GEOLOGICAL
SURVEY
OF CANADA

1872-73

888

SURVEYOR
GENERAL

GEOLOGICAL SURVEY OF CANADA.

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

REPORT OF PROGRESS

FOR

1872-73.

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MAPS AND ILLUSTRATIONS ACCOMPANYING THIS REPORT.

Note.—All compass bearings in the report are stated in reference to the magnetic meridian.

The publication of the maps referred to in the reports of Messrs. Vennor, Bailey and Robb is deferred until additional surveys have been made in the districts to which they relate.

ERRATA.

Page 8 Fifth line from top, for 1861 read 1869.
9 Sixteenth line from bottom, for *Division M.* read *Division L.*
9 Last line for *railroad* read *railroad survey*.
18 Sixth line from top, for *those* read *these*.
21 Side note third line from bottom, for *quantity* read *quality*.
44 Twelfth line from bottom, for *Kootenay* read *Courtenay*.
49 Thirteenth line from top, for *west* read *east*.
49 Twenty-second line from top, for *west* read *east*.
53 Fourteenth line from top, for *east* read *exit*.
125 Sixteenth line from top, for *Agatawekaim* read *Agatawekami*.
127 Sixth line from top, for *lower* read *upper*.
127 Eleventh line from top, for *these rocks* read *gneiss rocks*.
128 Sixteenth line from bottom, for *angular* read *regular*.
130 Third line from top, for *it has* read *the rocks have*.
160 Eighth line from bottom, for *at* read *through*.
169 Eleventh line from bottom, for *dolerites* read *diorites*.
196 Last line, *or* omitted.
196 Side note, for *fossils* read *fossil*.
198 Fifteenth line from top, for *stream* read *streams*.
214 Second line from top, for *as the* read *as by the*.
225 Eleventh line from bottom, for *coa* read *coal*.
241 Nineteenth line from top, for *page* read *page* 239.
254 Fifth line from top, for *N.* 30° *W.* read *N.*
260 Ninth line from top, for 1,248,000 read 1,139,250.
260 Twelfth line from top, for 7,820,000 read 7,771,500.
263 Seventeenth line from bottom, for 2,940,000 read 2,885,625.
263 Eighteenth line from bottom, for 6,205,000 read 5,923,125.
268 Nineteenth line from top, for 5° 1′ read 51°.
271 Third line from bottom, for 6,680,000 read 7,053,750.
271 Fifth line from bottom, for 450 read 480.
275 Twenty-second line from bottom, for 5,850,000 read 5,760,000.

GEOLOGICAL SURVEY OF CANADA.

REPORTS

OF

EXPLORATION AND SURVEYS

1872-73

GEOLOGICAL SURVEY OFFICE

MONTREAL, May, 1873.

SIR,—I have the honor to transmit, for the information of His Excellency the Governor General in Council, the accompanying Reports relating to the surveys and investigations of the Geological Corps during the season of 1872–73.

I have the honor to be,

Sir,

Your Obedient Servant,

ALFRED R. C. SELWYN,

Director of the Geological Survey.

To

The Honorable JOSEPH HOWE, M. P.,

Secretary of State for the Provinces,

OTTAWA.

SUMMARY REPORT

OF

GEOLOGICAL INVESTIGATIONS,

BY

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

ADDRESSED TO

THE HONORABLE JOSEPH HOWE, M.P.,

SECRETARY OF STATE FOR THE PROVINCES.

SIR,—I have the honor to submit for the information of His Excellency the Governor General in Council the following Report of the progress made during the year 1872–73 in the Geological Survey of the Dominion, and in the Exploration of its mineral resources.

In Cape Breton and in other parts of the Province of Nova Scotia, and also in the Provinces of New Brunswick, Quebec, Ontario, Manitoba and British Columbia, examinations and surveys have been made, most of which are in continuation and extension of the investigations of preceding seasons, and of which Reports have been presented, and are now published in the volumes issued for 1870-71, and for 1871-72 respectively. **Regions in which explorations have been carried on.**

The greater part of my own time during the year has necessarily been occupied in the work incidental to the general supervision of the Survey, and much of it, during the early part of the winter, in attending to the printing of the Reports for 1871-72. In June I visited and examined the Acadia Iron Mines at Londonderry, Colchester County, Nova Scotia, for the purpose of investigating and reporting upon the character of the iron-ore deposits there, especially in reference to the probable extent of the veins and their permanence in depth. I also visited and examined parts of the Spring Hill coal-field in Cumberland County, Nova Scotia; the survey and exploration of which has occupied the attention of Mr. Scott Barlow during the past three seasons. The latter part of July and the months of August, September and October I devoted partly to investigations in the silver-bearing region around Thunder Bay, Lake Superior, and partly to a preliminary exploration westward from Lake Superior to Fort Garry, in which latter I was accompanied and assisted by Mr. Robert Bell. Relating to the explorations above named, the fol- **Labours of Mr. Selwyn.**

lowing reports have been received and are submitted herewith, together with the result of my own observations on the Londonderry iron mines, and on portions of the region explored between Lake Superior and Lake Winnipeg.

Additions to the palæontological collections.

In the palæontological branch of the Survey, Mr. Billings reports the following additions to the collections since the 1st of June, 1872 :—

	Specimens.
Presented by Major C. Grant, of Hamilton, fossils from the Hudson River, Clinton and Niagara formations.....	24
By Mr. F. W. Ramm, of Port Hope, one Orthoceratite from the Black River formation............	1
Collected by Mr. T. C. Weston, from the Silurian rocks at Hereford and Farnham, about............... ...	200
From the Potsdam rocks at the Straits of Belle Isle, Labrador..................................	500
From the Black River formation, Paquette's Rapids, Upper Ottawa..................................	200
From the Upper Silurian rocks at Arisaig, Nova Scotia	300
Collected by Mr. Thos. Curry, from the Upper Silurian and Devonian rocks at Port Daniel and Percé, Gulf of St. Lawrence..............................	2000
From the Hudson River rocks at Rivière des Hurons	191
Collected by Mr. A. H. Foord, from the Upper Silurian rocks at Port Daniel..............................	200
Collected by Professor Baily, Devonian fossil plants from New Brunswick..............................	41
Collected by Mr. G. F. Mathew from Upper Silurian rocks, New Brunswick...........................	19
Collected by Mr. G. F. Mathew from Carboniferous rocks, New Brunswick (fossil plants)..................	5
Collected by Mr. James Richardson, from the rocks of Vancouver and Queen Charlotte Islands, British Columbia..	947
Collected by Mr. Charles Robb, from the Carboniferous rocks of Cape Breton (fossil plants)..............	28
Collected by Mr. Scott Barlow, from the Carboniferous rocks of Cumberland County, Nova Scotia............	20
Total......................	4,676

In the collection made by Mr. Weston at the Straits of Belle Isle, there is a very fine series, including several species of the curious genus *Archæocyathus*. By slicing these for microscopic examination it may be possible to determine whether they should be regarded as sponges or corals, a point upon which there is at present much doubt.

Affinities of *Archæocyathus*.

The collection from Arisaig is especially valuable, as it contains a number of specimens which show the internal characters of the shell, such as the teeth and muscular impressions. These characters, which were wanting in the specimens previously collected, prove that many of the species from this locality, described in Dawson's Acadian Geology, are referred to wrong genera. In the examination and study of this collection, to which several weeks have been devoted, Dr. Dawson has afforded great assistance, by placing all his Arisaig fossils, including those originally described by Professor Hall, in Mr. Billings' hands for comparison. Without this assistance many of the species could not have been identified. It was proposed to publish the results already obtained in the first part of Vol. II. *Palæozoic Fossils of Canada*, which is now being prepared; and, with this object in view, Mr. A. H. Foord, the Artist to the Survey, has already figured a number of the specimens. On reconsideration, however, Mr. Billings thinks it will be better to defer publication until further collections have been made, and he has had an opportunity of examining the collections from the same locality which have been made by Dr. Honeyman, and are now in the Public Museum in Halifax. **Arisaig fossils.** **Assistance from Dr. Dawson.** **Publication of descriptions of fossils.**

The large collections made by Mr. Curry afford many important additions to our knowledge of the Upper Silurian and Devonian rocks of the Gaspé Peninsula. **Mr. Curry's collections.**

The Port Daniel collection contains a great many new species, and, including the collections previously made in the same locality by Sir W. E. Logan and Mr. Bell, supplies material which will occupy from seventy-five to one hundred pages of descriptive text in the second volume of the *Palæozoic Fossils of Canada*. The whole of these collections have been studied, and but little more remains to be done except to write the descriptions of the species. Before publication, however, a further collection is much to be desired. **The Port Daniel collections of fossils.**

The careful study and comparison of the fauna of the Middle and Upper Silurian rocks around the shores of the Gulf of St. Lawrence, together with a better knowledge of the geological structure of the region, will probably elicit some interesting and important facts in connection with its earlier physical geography and geology. Bearing on these questions, Mr. Billings finds that, though the Port Daniel and the Arisaig rocks—respectively on the northern and the southern shores of the Gulf, and distant from each other about 250 miles—are certainly both of Middle and Upper Silurian age, yet that a very wide and marked difference exists in their respective faunas; and that both of these differ as widely from that of the Middle and Upper Silurian of New York and Western Canada as they do from each other; while that of the Gaspé limestones north of Cape Maquereau, and of the Middle Silurian rocks of the Island of Anticosti, corresponds exactly with the New York type. **Remarks on the Middle and Upper Silurian rocks of eastern America.**

In the preceding Lower Silurian period, as also in the succeeding Devonian period, the respective faunas are alike throughout the regions referred to; thus, while doubtless a large part of the eastern area existed as dry land long prior to the close of the former period, as is indicated by the entire absence in it of all the upper members of the Lower Silurian series, which are so largely developed in the western area, yet the facts shew that the Upper Silurian period in eastern North America was preceded by oscillations of the surface, which resulted in the formation of barriers separating the eastern and western area, and limiting the distribution of their respective faunas, the eastern area being apparently divided by similar minor barriers; and further that the whole of these barriers were removed prior to the succeeding Devonian and Carboniferous periods.

At present neither the details of the geological structure, nor the distribution of the fauna of the regions affected by these movements, from the Gulf of St. Lawrence south-westward to the Atlantic shores of New England, are sufficiently well known to make it possible to indicate exactly the nature, position and extent of these ancient barriers. From the facts cited, however, it would seem that the altered rocks of Cape Maquereau, which are referred by Sir W. E. Logan to a part of the Quebec group (Geology of Canada, page 272), certainly formed a part of the main barrier between the eastern and the western areas. Its eastern extension will probably be found in Newfoundland; while, in the opposite direction, we have at present no certain evidence respecting it; though it seems probable that the greater part of New Brunswick and of eastern Maine would be included in the eastern area.

British Columbia fossils.

Of Mr. Richardson's large and valuable collection from British Columbia a preliminary study of the ammonites from the Queen Charlotte Islands has been made. Among them there are seven species which belong to the groups *Planulati* and *Macrocephali*, characteristic of the Bath and Coralline Oolite of England, and of the Brown Jura on the European continent. Judging from the ammonites alone, it would appear that some of the Queen Charlotte Islands rocks are Jurassic, and therefore occupy a somewhat lower horizon than those of Vancouver Island, the fossils from which have been determined to be Cretaceous. Until further study and comparison have been made of the whole of the collection, which contains a large number of genera and species, it will, however, be impossible to arrive at any definite conclusion respecting the relative age of these rocks. A noteworthy fact, however, is that not one of the seven species of ammonites above referred to has yet been found either in California or on the east side of the Rocky Mountains.

Lower Potsdam fossils.

Besides the study of the Gaspé, Arisaig and British Columbia fossils, considerable time has been devoted to the further study of the fossils of the Lower Potsdam rocks; the result of which will form a portion of the first part of Vol. II, *Palæozoic Fossils of Canada*, which will also contain figures and descriptions, chiefly of new species, from the Upper Silurian limestones and Lower Devonian sandstones of Gaspé, as well as the results of other palæontological investigations which have already been published in part in some of the scientific serials of Europe and America.

