur, without outlet.

Slumps take place during the summer thaw, in the valleys and along the cliffs, and small areas of solid blue ice are frequently uncovered. These melt to form cliffs which gradually recede into the uncovered portion. These areas of ice are deeply covered with a mantle of alluvium, and are apparently part of the original formation now exposed for the first time. They occur at different horizons above the sea, some being about 300 feet up. The fresh exposures sometimes have a heterogeneous structure, resembling cross-bedding formed in a snowdrift by winds from varying directions. In most cases the ice is homogeneous throughout, and in several cases the melting ice was seen to have a hexagonal needle crystal structure similar to that forming in rivers or freshwater lakes. The ice cliffs vary in size, none seen being over 200 feet in length and 15 feet in height, although in no case was the bottom seen. The ice is perfectly clear, fresh to the taste, and no layers of dirt were seen in it. The cross-section always appears to be lens-shaped.

The whole island appears to be composed of sandy mud with more or less gravel mixed with it. Boulders are concentrated in the gulleys in the valleys, and are occasionally met with on the hilltops. They are of various igneous and sedimentary rocks, well waterworn, and range in size up to over 3 feet in diameter.

Fossils were collected from the lower 200 feet of the island; they were concentrated in many places near the bottom of slopes by the washing down of mud. They are not uniformly distributed through the formation, but occur in scattered localities. Above 200 feet none were found, but the upper slopes are much more concealed by tundra than the lower. The fossils closely resemble those collected on the mainland in the similar formation at Kay point, 22 miles to the southeast of Herschell island, and are mostly pelecypoda. The formation on the Firth river, about 20 miles southwest of the island, is better stratified and more sandy, and the fossils obtained there were mostly gastropoda.

Reconnaissance Through the Mackenzie River Delta.

A reconnaissance through the Mackenzie River delta was undertaken in conjunction with the party making a geographical survey of the delta, during the summer of 1914.

In April a sled trip was made to Black mountain, on the west side of the delta, with the intention of making a section southwest into the mountains. It was found that the snow was too soft at the time to permit of doing this, so an examination of the face of the mountain, together with a collection of fossils from its beds, had to suffice.

Travelling on the river during the month of May is practically impossible. The west branch of the river broke on May 28, and was apparently clear of ice within 12 hours. The middle branch broke on June 2, part of the ice coming through the Aklavic and down the west branch.

As only one month's time was available and the work had to be carried out by whale-boat, the scope of the survey was limited.

The head of the Mackenzie delta is at Point Separation, about 15 miles below Arctic Red river, where the river begins to spread out into a great fan-shaped labyrinth of channels which at the Arctic coast has a width of over 90 miles.

On the west side of the delta, near its head, the foot-hills of the Rocky mountains rise abruptly from the alluvial plain. Farther north the mountains recede and the delta is bordered by rolling hills of sand and gravel, which are covered with tundra.

On the east side, rolling hills of sand and gravel border the delta from Kittigazuit south to near the entrance to the Eskimo Lake region. Exposures of rock appear on the hill-sides about this place, forming cliffs. From here south to Point Separation the highland is not visible from the east branch of the river, but a cliff of stratified rocks extends from near this point up past Arctic Red river.

The islands of the delta are composed of interstratified sand, gravel, or mud, with in places interbedded turf. Those on the west side of the delta are predominantly of mud. The central islands are mostly of sand, while those on the east side are commonly of gravel with some boulders.

Timber-line is about latitude 68° 38′ 55″; that is about the mouth of the Ministikuk river on the west side, and at Turnrait on the east branch of the river. Birch is common in the upper part of the delta, the largest seen being about 6 inches in diameter and 30 feet in height. It becomes scarcer and smaller as the limit of trees is approached. Poplar and alder are smaller in size, but have the same range as the birch. Willows are found down to the coast. Within a few miles of the coast they are 8 to 10 feet in height, but the coast willows are usually not more than 2 feet high. Spruce is by far the most abundant and important of the timber trees in the delta. It is universal and not unfrequently attains a diameter of 9 inches. The spruce around timber-line is about 25 feet in height and 5 inches in diameter.

The plane of the tops of the islands is about 4 feet above the average high water. After the break-up this summer the water dropped 12 feet in a few days at Iglukitaktok, which is on the west branch about 100 miles below Fort Macpherson. The outer islands of the delta rise above this plane. Richard island rises to 90 or 100 feet above high water, and Garry, Pelly, and Pullen islands present an irregular profile and hummocky appearance, but they are not so high as Richard. The three latter islands were not observed at close range.

Richard island is composed of coarse sand interstratified with mud. The top of the island is rolling and covered with tundra. Patches of gravel occur on the surface, concentrated, partly at least, by wind erosion. The high land rises in the form of cliffs from sand beaches. Coarse sand with a little gravel makes up the lower 20 feet and this is succeeded by muddy sand with some pebbles, not apparently stratified. No boulders were seen either in the formation or on the beach.

The small island just south of Richard was apparently joined to it at one time. A sandspit leads out from each towards the other. The small island is about 75 feet in height, with cliffs facing southwest and northwest, and with gentle slopes to the southeast and south. Most of the cliff is of sand containing patches of mud at intervals. The lower layers show distinct cross-bedding, others are evenly bedded, and no stratification at all is apparent in places. A gravelly layer appears near the top, and the whole is covered with tundra. A few boulders were seen on the beach.

Near the south end of the western side gradual slopes of gravel and sand rise to over 300 feet above the river and lead up to the rock cliffs of the foothills. Farther north are drumlin-shaped hills of sand and gravel, running approximately northwest and southeast, and occupying the country between the delta and the foothills.

The east face of Black mountain is made up of interbedded sandstones and shales which dip towards the west at about 12 degrees. Some of the sandstones are weathered to a brownish-red colour, and one stratum contains concretionary nodules which weather out almost spherical, the largest seen being about 14 inches in diameter. The formation is over 800 feet in thickness and some layers contain abundant fossils.

On the eastern side of the delta a cut bank of gravel at Nennariak, on the mainland opposite the south end of Richard island, rises 10 feet above the beach. The lower beds are of sand and gravel and exhibit well developed cross-bedding. They contain chunks of wood and coal in all stages of alteration from the former to the latter. The largest piece seen sticking out of the bank was 30 inches by 12 inches in cross-section. It appears to be the remains of driftwood which had been laid down with the gravels. A jaw of a rodent was dug out of this layer within 2 feet of a piece of coal.

The upper 2 feet is made up of interbedded sand and turf. The lower strip of turf, 3 inches in thickness, contains numerous bones of birds and fishes, and one piece of carved bone was also obtained from the same horizon.

South from Nennariak the country is about of the same height as Richard island and the hills have the shape of drumlins with long axes running northwest to southeast approximately. There is little difference in the altitudes of these hills, but there is a gradual rise towards the south where they emerge into a more or less rolling plateau. The highest elevation is near latitude 68° 43′ 15″, and a section taken at this point is as follows, descending from a level 530 feet above the river:

Section Taken at 68° 43′ 15″ on the East Side of the Mackenzie Delta, Descending from 530 Feet Elevation, through Apparently Horizontal Beds:

530 feet. Very fine-grained sand and mud, with boulders ranging in size from 16 inches diameter down to pebbles. The boulders are mostly of granite and quartzite, with some limestone, and slabs of sandstone and conglomerate. Boulders usually well rounded, although some are more or less facetted. No stratification.

450 feet. Partly consolidated sandstone and sandy shale, distinctly stratified. No fossils found. Limonite stain in some layers and along seams. Cross-bedded. Followed by fine-grained sandy mud, then a thin layer of shale, then more mud or silt, which contains angular pieces of a reddish sandstone or arkose. There is much iron oxide in some layers and in places the sand is cemented by it.
380 feet. A coarse quartz sand with some gravel, but no boulders. This sand is very light in colour and has distinct cross-bedding.
350 feet. Fine silty mud with some boulders. Resembles the formation at the top of the section. Passes into—
130 feet. Silt with more small pebbles than in the overlying formation.
70 feet. Similar silt with but few pebbles. Extends down to beach.

From the top of the hill two small lakes (about 800 feet by 400 feet) are seen in pockets between hills. They are without outlet, except at high water, and resemble glacial kettle-lakes.

South of this section the hills become lower again. The formations above the stratified sand-base thin out; the red layer disappears, and the chalky-white layer forms the capping. Finally the hills are tundra covered, with gentle slopes, and closely resemble those immediately to the south of Nennariak.

About 40 miles south of the above section, around the entrance to the Eskimo lakes, occurs the first rock in place on the east branch of the river. A cliff examined showed 75 feet of coarse sandstone, at the base, weathering red, which becoming finer grained passed abruptly, but apparently conformably, into very thin-bedded muddy sandstone or sandy shales 75 feet in thickness and with the top not exposed. The sandstone is composed of quartz grains together with a thick peppering of black oxide of iron. The strike of the beds is 230 degrees (true) with a dip of 11 degrees to the east.

South of this place the river winds out through mud-flats, and there are no more rocks seen until Point Separation is reached.

On the eastern mainland about Point Separation a number of tree stumps are exposed in a cut-bank, with their bases at a common horizon 6 feet below the top of the bank. These stumps are all upright, mostly over 18 inches in diameter, and the wood breaks off in circular slabs about one-quarter of an inch thick. It would appear to be an old level of the delta, representing a time when the trees attained a much greater girth than at present, and when different trees were represented. The present tree-growth on top of the bank includes birch, spruce, and poplar, none of them over 9 inches in diameter. There is still 3 to 4 feet of trunk attached to some of the roots. The tops are ragged and splintered as if the trees had been broken while still alive.

Preliminary Reconnaissance along the Arctic Coast between Chantry Island, in Dolphin and Union Strait, and Keats Point.

Part of the month of September, 1914, was spent working on the mainland near Chantry island. From November 18 to December 25 a sled trip was made as far west as Keats point, and the rocks along the coast hastily examined.

In 1848 Sir John Richardson made a boat voyage along this coast and gives a synopsis of the geology in his "Journal of a boat voyage in search of Sir John Franklin."

One feature common to the whole coast is the series of terraces which occur more or less well developed at intervals. These are fairly well preserved just west of Chantry island, and range up to over 45 feet above high water. Six distinct benches occur at one place in the lower 30 feet, and fossils were collected from the 15-foot and 30-foot horizons. These fossils may be duplicated on the present strand-line, and are given below.

The country rock, at least as far west as Point Clifton, is a light grey to buff coloured dolomite, sometimes with interbedded grey chert, and frequently containing fragments and nodules of the same. Ripple-marking and what seems to be mud-cracks were seen in some layers. A concretionary structure is quite common. It closely resembles that seen in the Kona dolomite near Marquette, Michigan, but the arches are only 1 to 2 inches across. The beds vary in thickness from a fraction of an inch to a few feet, and in grain from very fine to quite coarse and crystalline. They have a dip of about 10 degrees, a few degrees north of west.

About 15 miles east of Point De Witt Clinton, there is a cliff of conglomerate 40 feet in height with an 8-foot capping of sandstone. The conglomerate is made up almost entirely of pebbles of quartzite and chert, and has a few small seams of buff coloured sandstone interbedded with it. The overlying sandstone is coarse-grained and weathers reddish-brown.

About Point De Witt Clinton there are cliffs of very dark grey limestone 40 to 50 feet in height, with beds 3 to 4 feet thick and with a few thin beds of light grey limestone. At one place fine-grained diabase cuts through the limestone and spreads out as a capping to the cliff.

The hills about here are covered with a mantle of alluvium, resembling glacial morainic material, which weathers to a buff colour on the surface. It is at least 30 feet in thickness.

About Point Dease Thompson there are cliffs of limestone 30 feet in height, dark coloured at the base and lighter grey above, thin-bedded, and with encrustations of gypsum along seams and in fissures.

Keats point is made up of coarse, reddish coloured sandy dolomite.

The only fossils found were in two small blocks of dolomite found on the beach line near Chantry island. They are two species of brachiopoda, closely resembling some Trenton forms.

There are two distinct sets of glacial striæ in the vicinity of Chantry island, one set running east and west (true), and the younger set running north 77 degrees east (true).

FOSSILS DETERMINED BY FRITZ JOHANSEN, FROM THE TERRACES (GRAVEL AND SAND) ABOUT CHANTRY ISLAND.

15-foot Horizon.

Astarte (Tridonta) borealis.
Very prolific and many sizes.
Saxicava rugosa (Common.)
Cardium groenlandicum (Three specimens.)
Mya truncata (Common.)
Buccinum sp ? (Fragment.)
Cardium edule ? (Fragment.)

30-foot Horizon.

Mya truncata, *Saxicava rugosa*, *Astarte borealis* } Common and of various sizes.
Tellina calcaria (Two specimens.)
Tellina sp. ? (One large specimen.)
Mytilus edulis (Fragments.)
Patella sp. ? (One specimen.)
Balanus sp. ? (Fragment.)
Cardium edule ? (Fragment.)
Cardium groenlandicum (Fragment.)
Buccinum sp. ? (Fragment.)

Written at Cape Barrow, Coronation Gulf, August 5, 1915.

In reporting progress of the work on the copper-bearing rocks I may say that I have examined the rocks from the foot of Darnley bay to Cape Krusenstern, and have found no evidence of the existence of copper in that direction. A series of sediments is intruded by sills, or sheets of diabase at intervals from 20 miles south of Cape Lyons to Point De Witt Clinton; no diabase is then seen until one nears Cape Kendall in Coronation gulf.

The islands in Coronation gulf, on a line southeast from Cape Krusenstern to Point Epworth, are all of diabase; no amygdaloid was seen, but some of the islands are cut by narrow veins of calcite which contain occasional small patches of chalcocite.

The coast from Point Epworth to Grays bay is diabase cutting grey shale or red sandstone, which immediately underlies the shale; no amygdaloid nor copper is in evidence in this diabase of which the upper part has been removed by erosion.

The Laurentian granite, comes to within 3 miles of the coast at the Kogluktualuk or Tree river, and its western contact with younger sediments extends almost true south for over 30 miles. The northern border of this granite parallels the coast to the west end of Grays bay; it forms the southern shore of Grays bay and the whole coast from that place to the east side of Cape Barrow, where we are at present (August 5) encamped.

In addition to short trips inland made from the side of Darnley bay to locate the southern border of the coast series, and another up the Kogluktualuk river to follow the contact of the granite, I have notes on the geology up the Rae river for a distance of 75 miles, slightly north of west, and then 75 miles across country to the west side of Stapylton bay, furnished by J. R. Cox who made a topographical survey of that route.

At present we are waiting for the *North Star* to arrive with provisions and a launch to continue the survey into Bathurst inlet.

J. R. Cox and I came from Bernard harbour to Kogluktualuk river by sled, in June, bringing a large skinoomiak and an Evinrude motor. We left the river on July 30, as soon as practicable, and reached here August 2. This combination of boat and motor works well; the motor driving a loaded boat at about 5 knots per hour.

I hope to complete the survey of Bathurst inlet this autumn and then spend the remainder of the time working from Kogluktualuk to Rae river.

TOPOGRAPHICAL DIVISION.

(*W. H. Boyd.*)

The division has temporarily lost the services of A. G. Haultain who was granted leave of absence for overseas military service with the engineers.

Field Work.

Topographical field work was carried on during the season in the following areas: Mayo map-area, Yukon Territory; Revelstoke sheet, British Columbia; Pekisko map-area, British Columbia and Alberta; Sheep River map-area, Alberta; Athabaska lake, Alberta and Saskatchewan; Sudbury map-area, Ontario; east coast of James bay, Quebec.

Triangulation for the control of topographical mapping was carried on in the Crowsnest and Pekisko map-areas, British Columbia and Alberta, and also in the Sudbury district, Ontario.

MAYO MAP-AREA, YUKON TERRITORY.

A. G. Haultain in Charge.

This map-area covers approximately 1,000 square miles and embraces the country lying between the head of Haggart creek, on the north; the town of Mayo on the Stewart river, on the south; the west end of Mayo lake, on the east; and the junction of the north and south branches of the McQuesten river, on the west. The map will be published on a scale of $\frac{1}{250000}$ with a contour interval of 200 feet.

R. Bartlett was attached to the party as topographical assistant.

REVELSTOKE SHEET, BRITISH COLUMBIA.

F. S. Falconer in Charge.

The mapping of this sheet, which was started last year, was completed this season.

R. G. Scott, J. W. Spence, and A. Barrette were attached to the party as assistants.

PEKISKO MAP-AREA, BRITISH COLUMBIA AND ALBERTA.

D. A. Nichols in Charge.

This map-area, which is one of the proposed series of maps covering the Rocky Mountain coal fields, is the third one to the north of the International Boundary. The other two are the Flathead sheet (the southern boundary of which is the International Boundary), and the Crowsnest sheet. It is the intention to publish all the maps covering the Rocky Mountain coal fields on the scale of $\frac{1}{250000}$ with a contour interval of 200 feet.

The Pekisko map-area lies between latitudes 50° and 50° 30′, and longitudes 114° 08′ and 115° 08′ approximately.

J. A. Macdonald, J. B. Wilkinson, J. A. Circé, and H. M. Roscoe were attached to the party as assistants.

SHEEP RIVER MAP-AREA, ALBERTA.

C. H. Freeman in Charge.

The mapping of this area, which was started last year, was completed this season.

E. Leslie, J. R. Ross, and O. J. Gagnier were attached to the party as assistants.

ATHABASKA LAKE, ALBERTA AND SASKATCHEWAN.

B. R. MacKay in Charge.

The survey of this lake, which was started last year, was completed this season.

C. L. Larson was attached to the party as assistant.

SUDBURY MAP-AREA, ONTARIO.

E. E. Freeland in Charge.

This map-area is one of a proposed series covering the nickel region. These maps when completed will be published on the scale of $\frac{1}{62500}$ with a contour interval of 20 feet.

D. H. Calhoun, A. C. Evans, S. E. Prowse, J. H. T. Morrison, A. D. Crowe, J. N. Flood, and W. B. Musgrave were attached to the party as assistants.

EAST COAST OF JAMES BAY, QUEBEC.

W. E. Lawson in Charge.

This work consisted of a plane-table and micrometer alidade traverse controlled by latitude and azimuth observations. The object of the traverse is to form a base control for future exploratory work in that region. The traverse was started at Rupert House and was carried along the coast as far north as Fort George. The lateness of the season compelled the party to return after they had carried the work a few miles beyond Fort George. The coast between Rupert House and Fort George is very irregular; the actual coast line traversed being about 600 miles.

H. M. Peck was attached to the party as assistant.

TRIANGULATION.

S. C. McLean in Charge.

Rocky Mountain Coal Fields, British Columbia and Alberta. This triangulation, which is for the purpose of controlling the proposed series of topographical maps covering the Rocky Mountain coal fields, is a chain of secondary triangulation extending northerly from the International Boundary. It is proposed to carry the net as far north as the Grand Trunk Pacific railway in the vicinity of Jasper park. This season's work consisted in the extension of the net through the Crowsnest sheet and the Pekisko map-area.

Sudbury District, Ontario. This triangulation is for the purpose of controlling the proposed series of maps covering the nickel range.

R. C. McDonald was attached to the party as assistant triangulator and W. G. Archibald as assistant.

The results of the various triangulations carried on by Mr. McLean in the last few years will be published separately.

ZYMOETZ RIVER RECONNAISSANCE, BRITISH COLUMBIA.

The writer spent a few weeks with Mr. J. D. Mackenzie's party, who were working in Telkwa and Bulkley River districts. A reconnaissance was made of the country adjacent to the coal area on the headwaters of the Zymoetz river.