Dr. Dawson has kindly devoted considerable time and labour to the study and determination of the very interesting collection of fossil plants brought by Mr. Richardson from Vancouver and Queen Charlotte Islands; and he has also again given his valuable and gratuitous labour to the Survey in the preparation of a volume which will shortly be issued, containing illustrations and descriptions of the fossil plants of the Lower Carboniferous and the Millstone Grit formations of Canada. Acknowledgment of Dr. Dawson's labours.

During the winter Mr. Weston has done a large amount of valuable work, in cutting out, cleaning and ticketing fossils collected by himself and others. This work occupies much time, and requires great practice and more than ordinary skill. A large part of Mr. Weston's time has also been devoted to the preparation of slices of various fossils and rocks, the characters of which could only be determined by microscopic examimation. Amongst these may be mentioned eighty-nine mounted sections of the fossil plants from British Columbia. Also upwards of 200 similarly prepared slices of various fossiliferous rocks from the Eastern Townships and elsewhere. Mr. Weston has also devoted some time and attention to photographic work, with a view to facilitate the labours of Mr. Billings and Mr. Foord in describing and figuring organic remains. Besides other negatives he has succeeded in producing some very excellent micro-photographs, shewing the structure of the fossil plants from British Columbia on an enlarged scale, which will materially aid Dr. Dawson in the labour he has, as above stated, kindly undertaken in connection with the examination of this highly interesting fossil flora. Mr. Weston's work.

Mr. Billings has submitted some of the fossils from British Columbia to Mr. Meek, who is well known as the highest authority on the fauna of American Secondary formations. Mr. Meek's and Mr. Billings' observations on the fossil animals, as well as Dr. Dawson's on the plants, appear as appendices to Mr. Richardson's Report. Fossils submitted to Mr. Meek.

Since the retirement of Dr. T. Sterry Hunt at the close of last year, the chemical and mineralogical investigations of the Survey have been intrusted to Dr. B. J. Harrington, assisted by Mr. Christian Hoffmann. Respecting the work in the laboratory, Dr. Harrington reports as follows:

"Our laboratory work has consisted largely in the examination of economic minerals from different parts of the Dominion, and much useful information has been accumul..ted. Work of the chemical laboratory.

Examination of iron ores.

"Thirty-two specimens of iron ore from different localities have been examined. In nine cases the analyses were complete. In eleven others, sufficiently so to determine the value of the ores, while in the remaining twelve, only determinations of iron were made. A sample of the bar-iron made from the ore of the Acadia mines has also been examined for phosphorus.

Gold, silver and copper.

"Thirty-two specimens of quartz, mispickel, pyrites, &c., have been assayed for gold and silver, and six specimens for silver only. Fourteen of the samples are from the township of Marmora, and the results of their assay shew a great variation in the quantity of gold in different veins, as well as in the same vein at different depths. The highest yield of gold obtained was 4.90 ounces to the ton of 2,000 lbs., the highest yield of silver to the ton did not exceed 50 cents. Samples from a few localities near the line of the projected Canada Pacific Railroad between Lake Superior and Red River have been examined, but in most cases were found to contain little or no gold or silver. Assays have been made of forty-five samples of copper ore, all, except one, being from localities in the Eastern Townships.

Phosphate of lime.

"Twelve specimens of phosphate of lime have been examined for the information of persons interested in the development of the deposits of this mineral.

Coal.

"Proximate analyses have been made of twelve samples of coal, ten from Cape Breton, and two from British Columbia. The examination of the former coals shews them to contain a very small amount of ash, but a large percentage of sulphur. The average percentage of ash in the ten samples was 3.14, and the average percentage of sulphur 2.05." The analyses of the samples from Cape Breton appear in Mr. Robb's report submitted herewith.

"A series of the coals from Vancouver and Queen Charlotte Islands are now being analysed and the results will soon be ready for publication.*

Minerals and rocks.

"Many minerals of scientific interest have been identified by means of the blow-pipe, and among them there are three which do not appear to have been before observed in the vicinity of Montreal.

"Complete analyses have been made of twelve specimens of rocks and minerals from different parts of the Dominion, and partial analyses of three others. Among the rocks analysed is a serpentine from Lake Abbitibbé which contains both chromium and nickel. An analysis of the green pebbles in a specimen of the Lower Carboniferous conglomerate from Harvey settlement, New Brunswick, shews that they consist of a hydrated silicate of alumina with several per cent of potash and soda.

Brine from Nanaimo.

"The analysis of a brine from Nanaimo, in Vancouver Island, is being made by Mr. Hoffmann."

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* See *Appendix III.* Mr. Richardson's report.

A report has also been received from Dr. Harrington, and is submitted herewith, of an examination of samples of brick-clay from Fort Garry, made with special reference to their suitability, and to their proper treatment, for the manufacture of bricks. These clays were sent to the museum by Mr. J. S. Hargrave, and were accompanied by the following memorandum: Report on brick-clay from Fort Garry.

"Specimen No. 1. Surface clay, dark. When mixed with Nos. 2 and 6 makes a white brick with Townsley's machine.

Specimen No. 2. From three feet deeper than No. 1; when mixed with Nos. 1 and 6, makes a white brick with Townsley's machine.

Specimen No. 3. Sometimes found mixed with No. 2, but oftener about seven feet below the surface. Has been worked with a Chicago steam machine without sand or water. This brick has been a total failure.

Specimen No. 4. Found from fifteen to twenty feet deeper than No. 3. This is the deepest clay known in Manitoba. Mixed with No. 3, has made bricks with a Chicago steam machine without sand or water. Brick a failure hitherto.

Specimen No. 5. Sand from Point Douglas.

Specimen No. 6. Do. from near Silver Heights."

From Dr. Harrington's report on the above named samples, it will be seen that the want of success in the manufacture does not arise so much from defects in the clays, as from the manner of treating them, both in the preparing and in the burning.

I have the honor to be,

Sir,

Your obedient servant,

ALFRED R. C. SELWYN.

Montreal, May, 1873.

NOTES

BY

ALFRED R. C. SELWYN,

OF A PRELIMINARY GEOLOGICAL RECONNAISSANCE FROM

LAKE SUPERIOR,

BY THE ENGLISH AND WINNIPEG RIVERS, TO

FORT GARRY.

On the above named exploration, to about midway between Lonely Lake and Lake Winnipeg, viz. to Separation Lake, I was accompanied by Mr. R. Bell and the members of his party, who during the earlier part of the season had been occupied in prosecuting and extending the explorations which were commenced in the Lake Superior region by Mr. Bell in 1861. Details respecting the constitution of the party and other matters and incidents connected with the journey from Thunder Bay to Separation Lake are given in Mr. Bell's report, which also embraces accounts of the earlier operations of the season. As stated in his report, Mr. Bell arrived at Thunder Bay with his party on the 17th of June. On my arrival there on the 5th of August, I learnt that Mr. Bell had started the same morning on a trip with Mr. McIntyre from Fort William, and that he expected to be absent about ten days. Subsequently it appeared that Mr. McIntyre having occasion to visit the Hudson Bay Co's post at Lac Bois Blanc, Whitewood or Basswood Lake, by all of which names this lake seems to be known, had kindly offered Mr. Bell a passage in his canoe, and as an excellent opportunity was thus afforded to gain some information relating to the geological features of the route to be traversed from the Kaministiquia River *via* Pigeon River to Whitewood Lake, and thence to Sturgeon Lake on the Dawson Red River route, by which Mr. McIntyre proposed to return to Fort William, Mr. Bell gladly availed himself of the offer. At the same time Mr. Bell's party had been sent to make some further explorations in the valley of the Black Sturgeon River at the head of Black Bay. The results of this journey and of the explorations above named are given in Mr. Bell's report.

Continuation by Mr. Bell of explorations begun in 1861.

Trip to Basswood Lake.

Black Sturgeon River.

In the ten days interval between my arrival at Thunder Bay and the return there of Mr. Bell, and of his party, respectively on the 17th and on the 16th of August, I visited and examined a number of the principal silver-mining locations around the western shores of the bay, and extended my

Silver-mining locations of Thunder Bay.

exploration along the Red River road as far as the Mattawa bridge, twenty-three miles west from Prince Arthur's Landing. I was unable to visit the now celebrated Silver Islet Mine, and was also obliged to postpone to some future occasion an investigation which I hoped to make into the relations of the different members of the Upper Copper-bearing series, as exhibited in the country between Thunder Bay and the eastern shores of Nipigon Bay, and around Lake Nipigon.

To Mr. J. W. Dawson, C. E., Superintendent of the Red River road, and to Mr. E. Borron, Provincial Inspector of Mines, my best thanks are due, not only for much useful information, but also for their unremitting kindness and attention, and for their ready assistance in all matters in which the means at their disposal enabled them to facilitate our operations. Acknowledgment of assistance.

On the 19th of August our whole party left Prince Arthur's Landing, and proceeded, *via* the Red River route, to Lac des Mille Lacs, which is reached by the Height-of-Land Portage road, about one mile in length, between it and Lake Kashabowie. We arrived at Lac des Mille Lacs on the evening of the 21th of August, and were delayed there several days by the non-appearance of the Indians who had been engaged to accompany us as canoe-men and guides. On the 29th of August, Mr. Bell having succeeded in engaging other Indians, we were enabled to proceed on our journey, and left Lac des Mille Lacs by the Seine River. On the 10th of September we camped on the shore of Sturgeon Lake, and at mid-day on the 20th of the same month, we reached the Hudson Bay Company's Post on Lac Seul or Lonely Lake. Start from Prince Arthur's Landing.

On the 13th of September, on Sturgeon Lake River, about 14 miles west of Sturgeon Lake, we fell in with Mr. Jarvis, C. E., in charge of one of the Survey parties of the Canada Pacific Railroad, Division M. He was running the line eastward to Sturgeon Lake, and had come in from Fort Garry *via* the Lake of the Woods and Minnietaki Lake. From information which Mr. Jarvis gave us respecting this route, we decided to make our way out by the English and Winnipeg Rivers, as, though not the most direct, it seemed likely to prove the most expeditious route, and would not involve retracing our steps after reaching Lonely Lake. The Indians who accompanied us from Shebandowan had deserted us on the 5th of September, and the last of those who had accompanied us as guides from the Sturgeon Lake side left us at this camp, the state of our larder, I imagine, not being sufficiently attractive to induce them to favor us any longer with their company. Our party was, however, augmented here by the addition of six of Mr. Jarvis' men, whose services he no longer required, and who were anxious to return as quickly as possible to their homes on Red River. Starting on the 16th September from our camp at the crossing point of the railroad, we descended the Sturgeon Lake River, making Choice of route.

about ten miles to the head of the second rapids and portage, 210 yards in length. The following day, about four miles more brought us to the rapids and falls by which the Sturgeon Lake River discharges into Lake Minnietaki. Three portages were made in this distance, respectively 1,500 yards, 250 yards, and 1,280 yards in length. During the time of high water the greater part of these rapids could be descended in safety with loaded canoes. At the time we passed them the water was probably nearly at its lowest stage. The river is from thirty to fifty yards wide, and the length of the portages sufficiently attests its rough and turbulent character. The fall between Otter Lake and Minnietaki Lake is probably not less than one hundred and fifty feet. From Minnietaki Lake to Lonely Lake the canoe route is through such an intricate labyrinth of water that it is almost impossible for any one traversing it for the first time to do so without mistake; and the numerous bays, headlands and islands are so much alike, that it is equally difficult to be guided by instructions. None of our present party were acquainted with the route, and in consequence we several times took wrong turns, which led us into bays at the head of which neither portage-road nor outlet were to be found. Fortunately, when about one day's journey from Lonely Lake, and quite at a loss in which direction to seek for the portage, which we knew we must cross between the waters we were then on and those leading us to Lonely Lake, we encountered a roving Indian, who, in consideration of some small presents, put us on the right track, passing through a number of narrow swampy channels, where, without a guide, we should probably never have thought of seeking for the portage. Crossing this portage, 1,758 yards in length, we camped at the further end, on the banks of a small lake, the waters of which discharge by Canoe River direct into Lonely Lake, distant about seven miles in a straight line bearing N. 30° W Magnetic. The following day, the 20th of September, as already stated, we reached the Hudson Bay Post. Here we replenished our stock of provisions by the addition of a few pounds of pemmican, and in the afternoon, having been most hospitably entertained by Mr. McKenzie, whom we found in charge of the Post, we proceeded on our voyage down the lake, and camped on the west end of a large island, about two miles distant, and near the northern shore of the lake. From here to the outlet at the head of English River—except where we crossed several deep bays stretching to the north-eastward, generally beyond the limits of our vision, and from two to four miles wide—our course lay close to the north shore, and generally among islands of all dimensions, from a mere rock just showing above the water, to areas of several miles in extent. For twenty-five miles, or to near the first narrows, where the lake contracts to a width of less than a quarter of a mile, the direction we followed varied but little from west, magnetic. Thence, for about an equal distance to the outlet, our course was

Portages on Sturgeon Lake River.

Canoe route from Minnietaki Lake to Lonely Lake.

Arrival at Hudson Bay Post.

Islands in Lonely Lake.

W. 30° N. About a mile and a half below the outlet, we came to the first falls and rapids of the English River. These are passed by two portages, respectively of one hundred and one hundred and fifty yards in length, with a pool between the falls about 200 yards across. I estimated the height of the upper fall at about fourteen feet, and that of the lower one at thirty-five feet. On the 23rd of September, we camped at the foot of the lower fall. The following day about noon, we reached the junction of the Mattawa River, a considerable stream which joins the English River from the north-west, and drains a large section of country in that direction, including Red Lake or Trout Lake, and a number of other smaller lakes. Descending the English River you look directly up the course of the Mattawa, and you have here the somewhat singular phemomenon of two large streams meeting each other apparently from exactly opposite directions. The united waters turn south, at right angles to the course of both streams above their junction, and, after flowing about two miles, mostly bordered by swampy flats and lagoons swarming with water fowl, make a sharp turn to the east, and issue into a lake, which appeared to be about a mile and a half wide and two miles long. The course across this Lake, which we named Duck Lake, was about E. 20° S., and at the head of a small bay on the south-east side, we came to the third portage on the English River. The outlet from the lake is through a steep rocky gorge or canon, and between the former and the foot of the portage, which is 1,600 yards in length, the course of the river describes two-thirds of the circumference of a circle having a radius of about half a mile. This portage is about sixteen miles below the second. Just as we reached it, and before we could get our tents pitched, a storm set in which lasted almost without intermission for the two following days and nights, detaining us from the evening of Tuesday the 24th, to Friday morning the 27th. On the morning of the 26th, snow lay three to four inches thick on the ground. At 6 a.m. the thermometer registered 38°, at 3 p.m. 44° and at 9 p.m. 46°; the barometer at the same hours 28.48, 28.68 and 28.74. On the 23rd, at 9 a.m., the barometer had fallen to 28.02. This storm occasioned disastrous floods at the mouth of Red River, by which several lives were lost, and its ravages on the southern shores of Lake Winnipeg we subsequently witnessed.

Falls and Rapids on the English River.

Junction of Mattawa and English Rivers.

Duck Lake.

Portage 1,600 yards in length.

Violent storm.

Starting again on the 27th., we travelled about nineeten and a-half miles, and passed the fourth, fifth, sixth and seventh portages, respectively 60 yards, 75 yards, 50 yards and 66 yards in length. At each of these portages there are falls of from eight to twelve feet. The fifth, sixth and seventh are all within a length of one mile, and the last, at which we camped, and which we named Oak Point Fall, is remarkable for its wild and picturesque beauty, as well as for the first appearance of oak trees on the English River. Immediately below the fall is a lake about a mile wide,

Portages.

Oak Point Fall.

stretching to the north-east and to the south-west across the course of the river. Our guide informed us that at the head of this lake, about twelve miles distant in the direction first named, a large river discharges. At about seven miles nearly south from Oak Point portage, we reached the next fall and rapid. These are passed by a portage 700 yards in length, across a ridge which divides a small lake above the rapids from another commencing immediately below them and extending for the next five miles. Both these lakes are studded with islands, and vary in width from one to two miles, with very irregular and indented shore lines. Flower Lake River, fifty miles up which to the southward is Eagle Lake, joins the English River here, and from this point to our camp on Separation Lake, where the canoe-route *via* Sandy Lake to Rat Portage branches off, there are about twenty-eight miles of good canoeing without portage, through small lakes or lake-like expansions of the river, all of which are studded with a multitude of rocky islets, and bounded by wonderfully indented and irregular shore-lines.

Portage of 700 yards.

Flower Lake River.

Twenty-eight miles of good canoeing.

Leaving Separation Lake, the river contracts considerably, and the current is very swift, with numerous eddies and whirlpools. In about six miles, we came to the ninth, tenth and eleventh falls and portages, all of which occur in a distance of about two miles. These portages are respectively 210 yards, 180 yards and 360 yards in length, and the falls about eight, twelve and eighteen feet in height. Twenty-six miles further, the twelvth and last fall and portage on the English River is reached at about nine miles above the confluence of the Winnipeg, one mile below which is Island Portage. The Winnipeg River with its numerous and picturesque falls and rapids has been so frequently travelled, and has been so graphically described, first by Keating in 1823, in his "Narrative of an Expedition to the Source of St. Peter's River," and subsequently by Professor Hind, in 1858, in his "Report on the Canadian Red River Exploring Expedition," that it would be impossible, by merely passing along it as we did, to add anything to the details already given of it by those authors. We reached Island Portage early on the 2nd of October, and at 6 p.m. on the 6th arrived at Fort Alexander. Our traverse of Lake Winnipeg from Fort Alexander to the mouth of Red River occupied from the after noon of the 7th to the evening of the 11th, adverse winds having detained us for two days On the 13th of October we reached Fort Garry, having completed a canoe journey of about 550 miles in forty-four days travel, and made seventy portages of a total length of 14.79 miles

Portages.

Winnipeg River.

Arrival at Fort Garry.

The distances as estimated and laid down on my sketch map of the route from the outlet of Lac des Mille Lacs to Fort Alexander are approximately as follows:—

Distances between Lac des Mille Lacs and Fort Alexander.

	Miles.
From the outlet of Lac des Mille Lacs to Sturgeon Lake, including twenty-five portages, together 9,836 yards..........	100

	Miles
From our camp, south-east shore of Sturgeon Lake, to the Hudson Bay Post on Lonely Lake, with thirteen portages, together 7,848 yards..................................	81
From Lonely Lake Post to the English River.............	52
From the outlet of Lonely Lake to Separation Lake, where the canoe route to Rat Portage leaves the English River, with eight portages, together 2,801 yards..............	82
Separation Lake to the confluence of Winnipeg and English Rivers above Island Portage, with four portages, together 940 yards..	41
Thence to Fort Alexander by Lee River and Bonnet Lake, with twenty portages, length 4,595 yards..............	105
	461

Professor Hind gives the latter distance, *via* the main river and the Seven Portages, as one hundred and four miles; and the distance between Island Portage and Otter Fall he makes forty-nine miles, while my estimate is forty-seven.

From barometric observations on Lac Seul it would appear to be about 1,150 feet above the sea, giving a fall of 245.53 feet for the English River to Island Portage, and 276.47 thence to Lake Winnipeg, assuming the latter to be 620 feet above the sea, or the same elevation as Lake Superior. Height of Lac Seul above the sea.

Geological Features.

In Mr. Bell's report a full description is given of the geological features which were observed beween Lac des Mille Lacs and Separation Lake, and thence, *via* Sandy Lake, to the Lake of the Woods. The rapidity with which we were obliged to travel rendered it impossible to extend our observations beyond the immediate vicinity of the route followed, and even on it we were often for many miles together at such a distance from the land as to make it impossible to determine precisely what was the character of the rocks. Notwithstanding this, however, the main objects of this reconnaisance were fulfilled, in giving a general idea of the physical features of the country and of its geological structure. The most important and interesting point which has been ascertained in this connection is the occurence of a series of great parallel bands of schistose and slaty strata traversing this region, which hitherto was supposed to be almost exclusively occupied by Laurentian gneiss. The aspect and lithological character of these slaty rocks, and their apparent relations to the underlying Laurentian gneiss, are stated in Mr. Bell's report. It may, however, be remarked that though the facts observed undoubtedly lead to the conclusion, as stated by Mr. Bell, that the two series are in conformable Schistose and slaty strata overlying Laurentian gneiss.

sequence, yet it is far from improbable that this apparent conformity is only local, and that the result of a more extended and detailed investigation of the structure would serve to shew that there is in reality a very considerable break and much unconformity between the Laurentian gneiss and the overlying schistose and slaty strata. As regards the age of these so-called Huronian rocks, the evidence is not of the most satisfactory kind. While stratigraphically they rest directly upon highly crystalline and typical Laurentian gneisses, mineralogically they resemble as closely the chloritic, epidotic and dioritic strata of the altered Quebec group as they do those which on the shores of Lakes Huron and Superior are referred to the Huronian series.

Resemblance to rocks of the Quebec group.

A similar series of rocks occurs, as shown by the researches of Mr. James Richardson and of Mr. Walter McOuat, of the geological corps, in the regions lately explored by them around Lakes Mistassini and Abbitibbé. It is similarly related to the Laurentian gneisses, and associated with it there are serpentine and green schists holding magnetite in crystalline grains, and in the serpentine from Misstassini and Abbitibbe, both chrome and nickel have been detected; in the former by Dr. Hunt and in the latter by Dr. Harrington. The only organic form which has as yet been found associated with these rocks is the obscure coral mentioned in Mr. Richardson's report. [Geology of Canada, Report of Progress, 1870-71, page 294.] Notwithstanding this, and that Mr. McOuat failed to find any fossiliferous beds associated with the Abbitibbé rocks, yet I think there is not much room for doubting that the green schists of the Mistassini region are of the same age as those of Lake Abbitibbé; and as we have associated with the former serpentinous limestones holding corals, pronounced both by Dr. Dawson and Mr. Billings to be either *Tetradium* or *Favosites*, and the whole mineral aspect of the formations in both localities closely resembles that of portions of the altered Quebec group, it seems not improbable that they may be of the same age; and if so, then it becomes a question, in what way they are related to the Huronian series of Lakes Huron and Superior, as well as to the great bands of somewhat similar rocks which we find traversing, in a W. S. W. and E. N. E. direction, the entire region between Lake Superior and Red River. This very interesting and important question can only be determined by further minute and careful investigation: but whatever their geological age may be, their presence exerts a marked beneficial influence on the physical character and on the general fertility of the country where they occupy the surface. This fact in relation to a portion of two of the bands which we observed west of Lake Superior, was noticed by Professor Keating in 1823, who writes respecting these as follows: *

Rocks of Lakes Mistassini and Abbitibbé.

Rocks between Lake Superior and Red River.

* Narrative of an Expedition to the Source of St. Peter's River, performed in the year 1823.

"After passing Jack's Falls, a great change in the appearance of the river was observed, and was distinctly traced to a difference in the rock. The granite and syenite were replaced by a slate, which appeared to vary from a mica to a clay slate, presenting chiefly the character of the latter. It is very distinctly stratified. The strata are nearly vertical. Its junction with the granite was observed in many places; the slate was superposed. The hills which we had observed above Bonnet Lake did not continue after the slate had made its appearance. A corresponding change in the features of the stream is observed. The river expands considerably, being in some places several miles wide; it includes a great number of islands, all of which have a solid rocky foundation. The color of the rock is of a deep blue, or black, imparting the same hue to the water. The river is not deep, its current is swift, especially near the islands, but it is free from ripples. We observed none of the foaming rapids which characterized the lower part of the stream. The islands which in some places are countless, are generally small and of a form nearly square; from the vertical stratification of the rock their banks are perpendicular; they generally rise from ten to twenty feet above the level of the water. Their surface is covered with a thick growth of trees, which are for the most part, however, small. They consist of a dwarf species of pitch-pine, spruce, juniper, tamarack, &c.; the white birch becomes more abundant; the undergrowth is very luxuriant. The soil appears much better than that on the granite. In some parts the rock appears covered with a ferruginous incrustation, produced probably by the decomposition of iron pyrites which abounds in it. The difference in the rocks did not continue long, for after having travelled about fifteen miles the slate ceased, and was replaced by granite which soon passed into a decided syenite, producing a wilder and more uninhabitable country than any we had as yet seen. The syenite rises apparently in great confusion in steep masses which are rounded at their summit, they are covered with moss and support but a very thin growth of scrubby pines on their surface.