CANADIAN ARCTIC EXPEDITION

Messrs. Chipman and Cox, who are still in the north, have succeeded in doing much valuable geographical work. Mr. Chipman, who is in charge of the geographical work of the southern party, has sent out the following report from Bernard harbour, N.W.T., dated July 15, 1915.

"My last report was sent from Fort MacPherson in July, 1914. At that time we had completed most of the work we were able to do in the mapping of the Mackenzie delta, and were waiting for the freight and mail expected by the Mackenzie River steamer, and which we were to take to Herschell island. The steamer came on July 15 and left on the following day. We left for Herschell island on the 18th but delays incident to freighting, weather, and ice on the coast kept our boats as well as the others from the delta from reaching Herschell until the morning of August 6. The *Alaska* had reached there from the west a few hours previously.

The *Alaska* left Herschell on August 17 and reached this small harbour in Dolphin and Union strait on August 24. For several reasons it was essential that she make a return trip to Baillie island or possibly Herschell. She left here on September 6, reached Herschell without difficulty, but when on her way east again was forced to go into winter quarters at Baillie island. Mr. Anderson left her there on November 20, with a dog team and three men, and arrived here on Christmas day.

The non-return of the *Alaska* left here five members of the scientific staff and one Eskimo. We were short handed and the autumn months were necessarily spent in building our house and shed, securing meat for ourselves and twenty-one dogs, and in getting everything ready for the winter. In 1913, at Collinson point, the freeze up came on September 12. Here in 1914 our harbour did not freeze over until October 15, the strait partly froze over early in November, but it was not until the middle of November that travel along the coast was practicable. At this time the days are so short, with poor light, and storms are so frequent, that work at any distance from the base is not feasible.

This harbour is some 7 miles east of Cockburn point and southwest of the Liston and Sutton islands. The outer harbour is formed by Chantry and another smaller unnamed island extending nearly across the mouth of a shallow bay, from which extend several small bights. Vessels of light draught find good shelter in these bights and vessels of nearly any draught would find good shelter in the outer harbour. The one we are using is completely sheltered, has a very narrow entrance, with 12 feet of water in the entrance. This harbour is the first one east of Pierce point, except for partial shelter at Keats point. It was first used by Captain Joseph Bernard, with the trading schooner *Teddy Bear*, who wintered here in 1912-13; so we have, subject to later approval, given it his name.

Our astronomical position was determined on arrival here. This position (approximately, longitude 114° 46′ west, latitude 68° 47′ north) is being more accurately determined as opportunity offers and will be checked back to Herschell island and the boundary when we are on our way out. During the winter a series of observations for latitude were taken and a series of observations for local mean time were used for chronometer ratings. The Mackenzie Delta mapping was computed and plotted.

With Mr. O'Neill I left on March 17 for work to the westward. The month of April was spent in the vicinity of Darnley bay, and May in traversing the coast from Pierce point eastward. On May 21 we met Mr. Cox who had worked east and south from our winter quarters along the coast to the Rae river, up that to its source, then across country to Stapylton bay, and was working west to meet us.

After our arrival here, sled travel on the ice was still good, so on June 9 O'Neill and Cox went east planning to go over the ice from Cape Krusenstern to the mouth of Tree river. From there they will work inland and east along the coast to Cape Barrow where they will wait for the *North Star*. As soon as the *North Star* can leave here she will take the launch, fuel, and provisions to Cape Barrow, and I shall then join O'Neill and Cox in as much work and as far into Bathurst inlet as is possible, returning here before the freeze-up.

The Alaskan coast where we spent the winter of 1913-14 is a difficult one to map in that a great deal of the coast line is low and indefinite with small islands off shore. When this low coast is covered with snow and ice, it is difficult, and at any distance almost impossible, to distinguish the actual shore-line. Many of the rivers there have extensive deltas with low flats and islands. This coast, however, has a regular and well defined shore-line of rock, or boulders and gravel. None of the rivers coming to the coast east of Darnley bay seem to extend any great distance inland, for their valleys are small and both valleys and beds indicate a heavy run-off in a short time. The Croker is the largest river. Its delta is built out a short distance from the coast, and is 4 miles wide and extends inland for 3 or 4 miles. The river spreads out over this delta and none of its channels are very definite. The beds of Croker river and the other rivers are composed of heavy boulders, and the quick run-off is further evidenced by the continuous sand-bars built across their mouths when the water is low in summer and autumn. At the head of Darnley bay two fairly large rivers come to the coast.

Considering the time at which it was done and the methods, the existing map of the coast to the west of here is a tribute to the men who did the work. The control is good; and when one is travelling in the same direction and some distance off-shore, as were those who did the mapping, the chart seems to be accurate; but when one is following the shore-line carefully the detail can be greatly improved. In our traversing we have everywhere followed the shore-line carefully and have determined latitude, longitude, and azimuth at frequent control points."

BIOLOGICAL DIVISION.

BOTANY.

(*John Macoun.*)

During the past year I have been engaged chiefly in the collection and study of cryptogams, fungi forming the principal part of the collection, although mosses, lichens, seaweeds, and hepaticæ have not been neglected. The climate in the vicinity of Sidney, B.C., permits of collecting being done all through the winter, in fact many things can be collected to better advantage then than in the summer. Since my return from the field I have been rearranging my general collections in all lines, work in which I have been greatly helped by the microscope sent me by the department. My collection of flowering plants now numbers 826 species, duplicates of which have been sent to the department. The specimens now in my possession will, I hope, ultimately go to the Provincial Museum at Victoria or to the Experimental Farm at Sidney. Of lichens I have 195 species named and catalogued, and more than a thousand species of mosses, seaweeds, and fungi, most of which have been named; but these still await final arrangement. In addition to my work in the vicinity of Victoria and Sidney I spent seven weeks at Comox, my son, J. M. Macoun, being with me part of the time. While there I collected flowering plants and large numbers of cryptogams of all families, none of which have yet been fully reported on except the fungi, although all the other material is in the hands of specialists. Reports on all my collections are sent in to the Department by the specialists who examine them. The original reports are kept there, copies being sent to me. Last year I endeavoured to secure the assistance of a mycologist who had a good knowledge of fungi and was willing to spend the necessary time on the large collections of fungi I was making and I was fortunate enough to secure the services of Dr. John Dearness of the Normal School at London, Ont. Last February I mailed him the first lot of specimens and since then I have sent him 870 packets. Nearly all have been named and Dr. Dearness has described many new species from among those sent him. The lichens are named by G. K. Merrill, Rockland, Me., U.S.A., the mosses by Otto E. Jennings, Carnegie Museum, Pittsburgh, Pa., U.S.A., the seaweeds by F. S. Collins, North Eastham, Mass., U.S.A, and the hepaticæ by Miss Caroline C. Haynes, Highlands, N.J., U.S.A.

As I become more familiar with the cryptogamic flora of Vancouver island my collections become more valuable and I hope to spend part of next summer in the field as I did last year.

BOTANY.

(*J. M. Macoun.*)

Owing chiefly to the continued illness of the writer last winter and the absence of Miss Stewart on sick leave for six months very little office work other than that entailed by the routine of the division was accomplished during the ten months covered by this report. Many collections were as usual sent in for determination and this work, as in former years, has taken precedence of all other; as, besides being of assistance to local botanists and collectors throughout Canada it is our best means of keeping in touch with the very small number of those who are doing botanical work in the Dominion and many additions to the herbarium are secured in this way from them. The report on the Ottawa flora was revised by the writer and Dr. M. O. Malte and, although some further time must be spent upon it, it will be ready for publication at an early date. The only plants mounted were a few that had been brought in by members of the Geological Survey staff or donated to the herbarium by correspondents. The collection of flowering plants made on Vancouver island by Prof. John Macoun in 1914 was not touched, having been held over so that they might be worked up with the 1915 collections made in the same region. During Miss Stewart's absence the clerical work of the division was done by Miss McCann who kept no record of the number of letters written, the figures given below being only for the letters written since March.

Another season's work on Vancouver island being necessary before a beginning could be made on a systematic flora of that region, I was instructed to again visit the island and left Ottawa for that purpose June 1. After spending a few days at Sidney with Prof. Macoun, going over his collections, we went to Comox together where I made my headquarters for seven weeks, although a considerable part of the time was spent on the adjacent islands and in the interior of Vancouver island. When Prof. Macoun returned to Comox I went to Texada island where three weeks were spent. The flora of Texada island is of special interest as this island and those adjoining it form the northern limit of the plants of the Arid Transition zone on the coast, many species being found there that are characteristic of the flora of the dry interior of British Columbia. The flora of Whidbey island in the northern part of Puget sound, south of the International Boundary, is very similar, but the more southern islands of the Gulf of Georgia exhibit the flora one would expect to find in that region. The dryness of Whidbey island and a few smaller islands near it is explained by the fact that they are protected by the Olympic mountains westward; and a similar explanation may be found for the conditions found on Texada and adjacent islands. The high mountains westward on Vancouver island serve to protect these islands from the Pacific winds, the very heavy precipitation on the west coast of Vancouver island and the mountains themselves leaving little rain to fall as the west winds pass over Texada or the clouds may pass at too great an altitude as there is also great precipitation on the British Columbia mainland near the coast. Whatever the reason may be the fact remains that the flora of Texada island must be referred to the Arid Transition zone. As I had with me the necessary books and abundant material was collected, the flora of the whole region visited was pretty well worked out in the field.

While in camp at Comox and on Texada island I was assisted by Mr. William Spreadborough who, in addition to his other duties, made a good collection of birds and mammals and together we did considerable marine dredging. A detailed reference to the material collected will be found in Mr. Taverner's report.

At the request of the Director of the Provincial Museum at Victoria, and with your permission, I spent a few days at Victoria going over the whole collection there, renaming specimens where necessary and making lists of all the Vancouver Island plants represented in the museum for use in any future work that may be published on the flora of Vancouver island. I also visited Seattle for a few days in order to examine plants in the herbarium of the University of Washington. During the past fifteen years there has been considerable overlapping in the describing of species collected in the State of Washington and in southern British Columbia; and in order to straighten out the synonymy it was necessary to see the types or co-types there as many of the published descriptions are too poor to permit of the synonymy being worked out with certainty. I spent several days with Prof. Frye and Prof. Riggs with advantage to all three of us and also I hope to west coast botany.

The only collections brought in by members of the staff were one from the Bridge River district, Lillooet, B.C., by C. W. Drysdale, and one by C. E. Cairnes who accompanied F. J. Alcock to the Churchill region. Both collections were small but of considerable interest. More detailed reports on these plants appear in the summary reports of the collectors.

Since my return from the field, September 21, I have been engaged on the regular routine work of the division, chiefly in the naming of plants of my own collecting or of plants sent in for determination by correspondents. The official letters written since last March (to November 15) number 245.

The only botanical paper published by me during the year was one on "Hybridization in the Genus Viola" written in collaboration with Dr. M. O. Malte and published in The Ottawa Naturalist. The only assistance I have had in connexion with the herbarium is that given me by Miss Stewart who has performed her duties in her usual efficient manner.

Mr. Harold St. John was appointed a temporary assistant botanist last spring in order that he might collect specimens and report upon the flora of Saguenay county, Quebec. He is now engaged upon his full report which will be ready for publication in April. A brief summary of his season's work follows:

Botanical Reconnaissance on the North Shore of the Gulf of St Lawrence.

(*H. St. John.*)

In accordance with instructions, I spent the months of the past summer in a botanical reconnaissance of the north shore of the Gulf of St. Lawrence, Saguenay county, Quebec. For the first four weeks I was fortunate enough to have as a companion Dr. C. W. Townsend of Boston, an ornithologist, temporarily on the staff of the Canadian Geological Survey. His knowledge of the physiography, the natural history, the means of transportation, and of the inhabitants, resulting from three previous trips to the peninsula, was of invaluable assistance to me.

On June 24, 1915, we left Montreal by the steamship *Cascapedia* on our way down the St. Lawrence river.

On June 27 we disembarked from the steamer at Eskimo point where we found the schooner *Sea Star* waiting for us. This little 40-foot sailing vessel was our home and means of transportation almost throughout the time spent on the *côte nord*. In command of the vessel was Capt. A. E. Joncas, a public official of various departments of the Province of Quebec, being crown land agent, game warden, and justice of the peace. Half a life time spent as a trader on the coast had given him an accurate knowledge of the channels, the reefs, and rocks of this imperfectly chartered coast which enabled him to gratify our desire to visit this rocky island or to inspect the shores of that deep bay.

By successive stages of from 3 to 50 miles we moved down the coast towards our eastward destination, Blanc Sablon, over 300 miles away. Because of the sufficient diversity of the flora of the islands and the intricate coasts, and because of the inherent difficulties in travelling on land in those regions, I did not succeed in getting very far inland. Fourteen miles above tide water on the St. Augustine river was the farthest inland point attained.

Shortly before the end of July we reached the Canadian-Newfoundland-Labrador boundary line at Blanc Sablon, which was our farthest point east. There Dr. Townsend left me and returned to Boston via Newfoundland.

At the Straits of Belle Isle, instead of the prevailing granites and gneisses one finds horizontal table lands of what is apparently a coarse limy sandstone. This change of the country rock was very welcome, accompanied as it was by an almost complete change of vegetation. Here it was that the richest collecting of the summer was found.

With geniune regret I watched the Bradore hills fade out of sight as we reversed our course and left the Straits of Belle Isle behind. On the return the stops were sometimes at places touched at on the way down, but more often at new localities. This double survey of the same coast enabled me to give it a more thorough search for the various species composing its flora; and the fact that these two inspections were at different seasons, enabled me to find plants on the later visit which were invisible or unrecognizable previously.

On returning to Eskimo point I disembarked my chattels from the *Sea Star* and from a base on the shore spent several more days collecting in that rich, limestone region, in the immediate vicinity of the Mingan islands.

On September 15, my time was almost up, so I moved to Mingan, my last collecting point on the *côte nord*.

The following are the results of my work in collecting the vascular plants:

No. of species collected		500
"	sheets "	2,174
"	notes on the distribution of the plants	3,239

The most recent list of the vascular flora of the Labrador peninsula is by J. M. Macoun (Lists of the plants known to occur on the coast and in the interior of the Labrador peninsula. Ann. Rep. Can. Geol. Surv. Vol. VIII, 353 L-366 L, 1895). In this list the plants of the coast are tabulated separately, 253 in number. The fact that one summer's collecting on the southern coast alone has doubled the number of known species of the coastal flora indicates how much there is yet to be done in this comparatively little known region.

At the close of the season a short trip was made to Selkirk, Prince Edward Island, for the purpose of making a type collection of an undescribed *Potamogeton* which grows there in Shipwreck creek. My trip was terminated by returning to Boston on September 25.

According to agreement, I am studying the plants collected on this trip at the Gray Herbarium, under the direction of Prof. M. L. Fernald. As the flora of this region has never received any complete critical study, and as its special literature includes some fifty scattered reports extending back to early German ones in 1818, I estimate that it will take me some six months to complete my studies and to present my report to the department.

ZOOLOGY.

(*P. A. Taverner.*)

Previous summary reports made by me on the progress of the work of the zoological division have covered the calendar year from January to January. It should be noted that this report covers the year 1915 only to November 15, the date of writing. In the division during the year, there has been a constant growth along all lines and satisfactory progress has been made.

In the office, a greatly increased amount of correspondence and routine work has taken up much of our time.

Miss Winifred Bentley has devoted considerable time to the compilation of a bibliography of the literature of the ornithology of eastern Canada and Gulf of St. Lawrence and the foundation is being laid for a bibliography of Canadian ornithology.

C. H. Young, except while in the field, has been engaged in arranging and cataloguing the oological collections and caring for material as it came in; all of which he has attended to in his usual careful and painstaking manner.

A great part of the past winter has been spent on reports and papers for publication. Through the year the following papers have been published from the division:

The "Double-Crested Cormorant (Phalacrocorax auritus) and its relation to the salmon industries on the Gulf of St. Lawrence" by P. A. Taverner, Geol. Surv., Can., Museum Bulletin No. 13, pp. 1-24, Biological series No. 5, April 30, 1915.

This is a report on an economic investigation made during the summer of 1914 by the writer and his associates on Gaspe peninsula; the conclusion arrived at being, that the cormorants under discussion were more occupied with fish of non-economic value than with salmon and that the charges brought against them were exaggerated.

"Suggestions for ornithological work in Canada" by P. A. Taverner, Ottawa Naturalist, Vol. XXIX, April and May, 1915, pp. 21-28. The title suggests the scope of this paper; in it the attempt was made to present some aspects of scientific research that are generally little understood.

"Recommendations for the creation of three new national parks in Canada," by P. A. Taverner, Commission of Conservation, Canada, Sixth Annual Report, 1915, appendix III, pp. 303-310, 1 plate and 2 plates facing pages 112 and 114. In this was recommended the setting aside for game and bird reservations, Pelee point, Ontario, and Percé rock and the bird ledges of Bonaventure island off Gaspe peninsula, Gulf of St. Lawrence. At present writing these schemes are under consideration and well on the way towards adoption.

A popular work on the "Birds of Canada" has been planned and considerable progress made towards its completion. The services of Frank Hennessey were secured as illustrator and over one-half the original 100 coloured drawings necessary have been prepared and are in the plate maker's hands. The book is intended to be an introductory manual to the study of Canadian birds, and deals with the economic value of all common species, enabling the agriculturist and others to separate bird friend from foe.

Steps have been taken towards properly housing our study series; the experimental storage case mentioned in the previous report has proved highly satisfactory and a sufficient number is under construction to securely house all our present bird and mammal collections.

In the preparatory department of the division, a complete tanning plant has been installed and we are now able to soft tan our large mammal skins in a most satisfactory manner. The work is proceeding rapidly and much large, awkward material is being reduced to a more flexible state, in which condition it can be successfully protected against insect and other pests. Much work has also been done towards remaking many valuable skins from the older collections some of which, owing to hasty preparation, were rapidly disintegrating.

C. L. Patch and his assistant Claude Johnson have been preparing material for the museum and making ready small species groups for future exhibition. A few such groups have been put on exhibition. As soon as cases are available we will be able to put out a considerable amount of additional material of the most advanced museum *technic.*

A lobster group, that was temporarily opened to public view early this spring, shows a conventional section through the sea with a panoramic, painted background above showing Percé rock and the adjacent shores and a submarine view below with lobsters, a lobster trap, star fish, sea urchins, and other marine life in their natural habitat.

We have had through the summer, two parties in the field on the Gulf of St. Lawrence. One, under my personal direction, continued the work begun last year at Percé, Quebec, while Dr. Charles Townsend with the other explored the northern shore of the Gulf of St. Lawrence from Natashkwan to the Straits of Belle Isle (for details see preliminary reports following).

During the year, our collections were made use of for study by various people and institutions. The United States Biological Survey has availed itself of loans from our material several times and has returned the favour in various ways.

Numbers of specimens from all over the Dominion have been referred to us for determination and there has been a steady increase in the use made of our collections by local schools, their instructors, and classes.

One of the features of the work of the past year has been the institution of popular lectures given by various members of the Geological Survey staff, in our own halls as well as elsewhere, to various school classes and other organizations. Though these have been largely directed by Harlan I. Smith, the slides relating to zoological subjects have been prepared by this division. It is intended that these slide collections be considerably increased and arrangements perfected under which they can be loaned to scientific or educational organizations for lecture use, under a museum extension service.

Besides these slides we have acquired several moving picture films for like use. Some of these are our own taking, viz., one of the bird cliffs of Bonaventure island showing the home life of gannets and other sea birds, another is of wild geese, illustrating the extraordinary success obtained by Mr. Jack Miner in attracting this wary species about his home grounds. These films are of great popular appeal and of interest from both educational and scientific standpoints.