Extract from Prof. Keating's book.

"Previous to our arrival at Rat Portage, we observed that the rocks had again changed to a slate of which the stratification was very distinctly directed from east-north-east to west-south-west. The inclination was nearly a vertical one; the color of the slate is a dark green; it is very decidedly a micaceous slate, at least on Rat Portage. This produces the same feature which we had observed on the Winnipeg River above Jack's Falls, but which becomes more distinct in the Lake of the Woods."

Apart from the geological interest which attaches to the determination of the distribution of these rocks and of their precise relations to the underlying Laurentian gneiss, the foregoing facts shew that it is economically important that the extent of these bands should be defined; and that their mineral characters should be closely investigated is equally so, inasmuch

Mineral deposits and soil.

as the gold, the copper and the iron of the region, as far as known, are associated with similar strata, and thus, not only the best land, but likewise valuable mineral deposits are to be looked for within the limits which they occupy.

Route between Lac des Mille Lacs and Lake Winnipeg.

Except such as arises from causes connected with the presence of Huronian rocks as above described, or with the occurrence of superficial deposits of sand, clay, etc., but little variation is perceived in the general aspect of the country on the route which we traversed between Lac des Mille Lacs and Lake Winnipeg. On the mainland, and on the innumerable islands, the shores of the lakes and rivers very generally present bare rock surfaces. Bold cliffs and precipices are rare; the rocks either rise abruptly from the water for fifteen or twenty feet, or else slope gently upward, till, above the line of highest flood, they are concealed beneath a thin coating of moss-covered soil, supporting a thick undergrowth of brushwood, and a forest of poplar, aspen, birch, spruce and small tamarack, with occasionally a few red pine trees, standing singly or in small clumps, and which, though considerably taller than the rest of the forest, and hence conspicuous at a distance, are rarely of large size. The generally small size of the timber, however, is evidently not altogether due to the effect of unfavorable soil and climate, but in a great measure to the fact that nearly all the older trees have been destroyed by the successive fires which at one time or other have devastated every part of the country, and the effects of which are often conspicuously marked by the tall, dead branches and partially charred trunks which still tower above the younger forest. There are no prominent hills or even ridges; the highest elevations do not probably exceed four or five hundred feet above the intervening waters; and I think it is no exaggeration to say that the latter occupy fully one half of the whole surface area of the region. The surface is generally broken and undulating, and often rocky, but occasionally both lakes and rivers, are bordered either by extensive swampy flats or by banks of stratified sand, silt and clay, which often rise terrace-like at a short distance from the water's edge. The point on which the Lonely Lake Post stands is formed of these deposits, and to the westward of the Post, along the north shore, they are exposed in cliff sections for several miles. At the junction of the Mattawa and the English Rivers, where a small Indian Village and trading post is situated, presided over by Chief Pierre, there are similar banks of sand and sandy clay, resting on the ordinary grey Laurentian gneiss, which is exposed along the water's edge. The banks here rise steeply to about thirty feet above the water, and for some distance inland the country seems to be tolerably level, and the soil on this part of the river appears to be generally of fair quality. Small patches of it are cultivated by the Indians, who succeed in raising excellent potatoes, carrots and onions, and there is no doubt that many other crops

Small size of timber.

Absence of prominent hills, and extent of area occupied by water.

Crops raised by the Indians.

would flourish equally well, and would be cultivated by them if they were supplied with seed. Throughout the region, especially from Sturgeon Lake westward to Lake Winnipeg, there are considerable areas of soil suitable for cultivation. Areas suitable for cultivation.

The sands and clays, which for the most part form the soil of these cultivable areas, appear to be more widely distributed in the valley of the English River than they are in that of the Winnipeg. Professor Hind says:* "The Winnipeg River, until within a few miles from its mouth, flows through a desolate and irreclaimable rocky waste, furnishing a very small supply of timber for lumbering purposes in proportion to its length of 163 miles." This description applies equally to some parts of the English River, but the greater prevalence above alluded to of the superficial deposits in the valley of the latter appears to be accompanied by a corresponding amelioration in the character of the country. The same author remarks that "small patches, varying from 50 to 300 acres, of excellent drift clay occur at and below Islington Mission, but within a few miles of the mouth of the river an extensive area of good arable land is to be found." Islington is on the Winnipeg River about twelve miles above its confluence with the English River. On the lower part of the Winnipeg River, and around the south-eastern shore of Lake Winnipeg, the banks and cliffs, which are entirely composed of these drift deposits, form a very prominent feature.

Occasionally the cliffs are nearly perpendicular, and as much as fifty or sixty feet high. The sections which they afford shew alternating beds of fine and course sand, silt or mud and sandy clay. At most of the points and headlands, and in some of the bays where such cliff sections occur, the shore beneath is often thickly piled with small and large transported stones and masses of rock. Inland, similar stones and rock masses are found to be somewhat thinly and irregularly distributed, either resting on the surface or partially imbedded in the soil. Their distribution has clearly taken place long after the formation of the deposits upon which they rest, as their position is always on or beneath, and not in the cliffs, and it would seem that their accumulation upon the shores and at the points and headlands as described is the result of a twofold action. The wearing away and breaking down of the sand and clay cliffs by atmospheric causes brings the boulders within the influence of the waters of the lake, while their piling up in certain places may probably be explained by the shoving action of the ice upon the shores when breaking up in the spring. Respecting these deposits on the shores of Lake Winnipeg, Professor Hind writes:† "About five miles further south, I ascended a cliff, fifty feet high, consisting of stratified sand and marl, in which were imbedded primitive boulders of Sections of cliffs. Gigantic boulders.

* Report on the Canadian Red River Exploring Expedition, 1857.

† Ibid. page 252.

most gigantic dimensions. Some of them measured twelve to fifteen feet through; they were all water-worn and distributed throughout the cliff. The base of the cliff was well protected by an immense accumulation of these erratics which had fallen from the loose sand of the cliff."

From the foregoing it will be seen that the opinion of Professor Hind regarding the relation of those enormous boulders to the sand and clay deposits, differs from that which I formed respecting them. In support of my own view of the matter, I may say that in the only sections which I examined where the cliffs were sufficiently steep to prevent the lodgement on the slope of boulders falling from above, or presented vertical sections, I saw no boulders except at the base and on the summit.

Fossils.

A few fossils were collected from loose fragments of limestone on the shores of Lake Winnipeg, and also from rock in position at the Stone Fort on Red River. Among them are several specimens of a lingula which Mr. Billings says is probably *Lingula Coburgensis*. That the Red River limestones are of the age of the Trenton group, has already been determined.

ALFRED R. C. SELWYN.

Montreal, May, 1873.

REPORT

BY

ALFRED R. C. SELWYN,

UPON THE

ACADIA IRON ORE DEPOSITS

OF

LONDONDERRY, COLCHESTER COUNTY, N. S.

The following observations on the above deposits are the result of an examination of them which I made in June last, extending over a period of eight days.

My attention was directed chiefly to ascertaining the character of the ore deposits, more especially as regards the quantity which they might reasonably be expected to yield if fully opened out; and whether they could then be made to supply permanently the requirements of a large annual manufacture of iron.

Description of Cobequid Hills.

The land on which the ores are found is situated in the township of Londonderry, on the southern slope of the Cobequid Hills. These are described by Dr. Dawson (Acadian Geology, page 579) as follows: "The Cobequid range, attaining at several points a height of 1200 feet, is the highest chain of hills in Nova Scotia; and forms in its whole length the watershed dividing the streams flowing into Northumberland Strait and Chiegnecto Bay from those flowing into Cobequid Bay and Mines Basin and Channel."

Extent of the Charcoal Iron Co's. property.

The property of the Acadia Charcoal-Iron Company extends nearly twelve miles in an east and west direction on the ore vein, with an average width of about four miles, and comprises 33,000 acres in contiguous lots, some of them cleared and cultivated, but the greater part covered with a fine forest of valuable hardwood timber. On the west it is bounded by the Port-à-pique River, and on the east by the De Bert River.

Valuable streams for water-power.

Twelve other streams and brooks, several of them large enough to be valuable as water-powers, traverse the property in a direction nearly north and south. A series of more or less parallel ridges or spurs from the main axis of the Cobequid Hills separates the streams, and slopes down to them on either side, often very abruptly, from elevations of one hundred to three hundred feet, forming steep valleys and ravines.

Character of rocks.

The rocks, which are often well exposed in these valleys and ravines and in places also on the hills, consist of grey, blue and olive slaty shales, alternating with bands of quartzite, and of hard grey and brown feldspathic sandstones, and have a general nearly east and west strike with a high southerly dip.

Division of property into two sections.

For convenience in describing it, the property may be divided into two sections, being respectively those portions which lie to the east and to the west of the present smelting works on Great Village River.

Names of streams.

The streams in the western section are Maddison's Brook, Cumberland Brook, Martin's Brook, Cook's Brook, and the east and west branches of Great Village River. In the eastern section there are Campbell's Brook, Mill Brook, Folly River, east branch of Folly River, Pine Brook and Totten's Brook. The water of all these streams and likewise that of the Port-à-pique and De Bert Rivers, empties into Cobequid Bay, the shore of which is distant about five miles from the southern boundary of the property.

Railway communication.

The section of the Intercolonial Railroad between Amherst and Truro passes for several miles through the eastern portion of the property, and a branch railroad three and a half miles in length is in course of construction from the main line to the site of the smelting works at the Forks of Great Village River. When this is completed, the mine and works will be placed in direct and easy communication with the important coal-fields of Pictou on the one side, and of Springhill on the other, and also with the ports of Halifax, Pictou, Truro and Amherst.

Condition of workings in eastern section.

On the eastern section of the property no mining operations are at present in progress, and I could therefore only examine the old surface explorations, which are indicated by a number of shallow pits and trenches on the course of the ore. None of these, at the time of my visit, were in such a condition as to afford the means of examining the vein in them, and therefore its presence and dimensions at these points could only be inferred from the character and the quantity of ore which has been raised from the various openings and is now piled on the banks, and from the testimony of the persons under whose superintendence the explorations were conducted. The general course of the fissure or vein in which the ore occurs is W. 8-10° N. and E. 8°-10° S. magnetic. It has a steep southerly dip of about 80°, and in its *strike* or level course it closely coincides with that of the metamorphic slaty shales and sandstones of Upper Silurian age, which form the *country* or wall rocks; and while there is every reason for believing that the fissure or vein is continuous through the entire east and west length of the property, it would nevertheless be premature to assert that it is throughout this distance accompanied by ore deposits. In both the eastern and western sections, there are considerable intervals, especially in the former, in which no ore has yet been found; perhaps only because it does not appear at the surface, through being concealed either by the superficial accumulation of soil, or by carboniferous strata, which, immediately to the east of Folly River, appear to overlap the line of strike of the ore vein. The longest interval in which, so far as I could learn, no ore has yet been found, extends from the west branch of Great Village River to the west bank of Campbell's Brook, a distance on the course of the vein of about 2 miles, (2 miles and 32 chains from subsequent measurement.)

Course and continuity of vein.

Great Village River.

The east branch of Great Village River flows through a deep narrow gorge or *canon*, in which the rocks are well exposed. This gorge crosses the course of the vein nearly at right angles, but no ore or any other distinct traces of the vein have been found either in it, or on the high grounds between the east and west branches of Great Village River. A fault or break in the stratification crosses the gorge, however, exactly where the vein ought to appear, and it is not improbable that the downward prolongation of this fault might lead to ore deposits. Proceeding eastward, the ground on the strike of the vein is much encumbered with drift; no ore croppings have yet been discovered, and so far as I could learn, no explorations by sinking or boring have been made between the east branch of Great Village River, and the west bank of Campbell's Brook. Here, however, at a point 450 yards north of the Base-line Road, a level stated to be 200 feet in length has been driven in search of the vein; and 136 yards further north, and about fifty or sixty feet above the first, is a second level, the length of which I could not ascertain. According to information received, the vein was reached in both these levels, and good ore taken out. Neither of them was accessible for examination at the time of my visit, and I could get no information about the thickness of the vein. On the "spoil-heap" at the mouth of the upper level, there were a few large and small fragments of fibrous brown hematite.

Fault.

Ground cove[red] by drift.

Levels reachi[ng] the vein.

From the Campbell's Brook levels to the elevated ground east of Folly River, is another interval in which no ore has been found, though some traces of ore are said to have been observed about mid-way near where the strike of the vein would intersect the line of the Intercolonial Railroad.

Interval in which no ore has been foun[d].

East of Folly River, the first exposure of ore is met with at Ross' Farm. Here a trench, now partly filled in, has been dug on the course of the vein (W 10° N.) 25 yards in length and apparently some ten or fifteen feet in depth, from which a considerable quantity of ochrey red ore has been raised, and used for the manufacture of paint. The workings have however, been abandoned and no ore raised for seven or eight years. One hundred yards further east, in which distance there appears to have been a number of small excavations, the vein has been opened upon for twenty-five yards in length to a depth of about 20 feet. Owing to the sides of this opening having fallen in, the vein was not exposed at the time of my visit. But it is stated to have a vertical position, with a width of eighteen feet at the west end and fifteen feet at the east end of the excavation. About six hundred tons of limonite, in large and small concretionary masses, have been raised here and are now piled on the bank. This work was done in 1864, since when no further explorations have been made and no ore raised.

Ross' Farm.

The ore is of the best quality, and there is no doubt that the vein is very largely developed in this part of the property. At the next exposure to the east a shaft has been sunk and large masses of ankerite and specular

Quantity of o[re].

ore with some limonite have been taken from it. The shaft having fallen in, I could not examine it, nor could I learn the depth to which it had penetrated the ore.

Eastward extension of vein.

From this shaft the extension of the vein eastward can be traced by surface indications to the end of the slope towards the valley of Pine Brook immediately in rear of David Slack's house and 430 yards north of the Base-Line Road, giving it a total length between Ross' Farm and Pine Brook of nearly one mile, with but few, if any interruptions.

uantity of ore.

Supposing it to average four feet in width for this distance, to a depth of only one hundred feet it might be expected to yield nearly 200,000 tons of ore, allowing ten cubic feet of ore to the ton of 2,000 lbs.

The vein has not been traced across the valley of Pine Brook.

Barn-hill lot.

Further eastward, however, on the Barn-hill lot, it again crops out and is stated to show ankerite with spathose ore in large quantities.

Peter Totten lot.

About three-quarters of a mile east of the Barn-hill lot, is the Peter Totten lot; here on the north side of a small swampy brook, a tributary of Totten's Brook, the vein has again been discovered and traced eastward for a quarter of a mile along the slope of the hill, in which an excavation has been made about fifteen feet deep, and twenty-five to thirty feet long and about 200 tons of ore have been raised from it. Dr. B. J. Harrington has made an assay of a specimen of this ore which I took from the heap and which appeared to me fairly to represent the whole, with the following result.

Analysis.

The iron was determined and calculated as hydrated peroxide.

Hydrated peroxide of iron	78.52
Carbonate of lime	20.61
Carbonate of magnesia	0.87
	100.00

Equal Metallic Iron 47.05 per cent.

It may therefore be considered a first class ore. The vein is stated to have a width here of eighteen feet, and as it is very favorably situated for being worked, large quantities of ore could be mined on this lot. Beyond the Peter Totten lot, the vein is said to have been traced eastward for about two miles, by fragments of ore scattered on the surface, but my examination did not extend further in that direction.

Division of western section of vein into four parts.

In the western section, I examined as far as possible, all the openings which have been made upon the vein. This part of the property may be divided into four parts, on each of which more or less ore has been discovered, and the relation of which to each other is shewn on the accompanying plan:

1. From Great Village River to Cook's Brook.
2. From Cook's Brook to Martin's Brook
3. From Martin's Brook to Cumberland Brook.
4. From Cumberland Brook westward to the boundary of the property.

The original workings, which were commenced in 1849, are situated in the first of these divisions; and for eight years they supplied all the ore which was smelted, amounting to 4,000 tons, yielding 1,000 tons of iron. None of these old workings are now accessible, having been abandoned since 1857. There appear to have been several levels driven into the hill, which rises abruptly for more than three hundred feet above the river bed, and on the summit a number of shafts have been sunk, the deepest of which is stated to have been seventy feet. The form of the ground here presents the greatest facilities for working the vein, and its proximity to the smelting works should also recommend it in preference to more distant localities; but the only work at present going on in this division is the raising of ankerite for use as a flux in the furnace. It can be quarried in the steep face of the hill fronting the works, (see plan) and delivered at the furnace for $1.10 per ton, the quantity available being practically inexhaustible. I could obtain no very satisfactory explanation why the mining operations in this locality were suspended, but on comparing the return given above of the produce up to 1857, with that which has since been obtained from ores which are carted to the furnace from a distance of two and a half to three miles at a cost of sixty cents per ton, it is seen that the ore which was mined at Great Village River works, was of a much lower percentage than that which is now used, or else that the smelting process then in use was very defective. From 1857 to 1861 the production of iron is stated to have been 4,000 tons from 9,000 tons of ore, and the same proportion has been maintained up to the present time, from a total of 60,000 tons of ore.

Original workings in Division 1.

Cost of ore at the furnace.

Production of iron.

The character and appearance of this part of the vein as observed by Dr. Dawson, when active operations on it were in progress, is fully described in his "Acadian Geology, (pages 583 to 586). It appears to have been traced by surface openings for about 880 yards, which carries it to within one hundred and eighty yards of Cook's Brook.

In the second of the foregoing divisions, a distance of about 1,150 yards, the only openings on the vein are one level and a few apparently shallow pits. These openings are close on the west bank of Cook's Brook, and directly on the course of the vein from Great Village River. In the level, which like all the other excavations described, was not accessible, the vein is stated to have been struck at fifty yards from the mouth, and of the level was then driven a further distance of three hundred feet on the course of the vein, which showed an average thickness of three or four feet. The ore here was chiefly specular iron, mixed with red ochrey ore and ankerite. There are now about fifteen tons of ore piled at the mouth of this level, but none has been taken to the furnace. The crop of the vein has not been traced over the hill westward from these workings to Martin's Brook, but there is good reason for believing that it will be found to be

Division 2.

Specular ore.

continuous in this direction. A thorough exploration of the intervening ground would be desirable. I could not learn that any ore had been found in Martin's Brook or that any excavations had been made there. Dr. Dawson informs me, however, that he found some thin veins of specular iron ore near to where the vein might be expected to shew itself in the bed of the brook. Proceeding westward, the next exposure of the vein occurs on the hill side, at about 350 yards to the south-west from the point in Martin's Brook above named. Here the vein was found to run nearly north and south, (see plan) and to underlie about 80° to the westward. It continued on the same course for about one hundred and eighty yards, when it gradually resumed its normal course of west 10°-13° north, on which it has been traced and more or less worked upon, to within one hundred and fifty yards of the Cumberland Road, a distance of about fifteen hundred yards.

Martin's Brook.

Division 3.

Extent of workings.

The most extensive workings on the property are on this part of the vein, and from them the whole of the supply of ore for the past fifteen years has been derived, except 2,959 tons which have been taken to the furnace from the mines on the west side of the Cumberland Brook. The crop of the vein has been worked in shallow pits and trenches for a length of 3,953 feet, and shews good ore throughout. The main workings, however, and those from which the greater part of the ore has been raised, are confined to a length of about 740 feet, on the eastern end of the vein. In this portion of it there are six levels at various depths. The deepest, No. 6 on the accompanying plan, has been driven about 1,000 feet and is there about 200 feet beneath the surface.

For 600 feet it passed through barren ground; ore was then struck, and the level has since been driven 400 feet on the course of the vein, which is found to hold ore at the depth above mentioned, of the same rich character and as abundant as it did at the surface, retaining an average thickness of from three to four feet. No. 5 level is about 120 feet above No. 6. In it, and also in the upper levels 1, 2, 3 and 4, both the north and the south branches of the vein have been more or less worked, but none of the levels have extended westward beyond the 1,340 feet shewn in the plan and section as line No. 1. On the summit of the hill 282 feet above the No. 6 level, and 2,648 feet from its mouth, a substantial, well timbered shaft has been sunk, and is furnished with a 10 horse-power engine, and winding and pumping gear. In this shaft, which was commenced fifteen feet south of the crop, the vein was struck at 85 feet from the surface. No ore has been raised from this shaft, and at the time of my visit it was full of water. By sinking it a further depth of 197 feet, and connecting it with the No. 6 and with the other levels, 1,300 feet in length of the vein would be opened up to a depth of from 220 to 280 feet. A very insignificant quantity of ore has yet been taken from this ground, and supposing the vein to

Timbered shaft, engine, &c.

continue through it, as there is every reason for believing it does, without any material change in its thickness or in the character of its contents, it may reasonably be expected to yield some seventy or eighty thousand tons of ore. Yield to be expected.

West of the Engine shaft, as far as can be judged from appearances on the surface, equal areas of the vein will probably be equally productive; and thus in this division of the property alone, the supply of ore is not likely to be speedily exhausted.

The mining Manager in charge of the Martin's Brook works stated that he could now without difficulty raise from the No. 5 and No. 6 levels, one thousand tons of ore per month, and deliver it at the furnace at Great Village River at ($2.00) two dollars per ton. The accompanying plan and section of the ground between Martin's Brook and Cumberland Road, shew the character and position of the workings in this division, and afford a good idea of the extent of ground which remains to be worked. The datum-line in the section is the No. 6 level, but it should be observed that there is no reason for supposing that below this level the vein will prove less productive. As already stated the vein has been traced in this division to within one hundred and fifty yards of the Cumberland Road, when it appears to have been lost on the brow of the hill, 153 feet above the brook. At about fifty or sixty feet below this point the "Vipond" level (see plan) has been driven 300 feet in search of the vein, without, however, meeting with the success which, from the direction and the length of the level might have been anticipated; and no trace of the vein has been found crossing the Cumberland Road or Brook, notwithstanding that the rocks are fairly exposed. This apparent interruption of the vein on approaching the intersecting valleys from either one side or the other, and its reappearance on the opposite hill side is a somewhat remarkable fact, for the explanation of which further careful investigation is required. It may not improbably be connected with the occurrence of a series of large transverse, and more or less parallel dislocations, the courses of which are marked by the valleys. Disappearance of vein on Cumberland Road and Brook. West of the Cumberland Brook in No. 4 of the foregoing divisions, the vein reappears on the hill side at about one hundred and fifty feet above the brook, the interval from the last exposure of it on the opposite side of the valley being about 300 yards. Division 4. The works here have extended for about 250 yards westward on the crop of the vein, most of the ore having been taken from shallow pits and trenches, the deepest not exceeding thirty feet. Ore is now being raised here from a level (Morrison's Hill level) in which the vein has been cut at 300 feet from the mouth and is stated to show a width of fifteen feet. Morrison's Hill level. There are now about 400 tons of ore on the surface. The position of the vein on this hill, if it is uninterrupted in depth, would enable it to be worked with great advantage from the Cumberland Brook, by an adit, which would probably not exceed five hundred feet in length before striking the ore. In this division a second parallel vein has also been discovered, and is known as the Farnen's Hill vein, the position of it, as shewn on the accompanying map, is about 920 yards north of the level on Morrison's Hill. It has a nearly east and west course, and underlies about 80° to the southward. One shaft thirty-seven feet deep has been sunk on it, and there are excavations at intervals along the crop for about one hundred yards, some of which are as much as twenty feet deep. About 200 tons of ore have been raised here, and are now piled on the bank. The vein has not been traced across the valley of Cumberland Brook, but traces of ore are said to have been found on the opposite hill, nearly due east of the outcrop on Farnen's Hill, and which may mark the continuation of the vein in that direction.

Farnen's Hill vein.