Though twelve months have not passed since the last report, our accessions have already numbered far beyond the total of any previous year. While the number of individual specimens so acquired has not been in any way remarkable the showing is good. In previous years we have received usually by purchase, one or more large collections which have counted largely in our catalogues. The obvious need of restriction in expenditure at present is excuse enough for our not making large purchases this year. With this in view, the great number of small accessions, most of them gifts or obtained by members of the Geological Survey staff engaged in other lines of work, show an awakening of interest in the public at large that is most gratifying. Amongst the accessions deserving of more than passing note is a number from the Gulf of St. Lawrence. These include many winter and late autumn birds including Eider Ducks, Iceland Gulls, Barrow's Goldeneye, Purple Sandpipers, and others of equal interest.

The Bernard collection from our west Arctic coast is also an interesting one, containing many species in breeding plumage, often in original mated pairs and accompanied by eggs or downy young, or young in early plumage. As these species are from the same general region as those received from R. M. Anderson of the Canadian Arctic expedition reported upon, in some detail, last year, and are really supplementary to those collections, it seems proper that a detailed account of them be given (See following list).

As said before other members of the Geological Survey staff have been untiring in collecting for us. As this is entirely upon their own initiative and in addition to their regular work our thanks are due to them. Their names appear in the following accession lists.

Accessions 1915.

By the Staff of the Zoological Subdivision.

15-21. By preparatory staff—C. L. Patch, C. H. Young, and C. E. Johnson, near Ottawa, Ont., May, Oct., and Nov.—
14 birds, skins and mounted, catalogue Nos. 8210-8211, 8227, 8230, 8232, 8234, 8238-8239, 8241, 8547-8548, 8552-8553, 8577.

15-23. By zoological expedition—P. A. Taverner, C. L. Patch, C. H. Young, and C. E. Johnson, at Percé, Que., and the Quebec Labrador, June-Aug. (See preliminary report following).—

25 mammals, Meadow, Red-backed, and Deer Mice, Chipmunk, Red Squirrel, Hares, Woodchucks, and Shrew, catalogue Nos. 2470-2494.

116 birds, skins, mounted, and 22 in alcohol, of various ages, of Puffin, Murre, Razor-billed Auk, Herring and Black-backed Gulls, Kittiwakes, and Old-squaw, catalogue Nos. 8283-8363, 8424-8429, 8514-8535, 8660.

30 birds' eggs and nests, catalogue Nos. 1077-1106.

2 reptiles and amphibians, Garter Snake, Percé, Que., Toad, Natashkwan, Que., catalogue Nos. 618-619.

100 insects, 20 Butterflies, 14 Moths, 22 Beetles, 44 Bees, Flies, and other insects not catalogued.

100 bird stomachs, 190 photographs, 43 autochromes, 15 water-colour plates, rock casts, group accessories, etc.

15-28. By office staff—Miss Winifred Bentley.—

Young Robin and egg in alcohol, Ottawa, Ont., catalogue No. 8384.

15-30. By office staff—Miss Winifred Bentley, Ottawa, Ont.—

Robin nestling, found dead, catalogue No. 8385.

15-60. By office staff—C. H. Young, Meach Lake, Que., near Ottawa.—

4 small mammals, Deer and Meadow mice, catalogue Nos. 2524-2527.

8 bird skins, Broad-winged Hawk, Hermit Thrush, Tree Sparrow, Least Flycatcher, Rose-breasted Grosbeak, Hairy Woodpecker, Goshawk, catalogue Nos. 8662-8669.

15-70. By preparatory staff—C. E. Johnson, St. Thomas, Ont., Sept.—

3 birds, Sapsucker, Cedarbird, Little Green Heron, catalogue Nos. 8571-8573.

2 mammals, Woodchuck, Chipmunk, catalogue Nos. 2528-2529.

15-77. By office staff—P. A. Taverner, Pelee point, Ont., Oct.—

9 birds, 2 Goldfinches, Chipping Sparrow, Palm Warbler, Long-tailed Jaeger (wing and head), and 4 Sharp-shinned Hawks in alcohol, catalogue Nos. 8557-8565.

1 salamander, *Ambystoma tigrinum*.

1 water-colour plate.

15-84. By preparatory staff—C. L. Patch, C. E. Johnson, near Ottawa, Oct.—

2 mammals, Red Squirrels, catalogue Nos. 2533-2534.

3 birds, Hermit Thrush, Tree Sparrow, House Sparrow, catalogue Nos. 8680-8682.

15-86. By office and geological staffs—C. H. Young and R. Harvie, near Ottawa, Ont., Oct. and Nov.—

3 birds, Ruffed Grouse, Hairy Woodpecker, Meadow Lark, catalogue Nos. 8683-8685.

15-87. By office and preparatory staff—C. H. Young, C. L. Patch, C. E. Johnson, near Ottawa, Ont., April—
1 mammal, Woodchuck, catalogue No. 2535.
28 birds, various species for mounting, catalogue Nos. 8632-8659.
1 set birds' eggs, catalogue No. 1109.

15-57. By botanical division—Wm. Spreadborough, per J. M. Macoun, Vancouver and Texada islands, B.C., June-Aug.
8 mammals, Squirrels, Deer Mice, and Bat, catalogue Nos. 2497-2504.
48 bird skins, catalogue Nos. 8430-8477.
58 lots starfish, crabs, and marine specimens in alcohol.
100 marine shells, not catalogued.

By Other Museum Divisions.

15-16. By division of mineralogy—E. Poitevin, Ottawa, Ont.—
1 Rose-breasted Grosbeak, catalogue No. 8240.

15-39. By division of palæontology (vertebrate)—Geo. Sternberg, Ramsay, Alberta, June-July.—
7 birds, Nighthawk, Horned Owl, Mallard, Spotted Sandpiper, Rough-legged Hawk, Ruffed Grouse, catalogue Nos. 8399-8405.
12 sets birds' eggs, 3 sets Mallard, 3 sets Spotted Sandpiper, 2 sets Cedarbird, 1 set Nighthawk, 1 set Ruffed Grouse, 1 set Savanna Sparrow, catalogue Nos. 1065-1076.

15-41. By division of palæontology (vertebrate)—Geo. Sternberg, Red Deer, Alberta.—
1 Sparrow Hawk, catalogue No. 8406.

15-51. By division of palæontology (vertebrate)—L. M. Lambe.—
Fragment of duck (Barrows Goldeneye?) from recent deposits near Ottawa. Collected by J. E. Narraway, catalogue No. 8415.

15-71. By division of anthropology—E. Sapir.—
5 Photographs of mammals taken by Dr. Hawkes.

15-89. By division of palæontology (vertebrate)—Geo. Sternberg.—
1 Coyote skin, skull, and leg bones, catalogue No. 2541.
18 bird skins, 3 Sharptailed and 2 Ruffed Grouse, Mallard, 2 Shovellers, Scaup Duck, Bittern, Magpie, 2 Sharp-shinned Hawks, Western Red-tailed Hawk, Hairy Woodpecker, Western Grebe, and 2 downy Ducks in alcohol, catalogue Nos. 8687-8702.
2 snakes, catalogue Nos. 621-622.
21 fish (in alcohol), catalogue Nos. 1070-1090.

15-91. By division of palæontology (invertebrate)—E. M. Kindle, Bay of Fundy, summer of 1914.—
About 30 lots of shells and marine life (in alcohol) and dredgings, including crab, *Libinia emarginata* Leach, the first record for Nova Scotia, not catalogued.

By Geological Staff.

15-14. By M. Y. Williams and R. Harvie, near Ottawa, May.—
4 birds, Killdeer, Flicker, Sapsucker, Greater Yellowlegs, catalogue Nos. 8231, 8235, 8237.

15-31. By M. Y. Williams, Bruce peninsula, Ont., June.—
2 birds, Herring Gull and Loon, catalogue Nos. 8386-8387.

15-32. By M. Y. Williams, Georgian bay, Ont., July.—
2 Duck Hawks, jv., catalogue Nos. 8388-8389.

15-33. By W. Wright, eastern provinces, summer.—
Woodchuck skin and photographs, catalogue No. 2530.

15-35. By B. Rose, Blairmore, Alberta, July.—
Pocket Gopher skin, catalogue No. 2521.

15-43. By M. Y. Williams.—
Photograph of Prong Horn skull and horns.

15-55. By M. Y. Williams, Georgian bay, Ont.—
Merganser skin, catalogue No. 8423.

15-59. By R. Harvie, Megantic co., Que., summer.—
32 bird skins, catalogue Nos. 8479-8509.

15-63. By M. Y. Williams, Manitoulin island, Georgian bay, Ont.—
3 mammals, 1 shed deer horn, Porcupine, Hare, catalogue Nos. 2530-2532.
1 Great Horned Owl, catalogue No. 8567.

15-64. By M. Y. Williams, Manitoulin island, Georgian bay, Ont., Sept.—
2 birds, Loon and Herring Gull, catalogue Nos. 8568-8569.

15-66. By M. Y. Williams, Manitoulin island, Georgian bay, Ont., Sept.—
1 Pipit, catalogue No. 8546.

15-67. By H. C. Cooke, northern Quebec.—
Nestling Loon, catalogue No. 8686.

15-81. By M. Y. Williams, Manitoulin island, Georgian bay, Ont., Oct.—
2 birds, Pileated Woodpecker, Wilsons Snipe, catalogue Nos. 8578-8579.

15-85. By H. C. Cooke, Lake Olga, northern Quebec.—
1 Calf Moose skin, catalogue No. 2536.

By Presentation.

15-7. By Dominion Entomological branch—Dr. C. Gordon Hewitt.—
1 snake, *Charina bottaw*, Shuswap lake, B.C., catalogue No. 615.

15-10. By Frank C. Hennessey, Ottawa, Ont.—
26 bird skins taken at Winona lake, Indiana, catalogue Nos. 8170-8195.

15-13. By Prof. J. A. Allan, Edmonton, Alberta.—
Photograph of Cow Moose (dead) giving birth to twin calves.

15-15. By Wm. Duvall, Bonaventure island, Gaspe co., Que.—
3 Hermit Crabs in alcohol, not catalogued.

15-17. By Jas. Fleming, Alberta.—
1 Prong Horn skin and skeleton, catalogue No. 2537.

15-18. By Frank C. Hennessey, Ottawa, Ont.—
25 bird skins taken at Winona lake, Indiana, catalogue Nos. 8200-8209, 8242-8256.

15-19. By Dewey Soper, Preston, Ont.—
Photographs of birds and nests.

15-24. By F. Yeadon, Billings Bridge, Ottawa, Ont., July.—
Catbird in flesh, catalogue No. 8407.

15-25. By T. H. Thacker, Hope, B.C., May.—
1 snake (sp. ?), Hope, B.C., catalogue No. 620.

15-27. Dewey Soper, Preston, Ont.—
11 bird skins, Preston, Ont., catalogue Nos. 8373-8383.

15-29. By H. R. Narraway, Ottawa, Ont.—
1 Milk Snake, near Ottawa.

15-36. By Paul Armstrong.—
1 Great Blue Heron, near Ottawa, Ont., catalogue No. 8392.

15-38. By A. Miles, Ottawa, Ont.—
1 black Woodchuck skin, near Ogdensburg, N.Y., catalogue No. 2522.

15-40. By H. Mousley, Hatley, Que.—
Nest of Parula Warbler in situ, near Hatley, Que., catalogue No. 1107.

15-42. By D. Blakeley, Ottawa, Ont.—
1 young Muskrat, Ottawa, July, catalogue No. 2495.

15-44. By D. Blakeley, Ottawa, Ont.—
1 young Screech Owl, Ottawa, July, catalogue No. 8408.

15-45. By J. Nelson Gowanlock, Winnipeg, Man.—
5 bird skins, 2 Ruffed Grouse, Yellow-headed and Red-winged Blackbirds, Yellow-throated Vireo, near Winnipeg, Man., catalogue Nos. 8409-8413.

15-47. By Dr. H. M. Hare, Harrington Harbour, Quebec Labrador.—
2 bird skins, Ruffed Grouse and Green-winged Teal, Harrington Harbour, Que., catalogue Nos. 8365-8366.

15-48. By A. Noel, Ottawa, Ont.—
Albino Barn Swallow, Ottawa, catalogue No. 8414.

15-49. By Wm. McElroy, Richmond, Ont.—
1 Hummingbird nest in situ, Richmond, Ont., catalogue No. 1108.

15-52. By Dominion Parks branch, Ottawa.—
1 four-horned sheep, skin and skull, from captivity, Rocky Mountains park, Banff, Alberta, catalogue No. 2538.

15-54. By Dewey Soper, Preston, Ont.—
7 bird skins, Vesper and White-throated Sparrows, Indigo and Blue birds, Crested Flycatcher, Black-billed Cuckoo, and Mourning Warbler, Preston, Ont., catalogue Nos. 8416-8422.

15-58. By A. A. Dewar, Chelsea, Que.—
1 live Porcupine, Chelsea, Que., near Ottawa, catalogue No. 2523.

15-62. By J. P. Williams, Picton, Ont.—
1 Olive-backed Thrush, Picton, Ont., catalogue No. 8545.

15-65. By M. Noonan, Ottawa, Ont.—
1 Brown Creeper, Ottawa, Ont., catalogue No. 8570.

15-73. By Alpha Sheppard, Ottawa, Ont.—
1 Albino Robin, Ottawa, Ont., catalogue No. 8661.

15-74. By H. H. Pittman, Wanchope, Sask.—
1 Rough-legged Hawk skin, southern Sask., Oct., catalogue No. 8678.

15-76. By W. E. Saunders, London, Ont.—
3 bird skins, Acadian Flycatcher, Bewick's Wren, southern Ont., Harris Sparrow, Kansas, catalogue Nos. 8554-8556.

15-78. By W. Taylor, Vancouver, B.C.—
1 salamander (*Diemietylus tarosus*), Vancouver is., B.C.

15-80. By Dr. Chas. M. Townsend, Boston, Mass.—
13 vials spiders from Quebec Labrador, 1915, not catalogued.

15-83. By D. Blakeley, Ottawa, Ont.
1 Skunk, catalogue No. 2539.
Horned Lark, Ottawa, catalogue No. 8679.

15-90. By J. P. Williams, Picton, Ont.—
1 Red-tailed Hawk, jv., Picton, Ont., catalogue No. 8705.

By Exchange.

15-1. With Max M. Peet, Philadelphia, Pa.—
8 bird skins, various Austral species, catalogue Nos. 8162-8169.

15-11. With Provincial Museum, Victoria, B.C.—
1 Flemings Grouse, Atlin, B.C., catalogue No. 8196.

15-61. With Dr. Chas. W. Townsend, Boston, Mass.—
4 bird skins from Quebec Labrador, summer, catalogue Nos. 8510-8512.

15-75. With W. E. Saunders, London, Ont.—
3 bird skins (European specimens of Canadian species), catalogue Nos. 8549-8551.

By Purchase.

15-2. From Theodore Cleland, Osgoode Station, Ont.—
1 Snowy and 1 Great Horned Owl, Beaver Lodge river, Alberta, Oct., 1814, catalogue Nos. 8013-8014.

15-3. From Wm. Bodin, Miscou island, Gloucester co., N.B.—
21 birds in flesh, Red-throated Loon, 2 Iceland Gulls, Herring Gull, Black Duck, 2 Goldeneyes, 10 Old-squaws, American Eider, 2 Brant, Snowflake, Miscou island, N.B., catalogue Nos. 8015-8035.

15-4. From Arthur Eden, Gaspe basin, Que.—
2 Dovekies and 1 Black Guillemot, Gaspe, Que., Jan. and Dec., catalogue Nos. 8036-8038.

15-5. From Capt. James Bernard, P.E.I.—
113 bird skins and 33 sets of eggs from Arctic coast west of Dease strait, 1910-1914 (See detailed list following, catalogue Nos., Birds, 8039-8151, Eggs, 1028-1061.

15-6. From Wm. Duvall, Bonaventure island, Gaspe co., Que.—
10 birds in flesh, 1 Dovekie, 4 Barrows Goldeneye, 3 Eiders, Old-squaw, Purple Sandpiper, near Percé, Que., catalogue Nos. 8152-8161.

15-8. From Jas. B. Whiteoak, Foremost, Alberta.—
Kit Fox pup, near Brooks, Alberta, catalogue No. 2540.

15-9. From E. S. Norman, Mulvihill, Man.—
Great Horned Owl in flesh, Mulvihill, Man., Feb., catalogue No. 8199.

15-12. From E. S. Norman, Mulvihill, Man.—
2 Great Horned Owls in flesh, Mulvihill, Man., March, catalogue Nos. 8197-8198.

15-20. From Wm. Duvall, Bonaventure island, Gaspe co., Que.—
Double-crested Cormorant and Bronzed Grackle in flesh, catalogue Nos. 8226-8229.

15-22. From Wm. Bodin, Miscou island, Gloucester co., N.B.—
39 birds, fresh skins, 3 Gannets, 11 red-throated Loons in changing plumage, 2 Loons, 3 Herring Gulls, American Merganser, Old-squaw, 4 White-winged Scoters, American Eider, Horned Lark, Great Blue Heron, Brant, Miscou island, N.B., April-May, catalogue Nos. 8212-8224, 8257-8282.

15-26. From Wm. Bodin, Miscou island, Gloucester co., N.B.—
6 birds, 4 Robins, 2 Song Sparrows, catalogue Nos. 8367-8372.

15-34. From Wm. Bodin, Miscou island, Gloucester co., N.B.—
3 birds, Loon, Leach and Wilson petrels, catalogue Nos. 8390, 8391, 8566.

15-37. From Wm. Bodin, Miscou island, Gloucester co., N.B.—
6 birds, 3 Herring Gulls, 2 Hudsonian Curlews, Double-crested Cormorant, Miscou island, N.B., July, catalogue Nos. 8393-8398.

15-46. From Michael Blaise, Romaine, Quebec Labrador.—
1 Shoveller, Romaine, Que., June, catalogue No. 8364.

15-50. From Wm. Bodin, Miscou island, Gloucester co., N.B.—
5 birds, Marsh Hawk, 2 Black-backed Gulls, Great Blue Heron, and Black Duck, Miscou island, N.B., catalogue Nos. 8536-8540.

15-56. From Wm. Bodin, Miscou island, Gloucester co., N.B.—
2 birds, Black Duck and Double-crested Cormorant, Miscou island, Aug., catalogue Nos. 8543-8544.

15-68. From Wm. Bodin, Miscou island, Gloucester co., N.B.—
12 birds, 2 Herring Gulls, 5 Black-backed Gulls, Yellowlegs, Turnstone, Flicker, Hudsonian Curlew, Bonaparte Gull, Miscou island, N.B., Sept., catalogue Nos. 8670-8673.

15-72. From Wm. Duvall, Bonaventure island, Gaspe co., Que.—
4 Gannets in juvenile plumage, Bonaventure island, Que., Oct., catalogue Nos. 8674-8677.

List of Specimens Collected by Capt. Jos. Bernard, on the Arctic Coast, N. W. T., Canada.

Accession 15-5.

1. Pacific Loon, *Gavia pacifica.*
♂, ♀ original pair, nest and 2 eggs, June 30, 1910, Barter island, Alaska. ♂ and downy young, Aug. 1, 1913, Cash point, Victoria island.

2. Red-throated Loon, *Gavia stellata.*
July 25, ♂, ♀ and two downy young, original family, Aug. 1, 1913, Simpson bay, Victoria island.

3. Parasitic Jaeger, *Stercorarius parasiticus.*
♂, ♀, dark and light phases, original family, nest and two eggs, June 24, 1912, Cape Bathurst, Mack.

4. Long-tailed Jaeger, *Stercorarius longicaudus.*
♂, July 4, 1910, Barter island, Alaska.

5. Glaucus Gull, *Larus hyperboreus.*
♂, July 20, 1911, Coronation gulf.

6. Sabine Gull, *Xema sabini.*
♂ ♀ July 25, 1911, Austin bay, Victoria island; ♂ and 1 egg, June 20, 1912, Cape Bathurst, Mack.; ♂ and downy young, July 25, Austin bay, Victoria island.

7. Arctic Tern, *Sterna paradisæa.*
♀ Breeding, July 7, 1914, near Victoria island; ♀ ♀ and 2 eggs, June 24 and 28, 1912.

8. King Eider, *Somateria spectabilis.*
♀ ? July 1913, Cockburn point, Mack.

9. White-fronted Goose, *Anser Albifrons.*
Sex ? with nest and 4 eggs, June 24, 1911, Coronation gulf.

10. Black Brant, *Branta nigricans.*
♀ ? and 2 downy young, original family, July, 1911, Coronation gulf; nest and 5 eggs, June 20, 1912, Cape Bathurst, Mack.

11. Little Brown Crane, *Grus canadensis.*
♀ May 27, 1912, Cape Bathurst, Mack.

12. Red Phalarope, *Phalaropus fulicarius.*
♂ breeding, June 25, Arctic coast; ♂ July 3, 1910, Barter island, Alaska; ♂♂ June 20 and 24, 1912, Cape Bathurst, Mack.

13. Northern Phalarope, *Lobipes lobatus.*
♂♂♂ with 2 nests of 4 and 1 eggs, June 28, 29, 1911, Coronation gulf.

14. Stilt Sandpiper, *Micropalama himantopus.*
Sex ? and 3 downy young, original family, July, 1913, Cockburn point, Mack.; sex ? half fledged juvenile, 1913, Cash point, Victoria island.

15. White-rumped Sandpiper, *Pisobia fuscicollis.*
♀♀ June 1913, Cockburn point, Mack. A set of eggs said to have been collected with bird, but were lost in transit.

16. Red-backed Sandpiper, *Pelidna alpina sakhalina.*
♀ and 3 downy young, July 2, 1912, Cape Bathurst, Mack.

17. Semipalmated Sandpiper, *Erunetes pusillus.*
♀ breeding, June 21, 1910, Barter island, Alaska; sex ? breeding, June 28, 1912, Baillie island, Mack.; ♀ and 1 downy young, July 3, Baillie island; nest and 4 eggs, June 21, 1911, Coronation gulf.

18. Sanderling, *Calidris leucophæa.*
♂ June 6, 1913, Cockburn point, Mack.

19. Black-bellied Plover, *Squatarola squatarola.*
♂ July 25, 1913, Cash point, Victoria island; ♀ with nest and 4 eggs; ♂, breeding, nest, and 4 eggs; June 27-28, 1913, Cockburn point, Mack.

20. Golden Plover, *Charadrius dominicus.*
♂ ♀ nest and 4 eggs, June 28, 1912, Cape Bathurst, Mack. These specimens appear to be the Pacific subspecies *fulvus.*

21. Semipalmated plover, *Ægialitis semipalmata.*
Sex ? June 21, Cape Bathurst, Mack.

22. Ruddy Turnstone, *Arenaria interpres morinella.*
♂ and 1 downy young, Aug. 25, 1913; ♂ jv. Aug. 27, 1913; nest and 2 eggs, June, 1914. All Victoria island.

23. Rock Ptarmigan, *Lagopus rupestris.* (*Subsp.* ?)
Sex ? with nest and 11 eggs, June 19, 1911, Coronation gulf; ♂ Oct. 2, 1913, Victoria island.

24. American Roughleg, *Archibuteo lagopus sancti-johannis.*
♂, ♀ original pair with nest and 4 eggs, June 12, 1911, Coronation gulf.

25. Duck Hawk, *Falco peregrinus anatum.*
♂, ♂, one set 4 eggs, June 22-27, Cape Hamilton, Victoria island.

26. Short Eared Owl, *Asio flammeus.*
♂, ♀ original pair with nest and 4 eggs, June 24, 1911, Coronation gulf.

27. Horned Lark, *Otorcoris alpestris.*
♂ May 29, 1911, mouth of Coppermine river; ♂, ♀ June 6, 1911; ♀ ♀ June 15, 1911; 1 nest and 5 eggs, 1911. All Coronation gulf. These specimens are undoubtedly the subspecies *hoyti.*

28. Red poll, *Acanthis linaria.*
♀ ♀ ♀ ♀ ♀ and 5 nests and eggs (3, 5, 5, 4, 4,), June 12 to 16, 1911, Coronation gulf.

29. Snow Bunting, *Plectrophenax nivalis.*
♀ breeding, June 22, 1914, Barter island, Alaska; ♂ Sept. 27, 1914, Cape Bathurst, Mack.; ♀ ♀ ♀ with nest and 5 eggs, July 4, 1913; Cockburn point; Sex ? Aug. 1-19 Cash point, Victoria island.

30. Lapland Longspur, *Calcarius lapponicus.* (*Subsp.* ?)
♂, ♀ June 10 and 19, 1910, Barter island, Alaska; ♀ ♀ with 2 nests, 5 eggs each, June 15, 1912, Cockburn point, Mack.

31. Savanna Sparrow, *Passerculus sandwichensis* (*Subsp.* ?)
♀ June 20, 1911, Coronation gulf.

32. Tree Sparrow, *Spizella monticola.*
♀, 1911, Coronation gulf; ♀ Sex ? ♀ with 2 nests of 5 eggs each, mouth of Coppermine river.

33. Pipit, *Anthus rubescens.*
Sex ? ♀, 2 nests and 1 set of 5 eggs, June 13 and 15, 1911, Coronation gulf.

Gulf of St. Lawrence Field Work, 1915.

(*P. A. Taverner.*)

On June 1, accompanied by C. H. Young, C. L. Patch, and Claude L. Johnson, I left Ottawa for Percé, Quebec, the scene of some of our last season's work, arriving there the following day. We had to wait the coming of supplies on the steamer from Montreal so were not able to commence regular work until the fourth.

From that time on we worked the woodlands and shores about the village and made frequent visits to the bird ledges of Bonaventure island. The special duty of Mr. Patch and Mr. Johnson was the preparation and mounting of exhibition material and they were engaged throughout their stay collecting and mounting specimens, studying habits and attitudes, and making casts and photographs of rocks and acessories for reproduction in life history groups.

The writer and Mr. Young paid attention to the gathering of scientific information and material, filling gaps discovered in the previous year's work, photographing with both autochrome and ordinary plates, and taking moving pictures of bird ledges and their inhabitants. Owing to thick or stormy weather the latter work was delayed considerably and we were unable to finish it before the ship was ready to take us to the north shore. However, Mr. Patch continued this work at every possible opportunity allowed by fog or wind, and by our united efforts we finally obtained some 1,300 feet of most valuable and interesting film of this ornithological wonder.

On June 27 through the courtesy of the Department of Marine and Fisheries Mr. Young and myself were permitted to embark upon the Dominion Fisheries steamship *Princess* on a three weeks' voyage along the north shore of the Gulf of St. Lawrence, leaving Mr. Patch and Mr. Johnson to continue their work at Percé. As the ship was engaged in her work of regulating the fisheries, issuing licenses, and enforcing the regulations, her route was mapped out according to close schedule. Consequently, there was little opportunity for us to go ashore to explore or collect except at the regular stopping places. These were usually in the immediate neighbourhood of temporary or permanent fishing stations where collecting was poor owing to the depredations of fishermen and of the dogs that are the constant companions of the residents. However, the route closely followed the land and daily opportunities were offered for going ashore. Though collections were small, some knowledge of the country and its conditions was obtained.

The itinerary was as follows: Eskimo point, Natashkwan, Romaine, Harrington harbour, Great Mekattina harbour, Rocky bay, Bonne Esperance and Long point near Blanc Sablon. Here (June 30) we found ice coming in through the straits of Belle Isle, and were forced to turn back to Bonne Esperance. We were again driven from our anchorage by incoming ice and forced to retreat farther to Rocky bay where we were detained by fog and ice several days, reaching Blanc Sablon finally July 8. From thence we returned over our previous route, calling at about the same localities as before and finally after a short stop at Ellis bay, Anticosti, reaching Percé July 15.

Coincident with this trip Dr. Charles Townsend, in company with Mr. Harold St. John, both in the interests of this institution, cruised along the same coast in a small fishing schooner. As in this manner they were able to reach any desirable point and were only slightly governed by prearranged schedule, they had most admirable facilities for the study of the coast. A summary report by Dr. Townsend follows so that there is no necessity for enlarging further upon our results on this coast, except perhaps to say that the alarming conditions threatening the existence of the eiders and larger birds, of which he speaks, are far from overdrawn. I must, therefore, urge that steps be immediately taken to conserve these valuable species on the north shore of the gulf and on the Labrador coast. It is more than an æsthetic or academic question in this region. It is more than a matter of game supply for the sportsman. The sea fowl on the Labrador coast are almost a necessity of life to the inhabitants and furnish practically all the animal food available. The country supplies fish in abundance; but supports absolutely no economic vegetation and the raising or keeping of live stock, other than dogs, which are fish-fed, is now, and for all we can see will be in the future, impossible. The conservation, therefore, of these birds is an important and pressing question and should be taken in hand at the earliest possible moment, so that the rigours and hardships of this inhospitable climate be not greatly increased through this impending extermination of the only source of native fresh meat.

On this trip we had every possible comfort and courtesy shown to us by Captain Chalefour, commander of the ship, his officers and men, and were given every possible opportunity consistent with the regular work of the cruise to conduct our incidental work. To them and to the Department of Fisheries who put the accomodations at our service we, therefore, desire to extend out thanks.

On our return to Percé we found the work of Mr. Patch and Mr. Johnson well advanced and that considerable progress had been made in the collection and preparation of the exhibition material. They had been delayed by bad weather considerably during our absence, however, and a more prolonged stay was deemed necessary for their work. Mr. Young and myself had already secured good representative study collections at Percé. We, therefore, only remained long enough after our return to finish a few odds and ends of work before we returned to Ottawa July 26.

It had been intended to proceed to the Magdalen islands from the north shore, but transportation thence from Percé was difficult, and as important and pressing work was awaiting us in Ottawa, we were unable to carry out these original plans. Messrs. Patch and Johnson remained at Percé until August 26. On the whole, the results of the trip were very satisfactory.

Though no great number of specimens was secured those that were obtained were needed in our series and filled many gaps left open from last season's collecting. The specimens gathered for exhibition purposes were mounted on the spot immediately after close study had been made of the living species in their natural habitat and they will furnish material for many life history groups that should be of interest to the public.

The rapid trip along the north shore, while not producing many specimens, gave us a fair lot of valuable skins and a first hand knowledge of the coast and its conditions that will be of inestimable value when we come to our contemplated report on the birds of the Gulf of St. Lawrence.

Preliminary Report of an Expedition along the North Shore of the Gulf of Saint Lawrence.

(*Chas. W. Townsend.*)

The especial object of this expedition was the study of the birds between Natashkwan and Blanc Sablon, an extent of some 250 miles. This particular region is of great interest to the ornithologist as it is the country visited by Audubon in 1833 in his famous Labrador trip. I had studied the birds to the eastward of Blanc Sablon in 1906, and to the westward of Natashkwan in 1909 and 1912.

With Mr. Harold St. John, botanist, the coast was explored in the 40-foot schooner *Sea Star*, Captain A. E. Joncas, and I wish to record here my gratitude to Captain Joncas for his interest in the objects of the expedition. Mr. St. John and I arrived at Esquimo point by steamship *Cascapedia* on June 27. I sailed the next day with M. Johan Beetz to Piastre bay where Mr. St. John joined me five days later on the *Sea Star*. This gave me an excellent opportunity to study the birds of that region from life and also in the interesting collection of M. Beetz, to whom I am indebted for much valuable information and for great hospitality. I found no less than six species in his collection heretofore unrecorded from the Labrador peninsula, namely: Kumlein's Gull, European Widgeon, Lesser Scaup, Kildeer, Red-winged Blackbird, and Cliff Swallow. Three days were spent at Natashkwan which may be considered the point on the coast where the Hudsonian zone on the west meets the Arctic zone on the east. We spent six days at Romaine and Old Romaine, and explored the surrounding regions. On July 14 we reached Wapitagun and were fortunate in finding two islands where the bird life was so plentiful as to recall the old days of Audubon. Double-crested Cormorants are still abundant, but I saw only one Common Cormorant as these birds have been largely driven away from the cliffs of Cape Whittle.

We continued down the coast, stopping for a few hours or a day or two at favourable places. At Sealnet point I was so fortunate as to find the breeding place of some two hundred pairs of Ring-billed Gulls. Although I saw several Caspian Terns along the coast I did not find their nests. Both of these unusual birds were found by Audubon in 1833. We anchored, among other places, at Harrington, Mutton bay, Hare harbour, Sparr point, St. Augustine river, Shekatika, Old Fort, St. Pauls river, and Bradore bay. I left the *Sea Star* at the last named place on July 27, and went to Blanc Sablon where I was most hospitably entertained by Mr. Edwin G. Grant until my departure for Boston *via* Newfoundland on August 2. At Blanc Sablon I found Song Sparrows; the only previous record for this bird for the Labrador peninsula is that of Low for Lake Mistassini.

On this expedition I observed seventy-eight different species of birds, made fifty-eight bird-skins, took numerous photographs of the coast and of birds, their young, nests, and eggs, and made full records of all my observations.

I wish to emphasize here the great need of efficient bird protection on this coast before it is too late, and to record the sad fact that wherever man goes on this coast the birds disappear. The bird life is too valuable and interesting an asset to be so wasted and destroyed. Bird reservations or refuges watched over by guardians will alone save the remnant from extinction. This matter is urged here on account of its importance and that no time may be lost.

CANADIAN ARCTIC EXPEDITION, 1915.[1]

(*R. M. Anderson.*)

Dolphin and Union Strait, July 29, 1915.

Mr. Fritz Johansen, marine biologist, botanist, and entomologist, has carried on extensive work throughout the year. He has collected and preserved considerable marine and fresh-water biological material from the harbour and from the neighbouring lakes, ponds, and streams. A practically complete collection of the local flora in large series has been preserved and the large collections made at Collinson point, Alaska, and at Herschell island, Yukon Territory, arranged. A considerable number of interesting entomological specimens have been obtained here, and he has also succeeded in raising larvæ collected the previous season at Collinson point, and in working out some hitherto unknown points in the life-history of various forms of Arctic insects. Some work was also done on forest insects at the northern limit of trees (spruce) during a short trip up the Coppermine river in February.

In the line of mammals and birds I have collected about five hundred specimens besides a number of sets of eggs with nests, and have made a number of notes on the vertebrate fauna. A considerable number of the nests of Arctic birds have been photographed in situ. The present station, where we are per-

[1] Zoological extracts from general report.

force confined during the most interesting and fruitful part of the year. for field collecting, *i.e.*, the early part of the summer, on account of being unable to move either by sled or by boat, is a very unfavourable place for land animal and bird life, as the land for many miles back from the coast is very stony, rocky, and barren, affording little sustenance for most of the species. I hope to obtain more specimens in the latter part of the summer, while with the boat survey along the southern portion of Coronation gulf. I have obtained a number of photographs of birds and animals in life, and Mr. George Wilkins, who has been with us since the latter part of May, has also made for me a series of photographic studies of the living forms that have been available around the station.

.....I am sending four cases of bird and mammal skins out to Herschell island by the *North Star*, all that are in condition for packing and shipment.

ENTOMOLOGY.

(*By C. Gordon Hewitt, D.Sc., Dominion Entomologist, Honorary Curator.*)

During the year twelve steel cabinets, each holding fifty insect drawers, have been installed, but some delay has been experienced in preparing the drawers for the reception of the insects. It is expected that the transfer of the insects into the new drawers will soon be possible.

In the meantime considerable additions have been made to the national collection, the major portion of which it is intended to transfer eventually to the Victoria Memorial Museum, but of which the greater part is now in the offices of the Entomological Branch of the Department of Agriculture. These additions have resulted from the extensive collections made by the field officers of the Entomological Branch in the different provinces. Collections were made in all the provinces with the exception of Prince Edward Island. Small collections of insects have been brought in by certain members of the Geological Survey and it would be a great advantage if members of the Survey would make collections, however small, if this can be accomplished without interference with their regular work. By carrying a small killing tube large numbers of insects could be collected without extra trouble and in the case of surveys in new regions such collections would be most valuable.

The arrangement of the collections in the Entomological Branch is proceeding very satisfactorily. Valuable assistance was received from Dr. J. M. Aldrich of the United States Department of Agriculture during a visit in December, in the identification of the Diptera. We are also indebted to Col. Thomas L. Casey of Washington, D.C., for his assistance in examining the Coleoptera during a visit he paid us last summer. During the year we have been able to avail ourselves of the help of Dr. L. O. Howard, Chief of the Bureau of Entomology of the United States Department of Agriculture, and of his assistants in the bureau and in the United States National Museum, for which help we are most grateful. It is anticipated that a large amount of valuable material will have been collected by the Canadian Arctic Expedition and that important biological notes on many of our interesting northern insects, particularly mosquitoes, will have been made by Mr. Fritz Johansen.

DIVISION OF ANTHROPOLOGY.

Part I.

ETHNOLOGY AND LINGUISTICS.

(E. Sapir.)

Museum.

Exhibits.

Owing to continued lack of facilities for exhibition, the museum exhibits in anthropology have remained practically unchanged throughout the year. The most striking ethnological additions are a Chipewyan birch-bark canoe, an Athabaskan skin canoe from Yukon Territory, and a Tsimshian house model, which have been placed above three of the cases; a small Kwakiutl totem-pole, a small Tsimshian totem-pole, and five fragments of Tsimshian painted house boards, which have been placed on one of the walls of the hall; and a large Tsimshian oulachen net, which has been suspended from the ceiling. A special collection of native types of snowshoe (embracing fifteen pairs from different tribes of the Dominion) has also been installed on another of the walls.

The Montagnais collection has been labelled in part. A Canadian Sioux painted tipi with porcupine-quill ornaments attached has been placed on exhibition in the tower hall on the same floor.

Accessions of Ethnological Specimens.

Over eleven hundred ethnological objects obtained either by gift, by purchase in the course of regular field work of the division, or by purchase of material not directly obtained in connexion with field work, have been added in the course of the year to the collections of the Museum. This represents a falling off in comparison with previous years, a falling off due primarily to the necessity induced by the European war of economizing in expenditures. However, the large collection of J. A. Teit (Athabaskan tribes of British Columbia), obtained for the Survey in the course of the year, has not yet arrived at the time of writing. There is also due a large ethnological collection made for the Survey among the Copper Eskimo by D. Jenness, of the Canadian Arctic expedition.

The gifts embrace:

From Mrs. Guy M. Drummond, Montreal, Que.—
    2 pairs Montagnais snowshoes.
    1 pair Western Cree snowshoes.

From F. G. Speck, Philadelphia, Pa.—
    2 Montagnais specimens.

From C. M. Warner, Napanee, Ont.—
    Cast of Iroquois war-club (cast made by F. W. Waugh).

The ethnological specimens obtained in the course of regular field work for the Survey are as follows:

By C. M. Barbeau.—
    3 Tlingit specimens from Port Simpson, B. C.
    23 Haida specimens from Port Simpson, B. C.
    238 Tsimshian specimens from Port Simpson, B. C.
    1 Bella Bella specimen from Port Simpson, B. C.