To aid in forming sound and reliable conclusions respecting the nature of the veins, and the permanence of the ore deposits in depth, a careful measured survey should be made, from which to construct a plan, and longitudinal and cross sections, shewing accurately all the surface features and the outline of the ground, as well as the position, extent and depth of all the workings and the relative heights of the several ore croppings. The limited time which I could devote to the examination, and the want of any correct plans of the ground, as well as the condition, already mentioned of all the old workings, rendering them inaccessible for the purpose of examination, are causes which have combined to render my investigation less complete and satisfactory than it might have been under more favorable circumstances. I may, however, notwithstanding, state, that while there are no good reasons for supposing that at a greater depth than has yet been reached the vein will be found to be of greater width, and more regular position, neither are there any grounds whatever, for anticipating a change in the contrary direction; but that it will maintain characters corresponding with those which it exhibits on the line, where it is cut by the present surface, to depths far beyond those to which profitable mining can be carried is, however, in my opinion a view which is strongly supported by the probable circumstances connected with the origin of mineral veins of this kind, as also by the practical experience which has been gained elsewhere in working them. And though I was unable to verify by personal examination many of the statements respecting the appearance and dimensions of the vein where it has been exposed in old excavations, still the evidence I collected, and the facts I was able to determine, bearing on these points, are in my opinion of such a character as fully to warrant the conclusion, that no apprehensions need be entertained of any failure for years to come, in the supply of ore which the veins are capable of yielding, even if drawn upon to a much larger extent than heretofore.

Need of a careful survey.

Supply of ore.

So much has already been written and published by various authors, respecting the richness of the Londonderry ores and the excellent quality of

Quality of ore.

the iron made from them, and they have also been so thoroughly tested by practical working that it is superfluous for me to add anything on this subject. I have, however appended for reference the results of some of the examinations which have from time to time been made of them by different analysts; and also some analyses made by Dr. B. J. Harrington of specimens which I collected from different portions of the vein.

The accompanying map on a scale of 400 yards to one inch, of the western section of the property, is plotted and drawn from measurements which I made on the ground, and the plan and longitudinal section of the vein, and the workings on it, in division 4 of the same section, are reduced from documents which were furnished me by Mr. Livesey. Map.

ALFRED R. C. SELWYN.

Montreal, 12th Dec., 1872.

ANALYSES OF IRON ORE FROM LONDONDERRY. Analyses.

Ankerite. 3 Varieties.	Dawson. White.	C. J. Jackson.. Yellow.	C. J. Jackson. Brown.	H. How. Brown.
Carbonate of Lime	54.0	43.80	49.20	51.61
Carbonate of Iron	23.2	23.45 }	20.30	19.59
Carbonate of Manganese		0.80 }		
Carbonate of Magnesia	22.0	30.80	30.20	28.6
Silicious Sand	0.5	0.10		0.13
	99.7	98.95	99.70	100.00

Yellow Ochrey Ore.	Dawson.
Peroxide of Iron	74.52
Alumina	4.48
Carb. of Lime and Magnesia	40
Silica and Silicates	6.20
Water mostly combined	14.40
	100.00

Red Ochrey Ore.	Jackson.
Peroxide of Iron	70.20
Alumina	6.80
Carb. of Lime	5.60
Carb. of Magnesia	2.80
Silica	14.40
Oxide of Manganese	0.40
	100.20

Mr. J. L. Hayes states respecting the quality of the Londonderry ores: "There is no trace of sulphur, arsenic or any foreign matter which can deteriorate the quality of the iron, or of titanium or chrome, which would render the ores refractory."

The ankerite appears to be generally mixed with spathose iron in considerable quantity, and is also traversed by thin veins of specular iron. It is consequently valuable not only as a flux but also as an ore containing from twenty to fifty per cent. of iron.

NOTES

ON SAMPLES OF IRON,

FROM THE

ACADIA MINES, NOVA SCOTIA.

BY

BERNARD J. HARRINGTON, B. A., Ph. D.

The accompanying analyses illustrate accurately the composition of six samples of ore from the Acadia mines, Nova Scotia.

Numbers I, II, and III have been made by myself, Nos IV, V and VI by Mr. Christian Hoffmann. In each case the mean of two closely agreeing analyses is given.

On glancing at the results it will be seen that five of the ores are what are commonly known as "Brown Hematites," consisting mainly of hydrated peroxide of iron ("Brown Hematite," or "Limonite," when pure, contains 85.6 per cent of peroxide of iron, and 14.40 per cent of water). The remaining ore (No VI) is what is known as "Specular Ore."

No I. (Cumberland Brook, North Vein) is a hard compact ore of a dark brown color and without lustre, except upon the surfaces of occasional cavities which are interspersed through it. The amount of phosphorus, though not so high as in many of the English "Brown Hematites," is nevertheless too large for it to be considered as a first class ore.

No II. (Cumberland Brook, South Vein) is yellowish-brown in color, earthy and rather friable. The large amount of manganese which it contains is worthy of note.

Nos IV. and V. (Martin's Brook and Ross' Farm) are of a dark brown color, and occur in lustrous botryoidal masses exhibiting a fibrous structure when broken.

No III. (From the Peter Totten Lot). The analysis of this sample shows it to be an exceedingly good ore. It differs from those already described in containing over 20 per cent. of carbonate of lime, and in being entirely free from phosphorus. Its freedom from the latter element, and its high percentage of manganese, would render it particularly valuable in the manufacture of steel.

No. VI. (Cook's Brook). This, as already mentioned, is a true "Specular Ore," the sample examined having only a surface coating of hydrated peroxide. It occurs in small crystals or scales of a steel-grey color. Like the last this is a valuable ore, containing in a high percentage of iron, only 0.003 p. c. of phosphorus and no sulphur.

A sample of the "Acadia Bar Iron," said to have been made from the Martin's Brook ore, I find to contain only 0.018 per cent. of phosphorus.

On account of the small amount of earthy constituents in most of the above ores, they might be advantageously smelted by mixing with the earthy and silicious ores which abound in other parts of Nova Scotia.

B. J. HARRINGTON.

Montreal, Feb. 3rd, 1873.

I.

ANALYSIS OF SAMPLE OF ORE FROM CUMBERLAND BROOK, NORTH VEIN, ACADIA MINES.

Peroxide of Iron	82.13	Metallic Iron	58.27
Protoxide of Iron	1.00		
Protoxide of Manganese	0.72		
Alumina	0.66		
Lime	0.88		
Magnesia	0.25		
Silica	1.93		
Phosphoric Acid	0.86	Phosphorus	0.370
Sulphuric Acid	0.04	Sulphur	0.016
Water (hygroscopic)	0.44		
Water (combined)	11.07		
Total	99.98		
Insoluble Residue	2.05		
Specific gravity	3.77		

II.

ANALYSIS OF SAMPLE OF ORE FROM CUMBERLAND BROOK, SOUTH VEIN, ACADIA MINES.

Peroxide of Iron	79.68	Metallic Iron	55.77
Protoxide of Iron	—		
Protoxide of Manganese	2.51		
Alumina	0.63		
Lime	0.57		
Magnesia	0.34		
Silica	3.05		
Phosphoric Acid	0.44	Phosphorus	0.192
Sulphuric Acid	0.01	Sulphur	0.004
Water (hygroscopic)	0.78		
Water (combined)	11.65		
Total	99.66		
Insoluble Residue (Silica)	3.04		
Specific gravity	3.43		

III.

ANALYSIS OF SAMPLE OF ORE FROM PETER TOTTEN LOT. ACADIA MINES.

Peroxide of Iron	69.86	Metallic Iron	48.90
Protoxide of Iron	—		
Protoxide of Manganese	2.25		
Alumina	trace		
Lime	11.70		
Magnesia	0.42		
Silica	0.07		
Carbonic Acid	9.20		
Phosphoric Acid	—		
Sulphuric Acid	0.04	Sulphur	0.016
Water (hygroscopic)	1.33		
Water (combined)	5.74		
Total	100.61		
Insoluble Residue	0.07		
Specific gravity	3.29		

IV.

ANALYSIS OF SAMPLE OF ORE FROM ROSS' FARM, ACADIA MINES.

Peroxide of Iron	84.73	Metallic Iron	59.31
Protoxide of Iron	trace		
Protoxide of Manganese	0.23		
Alumina	0.23		
Lime	0.14		
Magnesia	0.14		
Phosphoric Acid	0.19	Phosphorus	0.086
Sulphuric Acid	0.01	Sulphur	0.004
Water (hygroscopic)	0.33		
Water (combined)	11.07		
Insoluble Residue	2.67		
Total	99.74		

Sp. gr. 3.98

The Insoluble Residue consisted of,

Silica	2.54
Alumina with trace of Iron	0.09
	2.63

V.

ANALYSIS OF SAMPLE OF ORE FROM MARTIN'S BROOK, ACADIA MINES.
(New Mine, No. 6 adit.)

Peroxide of Iron	82.65	Metallic Iron	57.85
Protoxide of Iron	trace		
Protoxide of Manganese	0.25		
Alumina	0.56		
Lime	0.15		
Magnesia	0.10		
Phosphoric Acid	0.38	Phosphorus	0.166
Sulphuric Acid	0.02	Sulphur	0.008
Water (hygroscopic)	0.31		

Water (combined)	10.51		
Insoluble Residue	4.79		
Total	99.72		
		Sp. Gr. 3.91	

The Insoluble Residue consisted of

Silica	4.51
Alumina with trace of Iron	0.28
	4.79

VI.

ANALYSIS OF SAMPLE OF ORE FROM COOK'S BROOK, ACADIA MINES.

Peroxide of Iron	96.93	Metallic Iron	67.85
Protoxide of Iron	——		
Protoxide of Manganese	trace		
Alumina	0.33		
Lime	0.04		
Magnesia	0.11		
Phosphoric Acid	0.007	Phosphorus	0.003
Sulphuric Acid	——		
Water (hygroscopic)	0.03		
Water (combined)	0.79		
Insoluble Residue	1.26		
Total	99.497		
		Sp Gr. 5.93	

The Insoluble Residue consisted of,

Silica	1.20
Alumina with trace of Iron	0.07
	1.27

REPORT

ON THE

COAL-FIELDS OF VANCOUVER AND QUEEN CHARLOTTE ISLANDS,

WITH A MAP OF THE DISTRIBUTION OF THE FORMER.

BY

MR. JAMES RICHARDSON;

ADDRESSED TO

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

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

GEOLOGICAL SURVEY OFFICE,
Montreal, 1st May, 1873.

SIR,—In the beginning of May last I received your instructions to proceed to British Columbia, for the purpose of continuing last year's exploration of the coal deposits on Vancouver Island; and a memorial having been transmitted to you through the Lieut.-Governor of that Province, and the Hon. Jos. Howe, Secretary of State for the Provinces, from the Hon. J. N. Ash and others interested in the anthracite coal-seams of the Queen Charlotte Islands, requesting a survey and report on the same, you were pleased to hand me a copy of the correspondence on the subject, leaving it at my discretion to take such action as circumstances might render expedient after my arrival in the country.*

In carrying out your instructions, I left Montreal on the 23rd of May and arrived at San Francisco on the 30th. I embarked on board the mail steamer Prince Alfred on the 5th June, and reached Victoria on the 12th; but a case of small-pox having occurred on board the steamer, I was delayed by quarantine regulations until the 27th.

Acknowledgment of assistance.

Having procured provisions, camping material, a boat and men, and, through the kindness of His Excellency the Lieut.-Governor, a free passage on board the Dominion steamer Sir James Douglas, commanded by Captain Clarke, we left Victoria on the morning of the 2nd July, and reached Comox Harbor, about 140 miles distant, on the afternoon of the 3rd. I have here to express my obligations to Capt. Clarke, not only for his attention and courtesy while on board, but for his many subsequent kindnesses, and particularly for his great care in forwarding throughout

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* See Appendix No. IV. p.——

the season letters and parcels addressed to myself, and conveying geological specimens directed by me to Victoria.

Immediately on arrival at Comox, field-work was commenced by the measurement of the neighboring rivers, the channels of which, during the months of July, August and September, are almost dry, and thus afford the best exposures of the measures. One or two trails were cut through the forest, but from the heavily wooded character of the country, these involved too much expense of time, and from the depth of the drift, afforded but a meagre amount of rock exposure, and were therefore not continued.

Commencement of field work.