By F. W. Waugh.—
44 Iroquois specimens from Six Nations reserve, Ont.
2 Iroquois specimens from Tonawanda, N. Y.

By J. A. Teit.—
86 Thompson River specimens from British Columbia.
2 Tahltan specimens from British Columbia.
1 Nez Percé (Shahaptian) specimen, obtained in British Columbia.

By J. A. Mason (collected in 1913).—
7 Chipewyan specimens from Resolution.
13 Dogrib specimens from Fort Rae and Resolution.
8 Slave specimens from Fort Rae.
2 Yellowknife specimens from Resolution.

Ethnological specimens obtained in the course of field work by members of the Geological Survey not connected with the division of anthropology are:

By H. C. Cooke.—
2 Algonquin specimens from Abitibi, Que.
19 Cree specimens from Waswanipi, Que.

By M. Y. Williams.—
4 Ojibwa specimens from Manitoulin island, Ont.

Ethnological specimens purchased otherwise than in course of field work embrace:

From H. A. Collins, St. Catharines, Ont.—
9 Tsimshian specimens from Skeena river, B. C.

From Frank Williams, Alberni, B. C.—
1 Nootka mask from Alberni, B. C.

From S. G. Ford, St. Johns, Newfoundland.—
1 Labrador Eskimo birdskin suit from Stupart bay, Hudson strait.

From Mrs. A. Leblanc, Hull, Que.—
1 Ojibwa stone pipe from Keewatin, Man.

From E. Renouf, Great Whale river.—
50 Eskimo specimens from Belcher islands (east coast of Hudson bay).
11 Eastern Cree specimens from Great Whale river.
2 Naskapi specimens.

From C. Leden, Chesterfield inlet.—
834 specimens of various Eskimo tribes on west coast of Hudson bay.

Photographic Work.

The gifts of photographs of ethnological interest embrace:

From Dr. C. F. Newcombe, Victoria, B. C.—
4 Tsimshian photographs from Kitkatla and Nass river, B. C.

From Field Museum of Natural History, Chicago, Ill.—
13 photographs of Tsimshian specimens.

From B. H. Buxton, London, Eng.—
1 Haida photograph from Massett, B. C.

From Dr. Lehmann-Nitsche, Museo de la Plata, Buenos Aires, Argentina.—
115 portraits of natives of central South America.

From Peabody museum, Cambridge, Mass.—
2 photographs of Passamaquoddy and Penobscot canoes.

From F. W. Waugh.—
1 photograph from Grand river, Ont.

The ethnological photographs taken or purchased for the Survey by members of the anthropological staff and by the photographic department embrace:

By E. Sapir.—
25 Alaskan Eskimo photographs (purchased).
1 Siberian Eskimo photograph (purchased).
4 Tlingit photographs from Alaska (purchased).

By C. M. Barbeau.—
2 Tahltan photographs from British Columbia (purchased).
1 Kootenay photograph from St. Eugene mission, B. C. (purchased).
3 Haida photographs from British Columbia (purchased).
15 Kwakiutl photographs from British Columbia (purchased).
130 Tsimshian photographs taken at Port Simpson, B. C.
4 Coast Salish photographs from British Columbia (purchased).
3 West Coast Indian pictures from British Columbia (purchased).
1 Eskimo photograph (purchased).
5 Saulteaux photographs (gift of Miss A. Bastien, Lorette, Q.).

By F. W. Waugh.—
61 Iroquois photographs from Six Nations reserve, Ontario.

By H. I. Smith.—
6 Micmac photographs from Indian island, N. B.
4 Tlingit photographs from Alaska (purchased).
4 Kwakiutl photographs from northern British Columbia (purchased).
26 Stoney photographs from Alberta.

By F. H. S. Knowles.—
112 Iroquois photographs from Tonawanda, N. Y.
90 Iroquois photographs from Six Nations reserve, Ont.
5 Blackfoot enlargements (purchased from F. R. Meyer, Buffalo).

By J. A. Teit.—
9 Chilcotin photographs from Spence Bridge, B. C.
9 Kootenay photographs from Spence Bridge, B. C.
18 Shuswap photographs from Spence Bridge, B. C.
336 Thompson River photographs from Spence Bridge, B. C.

By E. W. Hawkes.—
18 Labrador Eskimo photographs.
64 Labrador Eskimo photographs (purchased).
1 Micmac photograph (purchased).

By photographic division.—
38 photographs of Labrador Eskimo museum specimens.
3 photographs of Central Eskimo museum specimens.
1 photograph of Alaskan Eskimo museum specimen.
3 photographs of Haida museum specimens.
1 photograph of Bella Coola museum specimen.
4 photographs of Nootka museum specimens.
14 Tsimshian portraits.
2 enlargements from Tsimshian photographs loaned to C. M. Barbeau.

There have been received from members of the Survey not connected with the division of anthropology:

From H. C. Cooke.—
5 Eastern Cree photographs from Rupert House.

From Wm. McInnes.—
1 Ojibwa photograph from Eagle lake, Ont.

Forty-three lantern slides of West Coast Indians and specimens, and sixty lantern slides from Iroquois negatives on file at the Museum have been made by the photographic division and added to the stock for lecture purposes.

Photographic Exchanges.

There have been received from the Peabody museum, Cambridge, Mass., 44 Maya photographs in exchange for 50 Thompson River photographs from British Columbia.

Phonograph Records.

Phonograph records received in the course of the year as a result of ethnological field work undertaken by the Survey embrace:
From J. A. Mason (collected in 1913):
20 phonograph records from Resolution, embracing 2 Cree, 3 Chipewyan, 4 Yellowknife, 9 Dogrib, 3 Slave, and 5 Loucheux songs.

From J. A. Teit:
1 Cree, 4 Carrier, 2 Chilcotin, 20 Thompson River, 5 Shuswap, 5 Lillooet, 1 Sekanais, 1 Tsimshian, 1 Bella Coola, 3 Coast Salish, and 1 Crow records, obtained at Spence Bridge, B.C.
39 Tahltan, 20 Sekanais, 4 Carrier, 3 Tlingit, 3 Tsimshian, 2 Cree, and 1 Slavey from Dease lake, B.C.

Phonograph records purchased otherwise than in course of field work embrace:
From C. Leden:
19 Central Eskimo records from Churchill (collected in 1914).
From A. B. Reagan:
9 Ojibwa records from Nett lake, Minn.

Field Work and Research.

In the course of the year E. Sapir continued work on his monograph "The Na-dene Languages," referred to in the Summary Report for 1914. As this work has grown under his hands and will eventually form a rather large memoir, it was deemed advisable to present a preliminary report, embodying the main results of the work, to the American Anthropologist. "The Na-dene Languages, A Preliminary Report" was accordingly published in that journal (N.S., Vol. XVII, pp. 534-558). During February a number of chiefs from Nass river, British Columbia, visited Ottawa on government business. Opportunity presented itself to obtain valuable information on Nass River social organization from the best informed of these Indians, information which has been embodied in the form of a bulletin on "The Social Organization of the Nass River Indians," published during the year. In connexion with the meeting of the American Anthropological Association at San Francisco, to which Mr. Sapir was appointed as delegate of the Geological Survey, an important methodological problem presented itself in regard to the chronological reconstruction of aboriginal American culture. The problem turned out to be a fruitful one, and has been worked up by Mr. Sapir in the form of a memoir entitled "Time Perspective in Aboriginal American Culture, a study in Method," which will be published in the near future. A beginning was made on the preparation for publication of those Nootka texts that refer to legendary family history. These, with translations and editorial comments will make up an extensive memoir. The large body of other Nootka texts, including miscellaneous tales and such as refer to ethnological matters, will be worked up for publication as separate sets.

C. M. Barbeau spent a period of three months in the early part of the year at Port Simpson, B.C., on Tsimshian field work. An intensive study of the social organization in its static aspect was undertaken of nine or ten Tsimshian tribes formerly living along the Skeena river and on the adjacent coast. As complete a survey as possible was made of the details of organization of these tribes, a considerable number of legends bearing on the crests being collected in the course of the work. Considerable attention was paid to the artistic representation among these Indians of their crests. Mr. Barbeau also collected a large number of museum specimens and photographs bearing on the culture of the Tsimshian Indians. On the return to Ottawa the material in the Provincial museum at Victoria, B.C., and the Field Museum of Natural History at Chicago, Ill., that is of interest for a study of the Tsimshian, was carefully examined and in part photographed. During the summer, Mr. Barbeau spent three weeks in the collection of folk-tales among the French Canadians of Kamouraska county, Quebec. Over sixty folk-tales were collected, in addition to those already obtained in 1914. The field thus opened up proved unexpectedly rich and valuable and is obviously destined to throw considerable light on the interrelations of European and aboriginal folk-lore. As a first instalment towards the scientific study by Mr. Barbeau of French Canadian folk-lore, he has prepared a memoir of French Canadian folk-tales to be published by the American Folk-Lore Society. By request of the Dominion Parks Commission, the Division of Anthropology undertook to prepare a popular guide-book to the study of the Indians formerly inhabiting the region now occupied by the Rocky Mountains parks in Alberta and British Columbia. Mr. Barbeau undertook the actual writing of the guide-book, which is to be published by the commission.

F. W. Waugh spent a period of two months in field work among the Iroquois of Six Nations reserve, Ontario. A portion of the time was spent in prosecuting inquiries along a number of lines suggested by the work of previous seasons. The greater part of the time, however, was taken up with the collection of Iroquois folk-lore and mythology. About one hundred and thirty mythological and other tales were collected. This material is also of ethnological interest, as many references to witchcraft, medicine, divination, hunting, burial and other ceremonial customs, games, food preparation, and older handicrafts are found in it. This collection of folk-lore, like sets previously obtained by the division for other eastern tribes, will eventually help in throwing much light on the relation between European and aboriginal folk-lore. A number of valuable museum specimens was also obtained by Mr. Waugh in the course of the summer.

P. Radin continued to work up his manuscript on Ojibwa material, for publication by the Survey. The general paper on Ojibwa ethnology, referred to in the report for 1914, is now completed, also the second set of Ojibwa myths there mentioned. Further progress was made on the special paper devoted to Ojibwa religion and on the series of Ojibwa texts.

J. A. Teit spent a period of four months during the summer and autumn in continuing his ethnological reconnaissances among the Athabaskan tribes of British Columbia and Yukon Territory. A good deal of intensive work was done among the Kaska Indians, inhabiting the Dease River country between Dease lake and Liard river. The ethnological results include data on tribal divisions, material culture, social organization, and mythology. The division of the tribe into two exogamous phratries, Ravens and Wolves, was current among the Kaska as well as among the Tahltan, though not as much emphasized as among the latter. The latter part of the trip was spent in continuing researches among the Tàhltan of Telegraph creek, a good deal of new information being obtained on the social organization of this tribe. A large series of phonograph records of songs, photographs, and ethnological specimens was obtained in the course of the trip.

Canadian Arctic Expedition.

A letter dated January 5, 1915, from Bernard harbour, Coronation gulf, has been received from D. Jenness, the anthropologist of the Canadian Arctic expedition. It speaks of further progress in ethnological activity. A later report as to the work of the southern party, however, has come from Dr. R. M. Anderson, its executive head. This report is dated July 29, 1915, also from Bernard harbour. The portions of this that relate to anthropological work are here quoted:

"Ethnologically, D. Jenness has been able to accomplish a great deal of work among the hitherto little known groups of Eskimos in this region, including numbers of Akuliakattagmiut, Haṇeragmiut, Uallirmiut, Puiblirmiut, Pallirmiut, and Kogluktogmiut. He finds that these groups are not as definite as was formerly supposed, in fact the groups are pretty thoroughly mixed, both by intermarriages and by families shifting from one group to another, nearly every group containing individuals from other groups more or less remote. He has made good progress in linguistic work and vocabularies, made fifty or more gramophone records of various Eskimo songs and spoken words which he has had repeatedly reproduced before the natives so that he could get the text letter-perfect and translated for comparison with other Eskimo dialects. A considerable number of photographs of Eskimo people with their life and customs, have also been made by Mr. Jenness and other members of the party. Mr. Jenness' facility in learning the Eskimo dialects and the customs of the people has been of great service to the expedition in many ways. He made many trips in the winter, to the islands in the strait and to Victoria island, and in addition to his ethnographical work, usually obtained and brought home to the station on each trip, a quantity of fish, caribou, or seal meat, as well as engaging with natives to bring more meat over. While at the station Mr. Jenness acted practically all the time as interpreter and purchasing agent of the party in trading with the natives for fresh and dried meat, fish, skins, and clothing. In doing this work he collected a large number of specimens of Eskimo tools, weapons, and other implements, clothing of all kinds, stone lamps, and pots, a collection which is very complete for this region, and a large series of duplicates of many things.

"In the early spring, arrangements were made for Mr. Jenness to spend the summer with the Eskimos in the heart of Victoria island. He had a good quantity of provisions hauled across Dolphin and Union strait in early April and cached on the south side of Victoria island for his use if necessary in the autumn. He engaged a middle-aged Eskimo named Ikpukkuaq (who had been in that part of Victoria island before) together with his family, to accompany him and help him during the summer, Mr. Jenness supplying the man with a rifle and ammunition, which together with a tent and other things are to be given him if he serves Mr. Jenness faithfully and returns with him in the autumn. Mr. Jenness started on April 13, 1915, for Victoria island, with this family of Eskimos, and a few others who were thinking more or less seriously of joining the party. They started about the time the barren ground caribou began to migrate across to Victoria island in numbers, planning to follow the caribou migration north across the Wollaston peninsula, then go up to the head of Prince Albert sound, ascend a large river to a large lake called Tahieryuak, in the interior or west central part of Victoria island. When the snow disappeared they intended to cache their sleds, either at the head of Prince Albert sound or at the lake, and continue their journeys during the summer with pack dogs. That region is the summer hunting and fishing ground of a large number of the Kanghirmiut (Eskimo of Prince Albert sound) and Mr. Jenness hopes to gather much new and valuable ethnographical material concerning this hitherto little known group of Eskimos. Mr. Jenness expects to live with these Eskimos all the coming summer, and return to the south side of Victoria island in the autumn, following the caribou to the southward again, and return to the station at Bernard harbour as soon as the ice is strong enough to cross Dolphin and Union strait in the autumn.

"Mr. Wilkins brought a cinematograph outfit with him from the northern party's base on Banks island, and exposed about 2,000 feet of cinematograph film, principally views of the local Eskimos. He also obtained a small collection of Eskimo clothing, weapons, and instruments to send out for advertising purposes. Mr. Wilkins has made a very good series of portrait studies of most of the local Eskimos, men, women, and children, in full view and in profile, for Mr. Jenness' ethnographical work."

Manuscripts and Publications.

Manuscripts Received.

A number of manuscripts of ethnological interest were obtained during the year as gifts. These embrace:

From P. Radin.—

"Autobiography of a Winnebago Indian," manuscript of 103 pages (MS. 59).

From F. G. Speck, Philadelphia, Pa.—

"Studies of the Beothuk and Micmac of Newfoundland," manuscript of 66 pages and 4 negatives (MS. 71).

"Nova Scotia Hunting Territories" and "Prince Edward Island Band of Micmac," manuscript of 8 pages (MS. 66).

Manuscripts turned in to the division as a result of field work undertaken under the auspices of the Geological Survey include:

By E. Sapir.—

"A Sketch of the social organization of the Nass River Indians," manuscript of 40 pages (MS. 67a).

By E. W. Hawkes.—

"The Labrador Eskimo," manuscript of 170 pages (MS. 60).

By P. Radin.—

"The Ethnology of the Ojibwa of southeastern Ontario," manuscript of 216 pages (MS. 65).

"Literary aspects of North American mythology," manuscript of 49 pages (MS. 64).

By P. Radin and A. B. Reagan.—

"Ojibwa myths and tales," manuscript of 128 pages (MS. 67, including MSS. 9 and 31).

By W. D. Wallis.—

"Dakota ethnology," manuscript of 587 pages (MS. 69).

Ethnological manuscripts purchased in the course of the year embrace:

From Alex. Thomas, Alberni, B. C.—

"Ucluelet legend," Nootka text, manuscript of 105 pages (MS. 50 p.)

" 'owimhl'ni as a whaler," Nootka test, manuscript of 8 pages (MS. 50q).

"Tom's Wolf ritual," Nootka text, manuscript of 211 pages (MS. 50r).

From Frank Williams, Alberni, B. C.—

"Story of how Kwatiyat went for a walk," Nootka text, manuscript of 4 pages (MS. 70).

"Story of a young man who got married and became angry," Nootka text, manuscript of 2 pages (MS. 70a).

From F. G. Speck, Philadelphia, Pa.—

"Wawenock texts," manuscript of 52 pages and 3 negatives (MS. 72).

Manuscripts Submitted for Publication.

In the course of the year the following papers have been submitted to the Deputy Minister of Mines for publication by the division:

F. G. Speck.—

"Hunting territories of the Micmac Indians" (bulletin).

E. Sapir.—

"A Sketch of the social organization of the Nass River Indians" (bulletin).

F. W. Waugh.—

"Iroquois foods and food preparation" (memoir).

P. Radin.—
"Literary aspects of North American mythology" (bulletin).

C. M. Barbeau.—
"Huron and Wyandot mythology, with an appendix containing earlier published records" (memoir).

F. H. S. Knowles.—
"The glenoid fossa in the skull of the Eskimo" (bulletin).

E. W. Hawkes.—
"The Labrador Eskimo" (memoir).

Anthropological Publications.

The following bulletins were published in 1915:

V. Stefansson.—
"Prehistoric and present commerce among the Arctic coast Eskimo" (Bulletin 6, Anthropological Series No. 3).

P. Radin.—
"The social organization of the Winnebago Indians" (Bulletin 10, Anthropological Series No. 5).

P. Radin.—
"Literary aspects of North American mythology" (Bulletin 16, Anthropological Series No. 6).

F. H. S. Knowles.—
"The glenoid fossa in the skull of the Eskimo" (Bulletin 9, Anthropological Series No. 4).

E. Sapir.—
"A sketch of the social organization of the Nass River Indians" (Bulletin 19, Anthropological Series No. 7).

The following memoirs were published in 1915:

F. G. Speck.—
"Decorative art of Indian tribes of Connecticut" (Memoir 75, Anthropological Series No. 10).

"Family hunting territories and social life of various Algonkian bands of the Ottawa valley" (Memoir 70, Anthropological Series No. 8).

"Myths and folk-lore of the Timiskaming Algonquin and Timagami Ojibwa" (Appendix by Neil C. Fergusson) (Memoir 71, Anthropological Series No. 9).

E. Sapir.—
"Abnormal types of speech in Nootka" (Memoir 62, Anthropological Series No. 5).

"Noun reduplication in Comox, a Salish language of Vancouver Island" (Memoir 63, Anthropological Series No. 6).

C. M. Barbeau.—
"Classification of Iroquoian radicals with subjective pronominal prefixes" (Memoir 46, Anthropological Series No. 7).

"Huron and Wyandot Mythology" (Memoir 80, Anthropological Series No. 11).

PART II.

ARCHÆOLOGY.

(Harlan I. Smith.)

Exhibits.

The archæological exhibits have been made more complete by the addition of representative material resulting from our field work in Manitoba, such as was not previously possessed by the Museum.

Labels have been typewritten on paper harmonizing in colour with the cases and placed with most of the specimens.

Accessions.

The chief additions to the archæological collections are as follows:

Collected by Officers of the Department.

Accession 154. Archæological specimens, human bones, and photographic negatives, from Roebuck, Ontario. Collected by Mr. W. J. Wintemberg on Geological Survey expedition.

Minor additions from expeditions are as follows:

Accessions 156, 161, 166. Archæological specimens, human bones, and photographic negatives, from Manitoba. Collected by Mr. W. B. Nickerson on Geological Survey expedition.

Accessions 173, 175. Archæological specimens from Ontario. Collected by Mr. W. J. Wintemberg on Geological Survey expedition.

Accessions 159, 160, 162. Archæological specimens and photographic negatives, from British Columbia. Collected by Mr. Harlan I. Smith on Geological Survey expedition.

Other accessions include those sent in by officers of other divisions of the Geological Survey, as follows:

Accession 165. Chips and chipped points of greenish-grey laminated chert, from a prehistoric workshop near Milford creek, British Columbia. Collected by Mr. O. E. Leroy on Geological Survey expedition.

Accession 176. Grooved stone hammer and tip of chipped point of obsidian from Alberta. Collected by Mr. George F. Sternberg on Geological Survey expedition.

Accession 177. Archæological specimens from shell-heap in New Brunswick. Collected by Mr. A. O. Hayes on Geological Survey expedition.

Presented.

Gifts were received as follows:

Accessions 150, 151. Indian war-club from Francois lake, British Columbia; and a small axe, from Fraser lake, British Columbia. Presented by Mr. W. J. McAllan, Indian Agent, Stuart Lake agency, Fort Fraser, British Columbia.

Accession 152. Archæological specimens, from Victoria county, Ontario. Presented by Mr. George E. Laidlaw, The Fort Ranch, Victoria Road, Ontario.

Accession 153. Point chipped from chert, from Port Robinson, Ontario. Presented by Mr. E. R. Williams, Westboro, Ontario.

Accession 157. Mortar made of stone, from Crescent, British Columbia. Presented by Mr. W. J. Riley, Crescent, British Columbia.

Accession 158. Celt made of stone, from Great Fraser Midden, Eburne, British Columbia. Presented by Mr. Thomas J. Oakes, New Westminister, British Columbia.

Accession 163. Grooved adze made of stone, from near Telkwa, British Columbia. Presented by Mr. P. R. White, Hubert, British Columbia.

Accession 164. Pestle and mortar, from shell-heap at Crescent, British Columbia. Presented by Mr. G. Triggs, Crescent, British Columbia.

Accession 167. Grooved stone axe, from Sourisford, Manitoba. Presented by Mr. David Elliot, Sourisford, Manitoba.

Accession 168. Grooved stone hammer, from Arden, Manitoba. Presented by Mr. Russell McKenzie, Arden, Manitoba.

Accession 169. Grooved stone axe, from near Arden, Manitoba. Presented by Mr. D. McRae, Arden, Manitoba.

Accession 170. Knife chipped from chert, chips, and potsherds, from Foreman farm, east of Arden, Manitoba. Presented by Mr. J. C. Foreman, Arden, Manitoba.

Accession 171. Knife blade made of iron, from Arden Mound, Arden, Manitoba. Presented by Mr. J. F. Choate, Arden, Manitoba.

Accession 172. Unfinished butterfly banner stone, from Brant county, Ontario. Presented by Mr. F. W. Waugh, Geological Survey, Ottawa.

Accession 178. Archæological specimens, from Lytton, British Columbia. Presented by Rev. H. J. Underhill, Yale, British Columbia.

Purchased.

Accession 155. Archæological specimens, from above Tadoussac, Quebec. Purchased from Prof. Frank G. Speck, Philadelphia, Pennsylvania.

Field Work and Research.

Field work was carried on in eastern Ontario, southern Manitoba, and British Columbia, in an effort to explore where local and provincial archæologists were not already working and to add to the key or standard reference collections so far secured, namely, one of prehistoric Iroquoian culture from near Roebuck, Ontario, one of prehistoric Micmac culture from Merigomish, Nova Scotia, and the one obtained by the Geological Survey some years ago of the prehistoric culture of the interior of southern British Columbia.

The work in Ontario was carried on by Mr. W. J. Wintemberg who devoted the time from April 24 to May 20 in excavating at the prehistoric Iroquoian village site near Roebuck, Ontario. He uncovered and mapped the traces of the palisade across the farm of Mr. Nathaniel White, which, being under crop, was not excavated by him in 1912, when he explored the greater part of the site. This season's exploration also resulted in securing thirty-three human skeletons and many objects made by the prehistoric people of the place. Many of these skeletons were photographed in situ. Several of them show conclusively that the people suffered from terrible diseases which caused growths upon the bones and the abnormal union of certain bones. Their teeth also gave them great trouble. Among the important specimens found were an unfinished comb made of antler and two barbed fish hooks made of bone. Many fragments of pottery and of pipes made of pottery were also found. Some of the latter are sculptured to represent the human face and are of artistic merit.

From July 12 to 20 Mr. Wintemberg studied material from Ontario in the museums of Toronto.

In September, Mr. Wintemberg examined a mound-like knoll on Waupoos island, Prince Edward county, Ontario, and found it to be natural, but collected a few specimens on the island. An Algonkian site on the south shore of Weller bay, about 2 miles west of Consecon, was found to be small. A few specimens were collected on Bald head, an island in the bay, where large quantities of Algonkian material had been found. In October, he completely excavated one of ten similar mounds on Massasauga point, in the same county, but found only charcoal, clam shells, and bones of fish and mammals. A supposed earthwork near River Beaudette, Soulanges county, Quebec, was visited, and found to be natural. A mound near Maxville, Glengarry county, Ontario, proved to be natural but used as a burial place within a hundred years.

The work in Manitoba was carried on by Mr. W. B. Nickerson during July and August. Only one artificial mound was found in the region north of Alexander. It was on the most conspicuous headland overlooking the Assiniboine river and about 6 miles north of Alexander. This Mr. Nickerson explored and found to be a burial mound. Among the finds were one hundred and sixty-two marine shells ground across so as to form an eye to allow them to be fastened to a garment or strung as beads, and six cylindrical objects—beads or pendants—made of the columella of the conch. They indicate trade or expedition as far as the sea. Two groups, each of more than one hundred gravel mounds, on terraces in the Assiniboine valley, were found to be of natural origin, although resembling artificial burial mounds in appearance. No mounds were found in the valley of the Little Saskatchewan, and slight evidence of habitation. Near Arden, Mr. Nickerson explored a long mound, consisting of two dome-shaped ends with a connecting grade, and a broad, dome-shaped mound, in which were found parts of three human skeletons, a perforated disk made of shell, and two objects made of bone, probably used as bracelets. A third mound, within the village of Arden, had been previously disturbed. Several camp sites were found at the foot of the Assiniboine hills at springs forming small streams, also in the vicinity of Arden, along the White Mud river. Mr. Nickerson took seventy-five photographic films in connexion with this work and secured a number of the above listed gifts for the Dominion collections, from Messrs. Elliot, McKenzie, McRae, Foreman, and Choate.

The work in British Columbia was carried on by Mr. Harlan I. Smith, who inspected sites and collections near Kamloops, Lytton, and Yale, and photographed specimens from near Yale in three unobtainable private collections. These were of sculptures, among the most striking known from Canada. He also inspected the great shell-heap, the refuse of a prehistoric village at Eburne, found a few specimens, and noted that since his exploration here in 1898 much of the site left unexplored had been removed for roads or building purposes or had been covered by pavements and buildings so that many specimens had been lost and others could not now be reached. The above listed gift from Mr. Thomas J. Oakes was received and one fine mortar bearing the sculpture of a human face found at the site was promised as a gift to the Dominion collections by Mr. R.

J. Tait of Eburne, who kindly offered to send such other specimens as he might find. A shell-heap at the mouth of the north arm of Fraser river was visited. The museums of New Westminster and Vancouver were visited and in the Museum of The Art, Historical, and Scientific Association in the Public Library building, Vancouver, a sculpture from Yale was noted. Two small shell-heaps were located in Stanley park, Vancouver, one near but west of the north entrance, the other on the western side of the park. A rich, large shell-heap at Crescent said to contain cairn burials, was visited and the two gifts, listed above, of specimens from the heap were secured. This opportunity was taken to inspect a prehistoric fort consisting of a semi-circular embankment about 4 feet high by 8 feet wide with exterior ditch about 4 feet deep by 12 feet wide, defending the land side of a small area on top of a bluff overlooking the sea about a mile south of Crescent to which our attention was called by Mr. G. H. Whyte of the Hydrographic Survey in 1913. A fir stump about 10 feet in diameter, standing on the southwestern part of the embankment, suggested its age to be considerable. Photographs were taken of the fort, which it would be well to conserve by the establishment of a Provincial or Dominion park enclosing it as a historic landmark. Dean R. W. Brock of the University of British Columbia, Vancouver, reported large shell-heaps on Gabriola island. The Hon. Frank H. Shepard, M.P., of Nanaimo, gave information of a petroglyph, representing a salmon, close to Digman's wharf on the southern part of Gabriola island. Mr. William Hogan, of Nanaimo, referred to petroglyphs on the face of the rocks below the white house but above high tide on Jack point. A petroglyph south of the Brechin mine near Nanaimo, reported to us by Mr. W. J. Dick of the Conservation Commission, was photographed and a cave on the north end of Newcastle island where human bones have been found was noted. A shell-heap about 3 feet high was seen along the entire northern part of the west shore of Departure bay, and another about 20 feet above high tide where the biological station is located on the north shore. Important specimens in the Provincial museum at Victoria were listed and arrangements were made for securing casts of them.

A reconnaissance was made up the Skeena valley into the Bulkley as far as Hubert. Four extensive shell-heaps, marking as many ancient villages, parts of them shown to be at least several hundred years old by the large tree stumps on top of the top layers, were found near Prince Rupert. The southernmost is at the place marked Willaclagh on Dawson's map of 1879. Dried bodies are reported in a cave on Birnie island opposite Port Simpson. A high shell-heap with trees over a hundred years old standing on top was reported as at the quarantine station on Digby island. Human skeletons and specimens are said to have been found here in abundance and to have been turned over to Dr. C. F. Newcombe of Victoria. A very deep shell-heap and burials were also reported as on Little Digby island. A red pictograph of a salmon was reported as seen from Hocsall river between 10 and 15 miles above the Balmoral cannery. A village site was reported as 7 miles up Kitsumgallum river. The Indians report an extensive and old village site on the west side of Skeena river between Fiddler creek and Lorne creek. Graves are said to have been cut through by the Grand Trunk Pacific railway about half a mile below Cedarvale. A small camp site was discovered at the foot of the rapids in Skeena river opposite Terrace. A mound about 3 miles north of Kitwanga was visited and found to be a very symmetrical but naturally cut off bit of terrace, the top of which had been the site of at least two houses, possibly a fort or lookout of Indians or trappers. A village site, possibly modern, was seen on top of the first terrace above the flood-plain of Bulkley river south of Hazleton. A point chipped from stone for an arrow or knife is said to have been found at mile-post 194 on the Grand Trunk Pacific.

A small camp site was discovered at the mouth of Lake Kathlyn. It was higher above the water than expected. On excavation it was found to contain charcoal, ashes, fire cracked stones, bones of deer, beaver, fish, and other animals, some of them broken, others charred, part of a point chipped from stone, a point or barb made of bone, and the basal end of a sharpened piece of bone, possibly an awl. On the surface nearby were fragments of three bark peelers made of antler, which, however, may be of more recent date. The gift of an adze made of stone resembling in shape adzes of the coast and found on a camp site on the farm of Mr. P. R. White of Hubert was secured from him. This site, about 2 miles from Bulkley river, was farther from the river than expected, but near a beaver dam on the bank of a small creek.

Research on the material from the prehistoric Iroquoian village site near Roebuck, Ontario, has been carried on by Mr. Harlan I. Smith and Mr. W. J. Wintemberg, and on the archæology of Merigomish harbour, Nova Scotia, by Mr. Smith. Mr. Wintemberg has also added much to the data of his study of the bird stone ceremonial. Many additions have been made to both the card catalogue of archæological literature and the files of data. All the material collected during the field work near Merigomish, Nova Scotia, in 1914, 802 entries; in eastern Ontario in 1914, 134 entries; in Manitoba in 1914, 123 entries; on the prehistoric Iroquoian village site at Roebuck, Ontario, in 1915, 427 entries; during the field work in Manitoba and British Columbia, in 1915; about one-fourth of the collection received in 1914 from the Canadian Arctic expedition; as well as all the material otherwise acquired during the year, and some of the old material has been cleaned and catalogued. Some of the entries cover as many as twenty-four specimens.

PART III.

PHYSICAL ANTHROPOLOGY.

(*F. H. S. Knowles.*)

Museum.

Accessions.

Museum material coming under the head of physical anthropology was received in the course of the year as gifts and as a result of field work undertaken by the division.

The gifts embrace:

From Frederick Petrie.—

A lower jaw from Prince Rupert, B. C., found in the course of blasting when constructing the Transcontinental railway.

From J. A. Teit.—

A skull picked up on Canadian Northern dump $3\frac{1}{2}$ miles west of Spence Bridge on the north or right bank of the Thompson river.

From W. J. Wiley.—

A skull from Crescent, B. C.

The material obtained in the regular field work for the Survey is as follows:

By W. J. Wintemberg.—

32 skeletons from the Iroquoian village site at Roebuck, Grenville county, Ont.

By W. B. Nickerson.—
5 skeletons from mounds in Manitoba.

By F. H. S. Knowles.—
A skull and left humerus from an old, but post-European, Iroquoian cemetery on the bank of the Grand river at Middleport, Brant county, Ont.
Skeletal material from an ossuary near Sherks, Welland county, Ont.
Anthropometric schedules containing the measurements of three Nass River chiefs who visited the Museum in February, 1915.
694 anthropometric schedules containing the measurements of Iroquois from Tonawanda reserve, N. Y., and Six Nations reserve, Brant county, Ont., with some few Delawares and Mississaugas from the latter reserve.

Photographic Work.

During this year 59 negatives have been made illustrating cranial types among the Iroquoian and northern Algonkian tribes. This series comprises 25 photographs of crania from the ancient Neutral ossuary at Middleport, Brant county, Ont., excavated by Mr. Knowles in the summer of 1912; while, thanks to the kindness of Dr. R. B. Orr, of the Provincial museum, Toronto, of Mr. C. T. Currelly, of the Royal Ontario Archæological museum, Toronto, and of the Buffalo Society of Natural Sciences, Mr. Knowles, when on field work, was able to secure the following photographs:

18 negatives of Huron and Neutral crania in the collection at the Provincial museum, Toronto.

12 negatives of crania from mounds in Manitoba and from the "Serpent" mound, Otonabee, Ont., in the collection of the Royal Ontario Archæological museum at Toronto.

4 negatives of Iroquoian crania in the collection of the Buffalo Society of Natural Sciences.

In the course of field work, a number of photographs were taken of types among the Iroquois and Delaware Indians. Photographs such as these are of great importance. In the first place they illustrate the variety of types to be seen among any one tribe. Secondly, by exhibiting enlargements made from a selected series, differences in physical characteristics among the various Indian tribes of Canada can be shown readily, and in a manner that can be instantly appreciated by the general public.

Research.

Further progress has been made in the research into the physical characteristics of the ancient Iroquoian tribes. Starting with an examination of the skeletal material from the Neutral ossuary at Middleport, Brant county, Ont., notes and measurements from other Neutral remains are being gradually accumulated. Measurements of crania from Neutral ossuaries, in Clinton township, (Lincoln county), Oxford township (Kent county), Beverly township (Wentworth county), from near Jerseyville in Wentworth county, and, lastly, Humberstone township (Welland county), have been obtained from the cranial collection in the

Provincial museum at Toronto. Measurements of crania from an ossuary in Humberstone township (Welland county) and an ossuary near Sherks, in the same county, were obtained from the collection of the Buffalo Society of Natural Sciences. Under the guidance of Mr. W. Bryant, of the Buffalo Society of Natural Sciences, Mr. Knowles visited the site of the latter ossuary. In the course of the construction of a light railway, this burial pit had been broken into, so that the bones are now in a very fragmentary condition. A few of the long bones that were still whole, with some of the least injured crania, were collected, and the material, although scanty, will yet serve to add somewhat to our knowledge of the physical appearance of the ancient Neutral tribes. By kind permission of the Buffalo Society of Natural Sciences, a number of measurements were taken from skeletal material collected by the Society from interments, presumably Neutral. From the same collection measurements were obtained of a series of crania from a post-European Seneca cemetery.

Through the courtesy of Mr. C. T. Currelly, an examination was made of skeletal material from the "Serpent" mound, Otonabee, Ont., and from various mounds in Manitoba. Measurements were taken from these remains, and negatives made from a selected series of the crania. The remains from the Otonabee mound are of very great interest. Belonging, as they undoubtedly do, to members of Algonkian tribes who were the northern neighbours of the Hurons, their narrow noses and massive cheek-bones may afford some explanation of certain types met with among crania from ossuaries of the Iroquoian tribes; especially when we recall the custom of adoption so universal among the latter peoples.

Material of the greatest importance for our purpose has been furnished by the excavation of the ancient Iroquoian village site at Roebuck, Grenville county, Ont., so carefully and thoroughly carried out by the archæological section of the division. In 1912, fifty-one skeletons were recovered from this site. Measurements have already been taken from this material, but to the results of this work there must now be added a study of the further accession of some thirty-two skeletons procured from Roebuck, during this summer, by the archæological section. When the whole results of our examination into the remains of this tribe have been summarized, a very valuable addition will have been made to our researches into the physical characteristics of those Iroquoian tribes that once inhabited the southern regions of Ontario.

In May Mr. Knowles left Ottawa in order to prosecute his anthropometric work among the modern Iroquois. Since the Iroquois on the Tonawanda reserve, N.Y., are considered to be, on the whole, of purer blood than those on the other Iroquoian reserves, it was decided to start the season's work there. Great assistance to the work here was afforded by the kindness of Mr. A. C. Parker, of the New York State museum at Albany, N.Y. Some two months were spent at Tonawanda and the results of the work were highly satisfactory. Photographs were taken of a number of excellent types, and measurements of some 160 individuals were obtained. Six Nations reserve in Brant county, Ont., was next visited. This is the largest and probably most representative Iroquoian reserve in Canada. Both for this reason, and because a series of measurements from individuals on this reserve had been obtained in 1912, it was decided to continue anthropometric work here. Measurements of some 500 Iroquois were obtained, together with those of a few Delaware and Mississauga Indians. Combining this series with that obtained from the same reserve in 1912, we have now a satisfactory sample, illustrating the variation and averages that are likely to be found among the measurements of the Iroquois in Canada. In this reserve a number of very interesting types were noticed and a good series of photographs secured.

The result of the summer's field work on these two reserves makes it plain that, owing to the intermixture with Europeans of many nationalities, the measurements among the modern Iroquois exhibit an extraordinary range of variation. Taking the averages of the characteristic measurements of the width of the face and nose, it is evident that the mixture of European blood has greatly modified the ancient Iroquoian type; and yet, owing to the varied nationalities of the Europeans with whom these people have intermingled, the long period of time during which this intermixture has been going on, and the great probability and indeed almost certainty that, even in pre-European times, the Iroquoian tribes were composed of peoples exhibiting wide divergences in physical characteristics, it is evident that from the measurements obtained nowadays it would be quite impossible to disentangle the various elements entering into the physical characteristics of the very composite modern Iroquois. The measurements secured are, however, of great interest, precisely for their illustration of this wide variation among the Iroquois of the present day, while, when sufficient measurements have been obtained from the skeletal remains of the ancient Iroquoian tribes, it may be possible, with regard to those measurements that are at all comparable, to institute some comparison between the ancient and modern Iroquois.