A good deal of time was spent in collecting fossils, as it was deemed of importance to obtain as much definite evidence as possible of the age of the coal-bearing rocks. For this purpose, therefore, much care was taken in examining also the coasts of Denman and Hornby Islands.

Before leaving the neighborhood of Victoria, I had several interviews with the Hon. J. N. Ash, M.D., and others interested in the anthracite coal of the Queen Charlotte Islands, with whom arrangements were made that I should be taken on board the Hudson Bay Company's steamer, "Otter," when she visited Comox on one of her periodical trips along the coast northward, and be conveyed to the Islands in question, there to remain until a succeeding trip of the steamer, making in the meanwhile such an examination as the time would permit; and it was to be intimated to me by letter when the steamer might be expected at Comox.

Arrangements for visiting Queen Charlotte Islands.

In conformity with this arrangement, I embarked on board the Otter on the 22nd August, accompanied by Mr. Fawcet, one of the gentlemen interested in the Queen Charlotte anthracite, and arrived on the 28th at Cowgitz, situated on the north side of Skidegate Channel. This channel separates Graham Island from Morseby Island, these being two of the principal islands constituting the Queen Charlotte group. The steamer put into Cowgitz again on the 8th September, and, after having made such an examination as the time permitted, I was relanded at Comox on the 12th.

Return to Comox.

My explorations were then continued in the Comox field until the 26th of the month, when heavy rains began to fall, filling the streams and depriving me of the best means of examination.

By this time I had reached Qualicum River; and thence I proceeded by boat as far as North-West Bay, and on foot, along the Comox and Nanaimo trail, as far as Nanaimo, arriving on the 1st of October. While engaged in the examination of the coast and islands of this neighborhood, I was requested by Mr. Sandford Fleming, Chief Engineer of the Intercolonial and Canadian Pacific Railway, who had put into Nanaimo on his return to Victoria from Bute Inlet, to gather information for him respecting levels across the country from the mouth of the Qualicum to Alberni on the upper part of Barclay Sound. In order to comply with this request, it became necessary for me to return to Comox to obtain additional men

Qualicum River to Nanaimo.

Information for Mr. Sandford Fleming.

Qualicum River to Barclay Sound.

to assist in the transport of camping equipage and provisions, and nine days were subsequently occupied in the performance of the work.

Though acting in this instance on my own responsibility, I have been gratified by the expression of your approval; and the geographical results of the trip have already been forwarded by yourself to Mr. Fleming at Ottawa. I am happy to state that the geological facts obtained at the same time will be found to be of scientific value.

After this excursion I returned to Nanaimo on the 21st of October, and after the interval of a week, the weather becoming very wet, I left by the steamer Maude on the 29th, and reached Victoria the same evening.

In the neighborhood of Victoria additions were made, when weather permitted, to the results of last year's explorations; and, when confined to the house, attention was turned to the repacking of specimens, and five boxes of fossils and minerals were forwarded to Montreal by way of Panama. The tent and camp equipage belonging to the Survey were thoroughly cleaned and stored away in the office of the Canadian Pacific Railway, and Mr. J. A. C. Graham, of the Hudson Bay Company, obligingly allowed me to place the boat under cover on their premises. The whole of these materials, of which a list has been handed you, may be valued at about $300. I finally left Victoria on the 28th of November, and arrived in Montreal on the 14th of December.

Coal-Bearing Rocks of Vancouver Island.

Last year's Report.

In the preliminary Report addressed to you last year on the coal-bearing deposits of Vancouver Island, it is stated (p. 76) that belonging to these "there appears to be a narrow trough which may be said to extend from the vicinity of Cape Mudge on the north-west, and to approach to within fifteen miles of Victoria on the south-east, with a length of about 130 miles" that "on the north-east side, this trough lies beneath the waters of the Strait of Georgia, and on that side is bounded by crystalline rocks, coming apparently from beneath it, in Lasqueti, Texada and other islands, and on the main-land beyond, while on the south-west it occupies a strip along Vancouver Island, limited by a range of bold mountains of the crystalline series, which runs nearly parallel with the coast." This general trough was divided into two subordinate areas, separated from one another by crystalline rocks in the neighborhood of Nanoose Harbor, the north-western one of which was distinguished as the Comox, and the south-eastern as the Nanaimo coal-field (Report 1871-72, pp. 80. 81.)

Boundaries of the Comox coal field.

The part to be more particularly described at present is situated in the Comox coal-field. It is bounded on the south-west by the Beaufort Range of Mountains, on the north-east by the Strait of Georgia, and extending from Comox Harbor about twelve miles to the west, and about thirty miles to the south-east, includes Denman and Hornby Islands.

Measurements of the coast-line from about three miles north-westward of Point Holmes were made round to the mouth of Courtenay River, which flows into Comox Harbor, and thence to Deep Bay, opposite the south-east end of Denman Island. Following all the sinuosities of the line, its length exceeded thirty-two mi . The coast was further examined on foot, without measurement, for about twelve miles beyond. But in the whole distance, measured and unmeasured, only two small exposures of rock, situated on the south side of Comox Harbor, were met with. Measurements.

Additional measurements were made up the Courtenay River and its tributary the Puntledge, to Puntledge Lake, making together about nine miles, as well as three miles up Brown's River, which flows into the Puntledge about five miles from the lake. The partial measurement of last year on the proposed line of tramway to the Union Mine (Report 1871-72, p. 76) was verified and continued to the coal-seam, the correct bearing and distance from the coast being S. 61° W., a little over five miles and a quarter. The Trent River (Ibid. p. 76) was measured as far up as its general bearing was at right angles to the strike of the measures, giving a distance of six miles in a straight line from the coast, and the measurement was continued nearly half a mile further, up a small tributary, to the crystalline rocks. Bradley's Creek joins the Trent on the right side, about three miles and a half from the coast, and this tributary was measured for about three and a half miles up. The River Sable, a small stream on Baynes Sound Claim, (Ibid. p. 78,) was measured for three miles up from Fanny Bay.

From the exposures observed in these transverse measurements, and on the coast of Denman and Hornby Islands, has been ascertained all that I am enabled to give of the character and distribution of the coal-bearing rocks of the area in question. These rocks may be separated into seven divisions, which, in ascending order, may be referred to as follows: Divisions of the coal-bearing rocks.

A. *Productive Coal Measures.*
B. *Lower Shales.*
C. *Lower Conglomerate.*
D. *Middle Shales.*
E. *Middle Conglomerate.*
F. *Upper Shales.*
G. *Upper Conglomerate.*

DIVISION A.—*Productive Coal Measures.*

The most westerly point examined is on Brown's River, about nine miles N. 82° W. from the court house or steamboat landing, on the north side of Comox Harbor. There is here a continuous exposure of the strata, occupying the bed of the stream for a mile and three-quarters Division A.

in a straight line, with a bearing N. 84° E. It affords the following section in ascending order:

SECTION 1.

	Ft.	Ins.
Coal (1). Impure, and apparently in separated masses, of which two were observed on the strike in the breadth of the stream, (between thirty-five and forty feet) one of them on the right, about five feet long and seven feet thick, and the other on the left, seven feet long and two feet thick, both terminating somewhat abruptly. They are from eight to ten feet apart, and carbonaceous shale with a pale brownish streak and argillaceous odour fills the interval between them, and seems to occupy the space in continuation beyond them.....	7	0
Brownish-grey, slightly calcareous sandstone, the grains of which are composed of quartz mingled with feldspar and a few scales of mica, as well as a greater number of small flakes of blackish argillaceous matter. The mass is divided into beds of from three inches to four feet in thickness; many of the latter shew false-bedding, but would in general yield good building stone	132	0
Coal (2). Clean and bright..		3
Brownish-grey sandstone as before..	94	0
Coal (3). Clean and bright..	2	3
Brownish-grey sandstone as before..	33	0
Blackish argillaceous shale with a white streak, interstratified with thin seams of clean coal interlocking with one another.................	5	0
Brownish-grey sandstone as before..	110	0
Coal (4). Clean and bright, varying in thickness from six inches to..	1	0
Brownish-grey sandstone as before..	92	0
Coal (5). Clean and bright..	1	8
Black argillaceous shale with a white streak, and thin seams of coal	3	0
Brownish-grey sandstone...	86	0
Black argillaceous shale with thin patches of coal interlocking with one another..........	10	0
Light grey, massive sandstone, in beds varying from two to ten feet, and shewing little or no false-bedding..	95	0
Coal (6). Good and clean...	1	3
Black argillaceous shale...	4	0
Light grey sandstone, similar to the last.......................................	28	0
Black argillaceous shale with a white streak, interstratified with thin patches of coal interlocking with one another, some of them an inch apart, and altogether making up from ten to twenty per cent of the mass..	3	0
Coal (7). Clean and good...	1	8
Light grey sandstone, similar to the last.......................................	27	0
Coal (8). Good and clean...		6
Black argillaceous shale...	1	3
Coal (9). Clean and bright...	0	8
	739	6

The thicknesses of the sandstones in the above section are reduced from horizontal measurements, at right angles to the strike; and the inclination is determined by the dips of the coal seams and shales above and below the sandstones, so as to avoid errors from false-bedding. The dips vary in direction from E. 30° N. to E. 22° S. and the angles of inclination from 0° to 20°, with the exception of two or three in the middle of the distance, which are a little to the east of north, with an inclination of from 2° to 7°, and indicate an undulation or irregularity, for which a due allowance has been made.

Though to the westward of this section, on Brown's River, a mile intervenes before the flank of Mount Beecher rises up to indicate the presence of the crystalline rocks, they are yet supposed to be concealed by drift not very far off, on the west side of a shallow depression which appears to run east of south to an elbow in the Puntledge River. The distance to the elbow is about two miles, and to this point the upper stretch of the river flows in the same depression from the lake for a mile and a half. This depression marks the strike of the measures, and a rock supposed to belong to the crystalline series is seen in a rapid just below the outlet of the lake. The exposure, which does not exceed forty feet in length, consists of a brown-weathering igneous rock, shewing, according to Mr. Harrington, when sliced and examined under the microscope, both a concretionary and a porphyritic structure, with disseminated crystals, which appear to be feldspar, while the concretions are composed of two minerals which exhibit a radiating structure. When treated with an acid the rock assumes a light grey color, from the removal of the oxide of iron. Crystalline rocks concealed by drift.

There is not much doubt that the base of the productive measures, though not seen, immediately overlies this, while the summit is displayed on the Puntledge, about a mile and a quarter below the elbow, shewing that to be the direct breadth of Division A on this stream. The summit on the Puntledge is due south of the same horizon on Brown's River, and about a mile and a half from it. The details of the division in the Puntledge, however, are by no means well exposed, and none of the coal-seams are visible. This may be called Section 2, though a very imperfect one. Base of the productive measures. Section 2.