In addition to these results there is another very interesting side to anthropometric work among the modern Iroquois. Even at the present day, whether owing to the fact that some families have escaped altogether the influence of European blood, or, simply, to reversion to an ancestral Iroquoian type, there are still to be found among them individuals who are undoubtedly good representatives of Iroquoian types, and in their physical appearance must closely resemble the Iroquois seen by the first Europeans to explore this country. These individuals are few in number now, and must, as time goes on, become fewer still; nor is it probable that their place will be taken by others, so certain and so rapid is the assimilation of the Iroquois by the white.

Photographs, casts, and modelled busts and reliefs, form the only means by which we can hope to perpetuate these few records of the physical appearance of this most interesting people—that is to say, their appearance when still a confederation of tribes of purely Indian blood. A gallery composed of enlargements from photographs, casts taken in the field, and busts and reliefs modelled either from life or from measurements and photographs, of the most striking and purest types to be found among them nowadays, should prove both of the greatest general interest and of much historical value. It would illustrate in as complete a manner as it is ever possible to do at this period of their history, the variety of facial types that could once have been seen among the various Iroquois tribes.

Report on a Skeleton from near Savona, B.C., Submitted for Examination by Mr. C. Hill-Tout, Abbotsford, B.C.[1]

This skeleton is in a somewhat defective condition. Of the skull, the facial and basal portions, most of the right side of the brain case, and the lower jaw, are missing. The long bones also are in poor shape, but the femora are measureable and it has been possible to restore the left tibia so that its length can be estimated. The remainder of the skeleton is represented by fragments. The surfaces of the bones are unworn, nor are there any marks of abrasion.

Judging from the size of the articular heads of the long bones and from the characters of the skull, this skeleton is evidently that of a woman, and that she was well on in years is shown by the condition of the cranial sutures. Esti-

[1] Cf. geological report of C. Drysdale, pp. 91 and 92.

mating her stature from the lengths of her femur and tibia, according to Professor Karl Pearson's formulae, she was probably about 5 feet in height.

The vertebrae, and the knee, temporo-mandibular, and sacro-iliac joints, are arthritic, showing that this woman must have suffered from chronic rheumatism. Arthritic conditions of the joints are very frequently found in the skeletons of Indians, more especially in the case of individuals advanced in years. Very probably this is due, in great part, to exposure and hard conditions of life generally. An accessory facet on the anterior margin of the lower articular surface of the tibia indicates that this woman was accustomed to rest in a squatting posture, as is usual among primitive peoples.

The platycnemic shape of her tibiae and the strongly marked linea aspera on her femur bear witness to an active mode of life in her earlier years.

The loss of the face deprives the skeleton of characters of prime importance in diagnosing the race of the individual. In this case, however, the upper part of the nasal bones are still left. These bones are broad and rather flat; the root of the nose is not depressed but the line of the nasal bridge runs uninterruptedly up into the line of the forehead, all characters which can often be seen in the skulls of Indian women.

The detailed measurements and notes on these remains are as follows: the maximum breadth, as estimated, about 132 mm. The cephalic index would, therefore, be 74·6. But, owing to the fact that most of the right side of the skull is missing, and the certainty that there has been some posthumous distortion, the extent of which can not be judged, the accuracy of the measurements and the cephalic index of this skull must remain open to doubt.

The temporal muscles and those at the back of the neck are quite well developed. The mastoids are of medium size. The forehead is well arched and the brow ridges very slightly marked. There is a slight degree of "annular constriction" present. The glenoid fossa is deep; on the summit of the left eminentia articularis (the right temporal bone is missing) there is a small eroded patch, one of the arthritic conditions already noted. The nasal bones at their root are flat, and measured at their junction with the frontal bone, very broad, being probably about 17 mm. in diameter, but the limit of the left nasal bone is difficult to determine, owing to the ossification of the sutures here and the possibility of an abnormal extension of the nasal bone of this side and its consequent encroachment upon the junction between the frontal bone and the nasal process of the left maxillary. The minimum frontal diameter was evidently less than the inter-fronto-malar width, a condition usually present in Indian crania. The long bones are short and slight. The humeri are too defective for measurement; the olecranon fossa is imperforate. The length of the right femur measured in the straight position, is 377 mm. in the oblique, 374 mm., and the diameter of its head is 42 mm. The lower extremity of the left femur, particularly, exhibits much "lipping" of the margins and erosion of the articular surface. The length of the left tibia, with the articular spine included, is 308 mm. In both tibial shafts the transverse diameter, at the level of the nutrient foramen, is 20 mm., the antero-posterior diameter 31·5 mm. The platycnemic index is, therefore, 63·5. There is a slightly marked accessory facet on the anterior margin of the inferior articular surface of the tibia.

But few vertebrae are present and these are in a very fragmentary condition; enough are left, though, of some, probably lumbar, vertebrae, to show the "lipping" of the margins and erosion of the articular surfaces so characteristic of arthritis.

On the whole, then, from the survey of the general characters of this skeleton, there is nothing that would distinguish it from that of a modern Indian woman.

It would be interesting to compare this skeleton with those of the modern tribes inhabiting that region. But here we are confronted with the small amount of data afforded by the skeleton under discussion. The Indians in the immediate neighbourhood of Kamloops lake are the Shuswap; these tribes are of rather small stature, with small, brachycephalic, heads, and convex noses.[1] Now turning to the Savona woman: her height of 5 feet is within the limits of female stature in either a small or a tall people; nothing can be positively asserted from this character although the inclination would be to consider her as a member of a small rather than a tall tribe. Platycnemic tibiae and the "squatting facet" are both characters common to all Indian tribes, at any rate in their native state. Her head is small, and although its mere size might be paralleled by Indian female skulls from any locality, yet here again, as in the matter of her height, one would be inclined to place her among the small rather than the large-headed tribes. The nasal bones are broad and rather flat at the root, characters not restricted to any one Indian people and characters that do not affect the convexity and prominence of the nose. The length of the head falls within the limits of the lengths of Shuswap crania, but is also of a size that might be found in any Indian female skull. There remains the breadth of the head and the cephalic index, and here, at first sight, we might seem to have in these two characters a definite distinction between this skull and those of the tribes inhabiting this region, the width of the Savona skull being narrow and the index low as compared with the more brachycephalic proportions in the heads of the Shuswap tribes. But, it is necessary to remember the width of the Savona skull and its cephalic index (74·6) can be considered only as an estimate from the present proportions of this cranium. Almost certainly there has been some posthumous distortion in the case of this skull, the amount of this being difficult to determine, owing to the loss of the basal parts and right side. However, the main point is that this distortion is along the lines of a reduction in breadth with a compensatory elongation in length. Therefore, there must remain a strong suspicion that the index as at present estimated is lower than would have been the case had the skull been whole and in its correct shape. Furthermore Dr. Boas instances a Shuswap cranium having a cephalic index of 76[2]. The same authority gives a minimum cephalic index among 72 Shuswap Indians as 77[3]. In the skeleton this would be equivalent to a cephalic index of 75. Now the cephalic index of the skull under discussion as at present estimated is 74·6, or practically 75. Hence even were the amount of distortion negligible, it would still be a matter of doubt as to whether it would be correct to separate the Savona skull from the Shuswap group on account of its comparatively low cephalic index; the range of individual variations in the case of measurements and indices being always very considerable. Any attempt, therefore, to separate this skeleton from the skeletons of the modern Shuswap on the strength of the head breadth and cephalic index alone, must remain open to these very serious objections. On the whole, then, I think that we may justly say that any distinction between this skeleton and those of the modern Shuswap tribes, on the skeletal evidence alone, must be considered non-proven. Therefore, until and unless contrary evidence, geological or otherwise, can be produced, the presumption must remain that the Savona find is an interment of a modern or comparatively modern date.

[1] See Twelfth Report on the North Western Tribes of Canada, British Association for the Advancement of Science, 1898.
[2] See 7th Report on the Northwestern Tribes of Canada, British Association for the Advancement of Science, 1891.
[3] Physical Anthropology of the North American Indians, Zeitschrift fur Ethnologie, vol. 27.

GEOGRAPHICAL AND DRAUGHTING DIVISION.

(*C. Omer Senécal.*)

During the past year, one map compiler and a keeper of map records have been appointed on the staff of the geographical and draughting division, which at present comprises a chief officer, his assistant, eight map compilers and draughtsmen, one copper engraver, and two clerks.

The Gatineau, Onaping, and Rainy River maps, referred to in last report, have been completed during the year and copy is nearly ready for the engraver. Besides these, there are at present twenty-five maps in various stages of preparation for the engraver or lithographer, including five topographical sheets and twelve other maps, copy of which is practically finished and requires final revision only.

New general maps of Yukon Territory; Mistassini-Abitibi districts, Quebec; basin of upper Ottawa river, Quebec; and northeastern Ontario are under construction for the consolidation of geological data covering these respective areas, maps of which have been issued separately.

A map of the exploration of Taltson and Tazin rivers, in Saskatchewan and North West Territories, and one covering an area of central and western Nova Scotia comprising several new serial sheets on the scale of one mile to one inch, are in progress of compilation.

The compilation of the Nova Scotia serial sheets Nos. 85, 86, 87, 88, and 98, covering an area of 1,080 square miles, has been completed and the preparation of the engraver's and lithographer's copy awaits the completion by the geologist of the geological copy, legends, and sections.

Sheets Nos. 89, 90, 91, 96, 97, and 100 of the same series are also practically compiled, but require further revision of the topography.

The printing of the geological maps to accompany the French edition of the excursion guide-books of the Twelfth International Geological Congress was completed during the year. A list of these 138 maps is given in the Summary Report for 1913.

Attention was, as usual, given to the work of the Geographic Board of Canada of which the chief of this division is a member.

The maps listed below were in the hands of the King's Printer at the end of the year for engraving and printing.

Maps in Hands of the King's Printer, December 31, 1915.

Series A.	Publication number.	Title.	Sent to King's Printer.
37	1183	Beaverdell, B.C., geology	Feb. 4, 1915.
59	1230	Wheaton district, Yukon, topography	March 23, 1915.
63	1238	Moncton sheet, N.B., topography	March 1, "
66	1245	Brechin sheet, Ont., topography	April 18, "
67	1246	Kirkfield sheet, Ont., topography	April 18, "
150	1539	Ponhook Lake sheet, N.S., geology	Sept. 1, "
157	1567	East Sooke, B.C., topography	Nov. 18, "
158	1568	Nanaimo sheet, B.C., geology	July 27, "
159	1569	Nanaimo sheet, B.C., surface geology	July 27, "
160	1570	Nanaimo sheet, B.C., economic geology	July 21, "
169 to 173	1586 to 1590	Road materials in Ontario; 5 maps	Dec. 24, "
...	1599	Diagram of Roebuck site, Ont	Dec. 16, "
...	1600	Diagram of refuse heap No. 1, Roebuck site, Ont	Dec. 16, "
...	1002	Special map of Rossland, B.C., geology (reprint)	Oct. 1, "
...	1004	Rossland Mining Camp, B.C.; geology (reprint)	Oct. 1, "

The office engraver has almost completed the engraving of the topographical map of the Frank landslide (1903). He also engraved geographical projections for several topographical maps and corrected to date the plate of map of Yukon Territory, No. 917.

During the year, 142 sketch maps, diagrams, text figures, indexes, and miscellaneous drawings were prepared for the illustration of memoirs in course of publication by the different divisions of the Geological Survey, or for use in the Museum.

A list of the Geological Survey maps, received from the Printing Bureau during the calendar year, is appended herewith.

List of Geological Survey Maps Published During the Year 1915.

Series A.	Publication number.	Title.	Remarks.
		Yukon Territory.	
—	772	Klondike mining district, scale 2 miles to 1 inch	Topography and geology, reprint.
—	885	Klondike and vicinity, scale 8 miles to 1 inch	Water supply, reprint.
—	886	Klondike mining district, scale 2 miles to 1 inch	Topography and economic geology, reprint.
—	990	Portion of Conrad and Whitehorse mining district, scale 2 miles to 1 inch	Topography and geology, reprint.
122	1354	Upper White River district, scale, 1 : 250,000	Topography.
123	1354	Upper White River district, scale, 1 : 250,000	Topography and geology.
140	1443	Yukon-Alaska boundary, south sheet, scale, 1 : 125,000	Topography and geology.
141	1444	Yukon-Alaska boundary, north sheet, scale, 1 : 125,000	Topography and geology.
—	1489	Diagram of Bonanza creek, scale 2 miles to 1 inch	Meteorology.
—	1491	Diagram of southwestern portion of Yukon Territory, scale 20 miles to 1 inch	
		British Columbia.	
—	1001	Special map of Rossland, scale 400 feet to 1 inch	Topography, reprint.
—	1003	Rossland mining camp, scale 1,200 feet to 1 inch	Topography, reprint.
33	1179	Nanaimo sheet, scale, 1 : 62,500	Topography, reprint.
36	1182	Beaverdell area, scale, 1 : 62,500	Topography.
41	1191	Duncan sheet, scale, 1 : 125,000	Topography.
109	1313	Prescott, Paxton, and Lake mines, Texada island, scale, 1: 4,800	Topography.
110	1314	Prescott, Paxton, and Lake mines, Texada island, scale, 1: 4,800	Topography and geology.
111	1319	Vananda, Texada island, scale 2,000 feet to 1 inch	Topography.
112	1320	Vananda, Texada island, scale 2,000 feet to 1 inch	Topography and geology.
139	1412	Coal-fields of the province, scale 35 miles to 1 inch	Economic geology.

—	1413 to 1435	Twenty-three diagrams of coal-fields	Economic geology.
142	1445	Field, Kootenay district, scale 2 miles to 1 inch	Topography and geology.
143	1446	Shuswap lake, Kamloops district, scale 4 miles to 1 inch	Topography and geology.
20	1148	Victoria sheet, scale, 1 : 62,500	Topography, reprint.
70	1251	Victoria sheet, scale, 1 : 62,500	Topography and geology.
71	1252	Victoria sheet, scale, 1 : 62,500	Topography and economic geology.
21	1149	Saanich sheet, scale, 1 : 62,500	Topography, reprint.
72	1253	Saanich sheet, scale, 1 : 62,500	Topography and geology.
73	1254	Saanich sheet, scale, 1 : 62,500	Topography and economic geology.
146	1496	Stereograms of a block of ore-bearing country, Rossland	Economic geology.
—	1447	Diagram of Prairie hills and Dogtooth mountains, scale 2·6 miles to 1 inch	Geology.
—	1448	Diagram of Albert canyon, scale 1·4 miles to 1 inch	Geology.
—	1449	Diagram of Glacier, scale 1·9 miles to 1 inch	Geology.
—	1450	Diagram showing the geology of the railway belt between Golden and Revelstoke, scale 10 miles to 1 inch	Geology.
—	1457	Structure section of Selkirk and Purcell mountains from Moberly peak to Revelstoke	Geology.
—	1458	Diagram of major subdivisions of Cordillera and approximate distribution of Shuswap terrane in southern British Columbia.	Physiography.
	1507	Index map showing Interior plateaus, scale 100 miles to 1 inch	
—	1518	Plan and sections of the principal mines, Rossland	Economic geology.
—	1547	Longitudinal projection of Centre Star mine, Rossland	Economic geology.
—	1548	Longitudinal projection of Columbia-Kootenay mine, Rossland.	Economic geology.
—	1549	Plan of 450-foot level, LeRoi mine, Rossland	Economic geology.
—	1550	Plan of 850-foot level, White Star mine, Rossland	Economic geology.
—	1551	Hypothetical sections, Rossland	Economic geology.
—	1530	Diagram of silver-lead mines on Wallace mountain, scale 1,250 feet to 1 inch	Economic geology.
147	1528	Cranbrook, Kootenay district, scale 4 miles to 1 inch	Topography and geology.

List of Geological Survey Maps Published During the Year 1915—(*Continued*).

Series A.	Publication number.	Title.	Remarks.
		Other Provinces.	
—	963	Alberta.—Moose Mountain region, scale 2 miles to 1 inch	Topography and geology, reprint.
—	1494	" —Perspective diagram of the foothills	Geology.
58	1226	Alberta, Saskatchewan, and Manitoba.—Nelson and Churchill rivers, scale 16 miles to 1 inch	Exploration and geology.
117	1338	Saskatchewan.—Wood Mountain coal area, scale 4 miles to 1 inch	Economic geology.
116	1337	Ontario.—Southwestern portion of the province, scale 12 miles to 1 inch	Geology.
144	1479	Ontario and Quebec.—Hunting territories of Timagami, Timiskaming, Kipawa, and Dumoine Indians, scale 16 miles to 1 inch	Ethnography.
— — —	1522 to 1527	Ontario and Quebec.—Six diagrams and sections, Laurentian plateau	Geology.
—	1478	Quebec.—St. Lawrence submerged coastal plain, scale about 21 miles to 1 inch	Physical geography.
—	1490	Diagram of the City of Montreal and vicinity, scale 2,400 feet to 1 inch	Economic geology.
137	1396	Nova Scotia.—Arisaig, Antigonish county, scale $\frac{3}{4}$ mile to 1 inch	Geology.
138	1397	Arisaig-Antigonish, Antigonish county, scale 2 miles to 1 inch	Geology.

PHOTOGRAPHIC DIVISION.

(*G. G. Clarke.*)

Report of work done by the photographic division during 1915.

Contact prints	4 × 5 to 36 × 48	12,957.
Bromide enlargements	4 × 5 " 40 × 72	610.
Films and plates developed	3¼ × 4¼" 6½ × 8½	5,082
Dry plate negatives made	4 × 5 " 11 × 14	612.
Wet plate negatives made	8 × 10 " 24 × 30	197.
Prints on zinc plates	11 × 14 " 24 × 36	6.
Photostat copies	7 × 11 " 11 × 14	357.
Lantern slides	3¼ × 4¼ "	662.
Photos and titles mounted		578.

LIBRARY.

(*M. Calhoun, Acting Librarian.*)

The additions to the Library during the year 1915 have been fewer than usual owing to the cutting off of a large number of German, Austrian, and Belgian publications since the beginning of the war. The following additions have been made:

Books purchased, 522; books received by gift or exchange, 740; periodicals resubscribed for, 102; periodicals subscribed for, 17; pamphlets received, 186. A large number of maps were also received.

During the year 503 volumes were prepared for binding, and sent to the Printing Bureau for that purpose.

In addition to the current cataloguing, the re-cataloguing of the old volumes in the palæontological section was completed. In anthropology, it was considered necessary to expand the classification used for the last four years. Consequently, most of the books in that section were re-catalogued.

A large number of publications, the accumulation of many years, some of which had never been actually united with the library, were sorted and critically examined. A great many of these, consisting of books not within the scope of this library, were given to other departmental libraries, where they were needed and appreciated. All volumes of value to the librarv, including duplicates, were placed on the shelves or in the library annex.

PUBLICATIONS.

(*M. Sauvalle.*)

The Following Reports Have Been Published Since January 1, 1915.

1022. MEMOIR No. 57. Corundum, its occurrence, distribution, exploitation, and use s By A. E. Barlow. Published May 8, 1915.

1248. MEMOIR No. 34. The Devonian of southwestern Ontario. By C. Stauffer. Published November 18, 1915.

1322. MEMOIR No. 46. Classification of Iroquoian radicals and subjective pronominal prefixes. By C. M. Barbeau. Published June 24, 1915.

1385. MEMOIR No. 50. Upper White River district, Yukon. By D. D. Cairnes. Published March 15, 1915.

1359. Summary Report of the Geological Survey for the calendar year 1913. Published January 23, 1915.

1383. MEMOIR No. 56. Geology of Franklin mining camp, B.C. By C. W. Drysdale. Published April 9, 1915.

1386. MEMOIR No. 58. Texada island. By R. G. McConnell. Published January 4, 1915.

1388. MEMOIR No. 59. Coal fields and coal resources of Canada. By D. B. Dowling. Published March 12, 1915.

1398. MEMOIR No. 60. Arisaig-Antigonish district. By M. Y. Williams. Published January 30, 1915.

1427. MEMOIR No. 62. Abnormal types of speech in Nootka. By E. Sapir. Published June 30, 1915.

1429. MEMOIR No. 63. Noun reduplication in Comox, a Salish language of Vancouver island. By E. Sapir. Published June 30, 1915.

1461. MEMOIR No. 67. The Yukon-Alaska Boundary between Porcupine and Yukon rivers. By D. D. Cairnes. Published February 19, 1915.

1451. MEMOIR No. 64. Preliminary report on the clay and shale deposits of the Province of Quebec. By J. Keele. Published April 26, 1915.

1453. MEMOIR No. 65. Clay and shale deposits of the western provinces, Part IV. By H. Ries. Published April 9, 1915.

1455. MEMOIR No. 66. Clay and shale deposits of the western provinces, Part V. By J. Keele. Published April 9, 1915.

1463. MEMOIR No. 68. A geological reconnaissance between Golden and Kamloops, B.C., along the line of the Canadian Pacific railway. By R. A. Daly. Published July 20, 1915.

1465. MEMOIR No. 69. Coal fields of B.C. By D. B. Dowling. Published June 14, 1915.

1469. MEMOIR No. 70. Family hunting territories and social life of the various Algonkian bands of the Ottawa valley. By F. G. Speck. Published October 7, 1915.

1470. MEMOIR No. 71. Myths and folk-lore of the Timiskaming Algonquin, and Timagami Ojibwa. By. F. G. Speck. Published October 7, 1915.

1476. Museum Bulletin No. 6. Pre-historic and present commerce among the Arctic Coast Eskimo. By V. Stefansson. Published January 8, 1915.

1485. MEMOIR No. 72. The artesian wells of Montreal. By C. L. Cumming. Published June 21, 1915.

1487. MEMOIR No. 73. The Pleistocene and Recent deposits of the island of Montreal. By J. Stansfield. Published July 27, 1915.

1492. Museum Bulletin No. 9. The glenoid fossa in the skull of the Eskimo. By F. H. S. Knowles. Published March 12, 1915.

1497. MEMOIR No. 74. A list of Canadian mineral occurrences. By R. A. A. Johnston. Published July 15, 1915.

1499. MEMOIR No. 75. Decorative art of Indian tribes of Connecticut. By F. G. Speck. Published July 7, 1915.

1501. Museum Bulletin No. 10. The social organization of the Winnebago Indians. By P. Radin. Published May 20, 1915.

1503. Summary Report for the calendar year 1914. Published July 8, 1915.
Separates: Report from the anthropological division.
Report from the topographical division.
Report from the biological division: zoology.

1505. MEMOIR No. 76. Geology of the Cranbrook map-area. By S. J. Schofield. Published July 24, 1915.

1508. Museum Bulletin No. 11. Physiography of the Beaverdell map-area and the southern part of the Interior plateaus, B.C. By L. Reinecke. Published May 15, 1915.

1510. Museum Bulletin No. 12. On Eoceratops canadensis, gen. nov., with remarks on other genera of Cretaceous horned dinosaurs. By L. M. Lambe. Published May 27, 1915.

1513. Museum Bulletin No. 13. The double crested cormorant. Its relation to the salmon industries on the Gulf of St. Lawrence. By P. A. Taverner. Published May 8, 1915.

1516. Museum Bulletin No. 14. The occurrence of glacial drift on the Magdalen islands. By J. W. Goldthwait. Published May 20, 1915.

1520. MEMOIR No. 77. Geology and ore deposits of Rossland, B.C. By C. W. Drysdale. Published November 29, 1915.

1533. Museum Bulletin No. 15. Gay Gulch and Skookum meteorites. By R. A. A. Johnston. Published June 30, 1915.

1535. Museum Bulletin. No. 16. Literary aspects of North American mythology. By P. Radin. Published June 17, 1915.

1537. MEMOIR No. 79. Ore deposits of the Beaverdell map-area. By L. Reinecke. Published September 4, 1915.

1542. Museum Bulletin No. 17. The Ordovician rocks of Lake Timiskaming. By M. Y. Williams. Published June 10, 1915.

1545. MEMOIR No. 78. Wabana iron ore of Newfoundland. By A. O. Hayes. Published September 22, 1915.

1554. MEMOIR No. 80. Huron and Wyandot mythology with an Appendix containing earlier published records. By C. M. Barbeau. Published December 23, 1915.

1558. Museum Bulletin No. 18. Structural relations of the Pre-Cambrian and Palæozoic rocks north of the Ottawa and St. Lawrence valleys. By Kindle and Burling. Published August 12, 1915.

1561. MEMOIR No. 81. The oil and gas fields of Ontario and Quebec. By W. Malcolm. Published November 19, 1915.

1565. Museum Bulletin No. 19. A sketch of the social organization of the Nass River Indians. By E. Sapir. Published October 23, 1915.

1572. MEMOIR No. 82. Rainy River district, Ontario, surficial geology and soils. By W. A. Johnston. Published October 24, 1915.

1574. Museum Bulletin No. 20. An Eurypterid horizon in the Niagara formation of Ontario. By M. Y. Williams. Published October 20, 1915.

1576. Museum Bulletin No. 21. Notes on the geology and palæontology of the Lower Saskatchewan River valley. By E. M. Kindle. Published October 23, 1915.

FRENCH TRANSLATIONS.

1094. MEMOIR No. 2. Report on Hedley Mining camp. By C. Camsell. Published May 25, 1915.

1102. MEMOIR No. 5. Preliminary report on the Lewes and Nordenskiöld Rivers coal district, Yukon Territory. By D. D. Cairnes. Published June 9, 1915.

1172. MEMOIR No. 19. Mother Lode and Sunset mines, Boundary district, B.C. By O. E. LeRoy. Published August 16, 1915.

1189. MEMOIR No. 23. A portion of the coast of British Columbia and adjacent islands between Strait of Georgia and Queen Charlotte sound, B.C. By J. A. Bancroft. Published October 22, 1915.

1209. MEMOIR No. 22. Preliminary report on the serpentine and associated rocks of southern Quebec. By J. A. Dresser. Published July 30, 1915.

1213. MEMOIR No. 43. St-Hilaire (Beloeil) and Rougemont mountains, Quebec. By J. J. O'Neill. Published October 23, 1915.

1214. MEMOIR No. 28. Geology of Steeprock lake, Ontario. By Lawson and Walcott. Published May 14, 1915.

1224. MEMOIR No. 29E. Oil and gas prospects of the northwest provinces. By W. Malcolm. Published June 7, 1915.

1229. MEMOIR No. 31. Wheaton River district, Yukon Territory. By D. D. Cairnes. Published November 2, 1915.

1243. MEMOIR No. 33. Geology of Gowganda mining division and vicinity. By W. H. Collins. Published April 7, 1915.

1256. MEMOIR No. 37. Portion of Atlin mining district, with special reference to lode mining. By D. D. Cairnes. Published July 31, 1915.

1292. MEMOIR No. 39. Report on Kewagama map-area. By M. E. Wilson. Published December 23, 1915.

1306. Summary Report of Geological Survey, Department of Mines, for the calendar year 1912. Published October 28, 1915.

1316. MEMOIR No. 44. Clay and shale deposits of New Brunswick. By J. Keele. Published November 30, 1915.

1325. MEMOIR No. 47. Clay and shale deposits of western provinces, Part III. By Ries and Keele. Published November 30, 1915.

1358. MEMOIR No. 52. Geological notes to accompany map of Sheep River gas and oil fields, Alberta. By D. B. Dowling. Published September 30, 1915.

1369. Notes on radium-bearing minerals. By W. Malcolm. Published May 4, 1915.

1394. Geology of a portion of eastern Ontario. By R. W. Ells. Published May 29, 1915.

1395. Report on the Pictou coal field, Nova Scotia. By H. S. Poole. Published June 26, 1915.

1411. Report on the Similkameen district. By C. Camsell. Published May 15, 1915.

1475. An outline of the physical geography of Canada; being a reprint of the appendix to the thirteenth report of the Geographic Board. By D. B. Dowling. Published January 1915.

1481. Guide to the collection of invertebrate fossils. Victoria Museum Guide. Published July 1915.

1513. Report on the Conrad and Whitehorse mining districts. By D. D. Cairnes. Published May 15, 1915.

1515. Museum Bulletin No. 1: Contains articles Nos. 1 to 12 of the geological series of Museum Bulletins, articles Nos. 1 to 3 of the biological series of Museum Bulletins, and article No. 1 of the anthropological series of Museum Bulletins.

1519. Guide to the collection of zoological specimens for the Victoria Memorial Museum. By P. A. Taverner. Published July 3, 1915.

1556. Report on the main coast of British Columbia and adjacent islands, New Westminster and Nanaimo districts. By O. E. LeRoy. Published December 6, 1915.

1571. The Falls of Niagara, by J. W. Spencer. Published November 2, 1915.

1596. MEMOIR No. 42. No. 1, Anthropological Series. The double curve motive in northeastern Algonkian art. By F. G. Speck. Published December 27, 1915.

ACCOUNTANT'S STATEMENT.

(*John Marshall.*)

The funds available for the work and the expenditure of the Geological Survey for the fiscal year ending March 31, 1915, were:

Details.	Grant.	Expenditure.
	$	$
Amounts voted by Parliament	555,237.50	
Civil list salaries		179,490.93
Explorations in British Columbia and Yukon		21,740.86
Topographical surveys in British Columbia and Yukon		14,744.36
Explorations in North West Territories		29,483.10
Topographical surveys in North West Territories		17,746.42
Explorations in Ontario		9,952.16
Topographical surveys in Ontario		715.46
Explorations in Quebec		14,030.64
Topographical surveys in Quebec		4,148.82
Explorations in New Brunswick		6,250.56
" in Nova Scotia		7,963.98
Topographical surveys in Nova Scotia		7,241.21
Explorations in general		6,054.57
Ethnological investigations		8,912.79
Palæontological "		4,609.17
Investigations of road metals		1,582.48
Archæological investigations		1,501.07
Arctic expedition		901.34
Publication of reports		50,945.84
Translation of reports		7,609.20
Publication of maps		16,402.85
Specimens for museum		15,460.68
Instruments and repairs		11,720.25
Wages, outside service		11,176.20
Printing and stationery		10,047.73
Miscellaneous		7,727.66
Library		5,512.31
Photographic supplies		2,464.53
Postages and telegrams		2,058.04
Civil government contingencies		1,918.40
Advertising		1,024.91
Legal fees		744.50
Compensation to J. F. Lyons, in lieu of quarters, fuel, and light		400.00
Balance of advances to field explorers in 1914-15, credited casual revenue		.20
Balance unexpended and lapsed		72,954.28
	555,237.50	555,237.50

Summary.

	Grant.	Expenditure.	Grant not used.
	$	$	$
Civil government appropriation...............	223,337.50	179,490.93	43,846.57
Explorations and surveys in Canada..........	175,000.00	157,994.18	17,005.82
Investigation of radium bearing ores in Canada	10,000.00	1,647.73	8,352.27
Publication of reports and maps; translating ..	75,000.00	75,000.00	
Purchase of books, instruments, miscellaneous .	54,000.00	51,037.60	2,962.40
Purchase of specimens for Victoria Museum....	15,000.00	14,794.38	205.62
Compensation to J. F. Lyons for quarters, etc..	400.00	400.00	
Civil government contingencies...............	2,500.00	1,918.40	581.60
	555,237.50	482,283.22	72,954.28

Casual Revenue.

Sales of publications..	130.86	
Sales of equipment..	260.00	
Unexpended balance of advances to field explorers............	5.32	
		$396.18

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PUBLICATIONS OF THE GEOLOGICAL SURVEY.

The Geological Survey was established in 1842 and "Reports of Progress" were issued, generally in annual volumes, from that date to 1885, the first report being that for the year 1843 published in 1845. Beginning with the year 1885, "Annual Reports" (new series) were published in volumes until 1905, the last being Vol. XVI, 1904. Many of the individual reports and maps published before 1905 were issued separately and from 1905 to the present, all have been published as separates and no annual volume has been issued. Since 1910, the reports have been issued as Memoirs and Museum Bulletins, each subdivided into series, thus:—

Memoir 41, *Geological Series 38.*
Memoir 54, *Biological Series 2.*
Museum Bulletin 5, *Geological Series 21.*
Museum Bulletin 6, *Anthropological Series 3.*

In addition to the publications specified above, a Summary Report is issued annually; and miscellaneous publications of various kinds including Reports of Explorations, Guide Books, etc., have been issued from time to time.

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Publications Issued 1910-1915 Inclusive.

MEMOIRS.

MEMOIR 1. *Geological Series 1.* Geology of the Nipigon basin, Ontario, 1910—by Alfred W. G. Wilson.

MEMOIR 2. *Geological Series 2.* Geology and ore deposits of Hedley mining district, British Columbia, 1910—by Charles Camsell.

MEMOIR 3. *Geological Series 3.* Palæoniscid fishes from the Albert shales of New Brunswick, 1910—by Lawrence M. Lambe.

MEMOIR 4. *Geological Series 7.* Geological reconnaissance along the line of the National Transcontinental railway in western Quebec, 1911—by W. J. Wilson.

MEMOIR 5. *Geological Series 4.* Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district, Yukon Territory, 1910—by D. D. Cairnes.

MEMOIR 6. *Geological Series 5.* Geology of the Haliburton and Bancroft areas, Province of Ontario, 1910—by Frank D. Adams and Alfred E. Barlow.

MEMOIR 7. *Geological Series 6,* Geology of St. Bruno mountain, Province of Quebec, 1910—by John A. Dresser.

MEMOIR 8. *Geological Series 8.* The Edmonton coal field, Alberta, 1911—by D. B. Dowling.

MEMOIR 9. *Geological Series 9.* Bighorn coal basin, Alberta, 1911—by G. S. Malloch.

MEMOIR 10. *Geological Series 10.* An instrumental survey of the shore-lines of the extinct lakes Algonquin and Nipissing in south-western Ontario, 1911—by J. W. Goldthwait.

MEMOIR 11. *Topographical Series 1.* Triangulation and spirit levelling of Vancouver island, B.C., 1909, issued 1910—by R. H. Chapman.

MEMOIR 12. *Geological Series 11.* Insects from the Tertiary lake deposits of the southern interior of British Columbia, collected by Mr. Lawrence M. Lambe, in 1906, issued 1911—by Anton Handlirsch.

MEMOIR 13. *Geological Series 14.* Southern Vancouver island, 1912—by Charles H. Clapp.

MEMOIR 14. *Biological Series 1.* New species of shells collected by Mr. John Macoun at Barkley sound, Vancouver island, British Columbia, 1911—by William H. Dall and Paul Bartsch.

MEMOIR 15. *Geological Series 12.* On a Trenton Echinoderm fauna at Kirkfield, Ontario, 1911—by Frank Springer.

MEMOIR 16. *Geological Series 13.* The clay and shale deposits of Nova Scotia and portions of New Brunswick, 1911—by Heinrich Ries assisted by Joseph Keele.

MEMOIR 17. *Geological Series 28.* Geology and economic resources of the Larder Lake district, Ont., and adjoining portions of Pontiac county, Que., 1913—by Morley E. Wilson.

MEMOIR 18. *Geological Series 19.* Bathurst district, New Brunswick, 1913—by G. A. Young.

MEMOIR 19. *Geological Series 26.* Geology of Mother Lode and Sunset mines, Boundary district, B.C., 1914—by O. E. LeRoy.

MEMOIR 20. *Geological Series 41.* Gold fields of Nova Scotia, 1914—by W. Malcolm.

MEMOIR 21. *Geological Series 15.* The geology and ore deposits of Phoenix Boundary district, British Columbia, 1912—by O. E. LeRoy

MEMOIR 22. *Geological Series 27.* Preliminary report on the serpentines and associated rocks, in southern Quebec, 1914—by J. A. Dresser.

MEMOIR 23. *Geological Series 23.* Geology of the coast and islands between the Strait of Georgia and Queen Charlotte sound, B.C., 1914—by J. Austen Bancroft.

MEMOIR 24. *Geological Series 16.* Preliminary report on the clay and shale deposits of the western provinces, 1912—by Heinrich Ries and Joseph Keele.

MEMOIR 25. *Geological Series 21.* Report on the clay and shale deposits of the western provinces, Part II, 1914—by Heinrich Ries and Joseph Keele.

MEMOIR 26. *Geological Series 34.* Geology and mineral deposits of the Tulameen district, B.C., 1913—by C. Camsell.

MEMOIR 27. *Geological Series 17.* Report of the Commission appointed to investigate Turtle mountain, Frank, Alberta, 1911, issued 1912.

MEMOIR 28. *Geological Series 18.* The Geology of Steeprock lake, Ontario—by Andrew C. Lawson. Notes on fossils from limestone of Steeprock lake, Ontario, 1912—by Charles D. Walcott.

MEMOIR 29. *Geological Series 32.* Oil and gas prospects of the northwest provinces of Canada, 1913—by W. Malcolm.

MEMOIR 30. *Geological Series 40.* The basins of Nelson and Churchill rivers, 1914—by William McInnes.

MEMOIR 31. *Geological Series 20.* Wheaton district, Yukon Territory, 1913—by D. D. Cairnes.

MEMOIR 32. *Geological Series 25.* Portions of Portland Canal and Skeena Mining divisions, Skeena district, B.C., 1914—by R. G. McConnell.

MEMOIR 33. *Geological Series 30.* The geology of Gowganda Mining Division, 1913—by W. H. Collins.

MEMOIR 34. *Geological Series 63.* The Devonian of southwestern Ontario, 1915—by C. R. Stauffer.

MEMOIR 35. *Geological Series 29.* Reconnaissance along the National Transcontinental railway in southern Quebec, 1913—John A. Dresser.

MEMOIR 36. *Geological Series 33.* Geology of the Victoria and Saanich map-areas, Vancouver island, B.C., 1914—by C. H. Clapp.

MEMOIR 37. *Geological Series 22.* Portions of Atlin district, B.C., 1913—by D. D. Cairnes.

MEMOIR 38. *Geological Series 31.* Geology of the North American Cordillera at the forty-ninth parallel, Parts I and II, 1913—by Reginald Aldworth Daly.

MEMOIR 39. *Geological Series 35.* Kewagama Lake map-area, Quebec, 1914—by M. E. Wilson.

MEMOIR 40. *Geological Series 24.* The Archæan geology of Rainy lake, 1914—by Andrew C. Lawson.

MEMOIR 41. *Geological Series 38.* The "Fern Ledges" Carboniferous flora of St. John, New Brunswick, 1914—by Marie C. Stopes.

MEMOIR 42. *Anthropological Series 1.* The double-curve motive in northeastern Algonkian art, 1914—by Frank G. Speck.

MEMOIR 43. *Geological Series 36.* St. Hilaire (Beloeil) and Rougemont mountains, Quebec, 1914—by J. J. O'Neill.

MEMOIR 44. *Geological Series 37.* Clay and shale deposits of New Brunswick, 1914— by J. Keele.

MEMOIR 45. *Anthropological Series 3.* The inviting-in feast of the Alaska Eskimo, 1914—by E. W. Hawkes.

MEMOIR 46. *Anthropological Series 7.* Classification of Iroquoian radicals and subjective pronominal prefixes, 1915—by C. M. Barbeau.
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