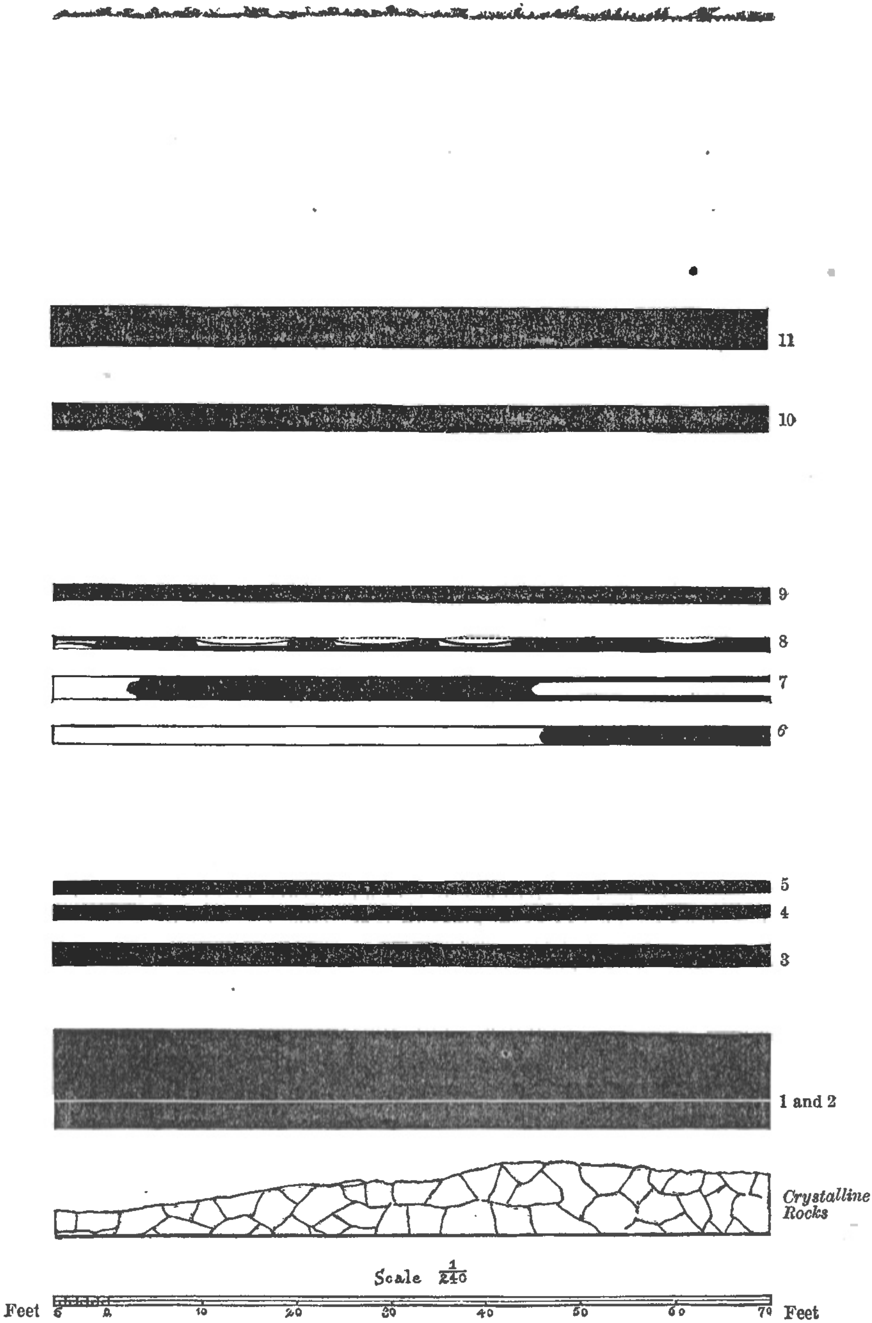
From the outlet of Puntledge Lake a bearing of S. 48° E. strikes the extremity of the line of the proposed tramway to the Union Mine, on the south side of the lake, and about a mile from it, the whole distance being about two miles and three-quarters. A section occurring at this mine in an almost perpendicular cliff, from the face of which a landslide had carried away all the trees and loose soil on the north side of a small stream flowing into the Puntledge Lake, was given in last year's Report (Report of Progress 1871-72, p. 77). But most parts of the cliff being out of reach, the thickness of many of the beds could only be ascertained approximately, having been merely estimated by the eye. A more favorable condition of the weather on the present occasion permitted me, by the aid of a rope tied to a tree at the top of the cliff, to descend Perpendicular cliff section at the Union Mine.

the whole face, and obtain exact measurements. The following is a corrected section in ascending order:—

SECTION 3.

			Ft.	Ins.
Brownish-grey, or light drab sandstone, and black argillaceous shale, interstratified with one another, and both holding flattened stems of plants			6	0
Coal (1). Of a dull earthy aspect, and containing upwards of twenty per cent. of ashes by Dr. T. Sterry Hunt's Analysis (Report of Progress, 1871-72, p. 99)	2	6		
Coal (2). Clean and bright	7	6	10	0
Brownish-black argillaceous shale			7	0
Coal (3). Clean and bright	2	4		
Brownish-black argillaceous shale	2	6		
Coal (4). Clean and bright	1	6		
Brownish-black shale	1	3		
Coal (5). Clean and bright	1	5	9	0
Brownish-black argillaceous shale, interstratified with brownish sandstones and brownish-yellow-weathering, hard, ferruginous beds from two to four inches thick			14	3
Coal (6). Clean and bright. This seam occupies the face of the cliff for a distance of only twenty feet, coming from the right, and then terminates somewhat abruptly, the corresponding space on the strike to the left being filled with black argillaceous shale, holding interstratified thin seams of coal	2	0		
Brownish-black argillaceous shale	2	9		
Coal (7). Clean and bright. This seam occupies the cliff for sixty-six feet coming from the right, and then terminates somewhat abruptly like the previous one; but on the right hand, there occurs in it a band of brownish-black, argillaceous shale, two feet thick, with thin patches of coal, and occupying about twenty-five feet on the strike, with about three inches of coal above and below	2	6		
Brownish-black argillaceous shale	3	0		
Coal (8). Clean and bright, varying in thickness from five to twelve inches, from inequalities sometimes at the top and sometimes at the bottom	1	0		
Brownish-black argillaceous shale	4	0		
Coal (9). Clean and bright	1	6	16	9
Brownish-black argillaceous shale			16	0
Coal (10). Clean and bright			2	8
Brownish-black argillaceous shale			6	0
Coal (11). Clean and bright			4	4
Brownish-grey or drab sandstone, slightly calcareous, the somewhat fine grains of which are composed of quartz, feldspar and a little mica, with small black flakes consisting of argillaceous or carbonaceous shale. The mass is divided into beds of from one to five feet thick, some of which shew false-bedding			30	0

The following is a diagram of the section as seen in the face of the cliff for the breadth of the slide, on a scale of one two hundred and fortieth ($\frac{1}{240}$th). Diagram of cliff section.



The deposits of this section rest visibly on the crystalline rocks which pave the brook at the foot. The course of the brook is south-east and north-west. In the former direction these rocks rise gradually higher among the coal-bearing strata, and at the distance of about a quarter of a mile up the brook, reach to within ten feet of the sandstones at the summit. Between the sandstones and the crystalline rocks, there occurs a coal-seam in the brook, of which the thickness could not be ascertained, owing to the depth of the water; beyond this the strata are concealed. Down the brook to the north-west, the crystalline series is exposed for about sixteen chains, and thirteen chains further on, a coal-seam of four and a half feet was last year visible, dipping N. 48° E. < 11° ; but at the present time was covered up by a slide. At seventeen chains across the measures to the right, two additional coal-seams were observed, with an interval between them of 192 paces, dipping in the same direction, the lower one two feet thick, with an inclination of five degrees, the upper one three feet thick with an inclination of eleven degrees. In ascending order a vertical section would be,

Coal-seam.

Four and a half feet seam.

Two feet seam.

Three feet seam.

Section 4.

	Ft.	Ins.
Coal	4	6
Measures concealed	54	0
Coal	2	0
Measures concealed	52	0
Coal	3	0
	115	6

Trial openings.

Openings for trial had been made on the two upper seams; but the concealed intervals render it at present difficult to say how the three are related to those in the previous section (3).

Crystalline rocks.

In a bearing S. 38° E. from section 3, a line of two miles and a third would strike the valley of Trent River at right angles, about five and a third miles from the coast. The crystalline rocks make their appearance at less than a mile and a half further up the valley, on a small tributary which has been already mentioned; the spot being about thirty chains above the junction of the tributary and the main stream. They are of mottled dark green and dull red colors, and present a concretionary and porphyritic structure, like the exposure at the outlet of Puntledge Lake. Resting upon them the following ascending section occupies the tributary and the main stream for a distance of a mile and a quarter:

Section 5.

	Ft.	Ins.
Coal (1). Clean and bright, resting on red and green crystalline rocks	0	2
Black carbonaceous shale, with thin patches of coal	4	0
Brownish-grey or drab, fine-grained sandstones, in beds of from six inches to five feet, which would yield good building stones, as well as perhaps tolerable grindstones	92	0

	ft.	in.	ft.	in.
Coal (2). Of a dull earthy aspect	1	0		
Brownish-grey sandstones as before	3	0		
Coal (3). Of a dull earthy aspect, mingled with black carbonaceous shale	3	0	7	0
Brownish-grey or drab sandstones, imperfectly seen			75	0
Black argillaceous shale			1	6
Brownish-grey sandstones, interstratified with black argillaceous shale, the sandstones predominating, but imperfectly seen			60	0
Coal (4.) Clean and bright	0	8		
Black argillaceous shale, with thin seams of coal	6	0		
Coal (5.) Clean and bright	1	9	8	5
Brownish-grey sandstones, interstratified with black argillaceous shale, the sandstones predominating			15	0
Coal (6.) Clean and bright			0	8
Brownish-grey sandstones, interstratified with black argillaceous shale, the sandstones predominating			30	0
Black, rust-stained, argillaceous shale, with short interlocking patches of coal, about an inch in thickness	1	0		
Coal (7.) Clean and bright	1	4		
Black argillaceous shale, with short one-inch interlocking patches of pure coal	2	6		
Coal (8.) Clean and bright	1	0		
Black argillaceous shale, with thin seams of coal	2	6		
Coal (9.) Clean and bright	3	8	12	0

These twelve feet of strata occur at the junction of the tributary with the Trent, and are exposed in the channel of the latter several times in a distance of about eight chains on the strike, which is N. 68° W. The dip is N. 22° E. > 50° and the thickness of the deposits is sometimes less, and sometimes more, than represented.

	ft.	in.
Brownish-grey or drab sandstones, in strata of from one to four and five feet thick, many of which show false-bedding	130	0
Black argillaceous shale	4	0
Coal (10.) Clean and bright	1	8
Brownish-grey or drab sandstones, in beds of from three to ten feet thick	24	0
Coal (11.) Clean and bright	1	0
Black carbonaceous shale	12	0
Brownish-grey sandstone	37	0
Coal (12.) Of a dull earthy aspect	0	6
Black argillaceous shale	10	0
Brownish-grey or drab sandstones	28	0
Black argillaceous shale	4	0
Brownish-grey or drab sandstones	41	0
Coal (13.) Clean and bright, varying in thickness from one foot to	1	8
Light-grey, fine-grained sandstones, slightly calcareous, in even beds of from three to ten feet thick. They would yield excellent, easily dressed building stones, and probably afford good material for grindstones and whetstones	59	0
Black argillaceous shale	4	0
Light-grey sandstones, similar to the last	47	0
	710	7

The next locality where the coal-bearing strata were met with on the strike to the south-eastward, is Bradley's Creek, already mentioned as a tributary of the Trent, the distance between the two streams being upwards of a mile. No crystalline rocks were met with in the portion of

Bradley's Creek.

the tributary examined, and the lowest exposure of the coal-bearing series occurred about three miles and eleven chains from the junction with the main stream.

The whole of the exposures belonging to this division on Bradley's Creek, occur in a transverse distance of one mile and three-quarters, being about the same as that holding those of the Trent, but the bearing N. 24° E, is somewhat oblique to that of the average dip. In some parts there are considerable intervals between the exposures. Where seen, the dips are steeper and more irregular, and it thus becomes very difficult to state the true thickness in a vertical column. For this reason I shall describe the deposits in this section (to be numbered 6) as they succeed one another in ascending order on the horizontal line.

Intervals between the exposures.

Section 6.

Resting on a few feet of brownish-grey sandstone the lowest coal-seam, which is clear and bright, is from fifteen to eighteen inches thick, and a few feet of brownish-grey sandstone overlie it. A quarter of a mile down the valley, there is a coal-seam eight inches thick, with a dip N. 32° E. < 32°. Nearly nine chains further occurs the coal-seam mentioned last year, (Report 1871-72, p. 76,) as three feet two inches thick, with a dip N. 27° E. < 18°. This is probably the same as coal-seam 5 of section 3. Twenty-eight chains beyond, resting on black argillaceous shale, is a seam shewing eight inches of impure coal. After an interval of fifty chains, again resting on black argillaceous shale, there is another eight-inch seam, displaying good coal, with a dip N. 40° E. < 18°. This supports 128 feet of light-grey sandstones, in beds of from one to six feet thick, similar in character to the two masses at the summit of section 3, which, with the band of black shale between them, shew a thickness of 110 feet. They may thus be considered to represent the same horizon; but above the sandstones of Bradley's Creek, no exposures occur for half a mile. The deposits of the two sections, 3 and 5, are on the Beaufort coal-mining claim.

Eighteen inch seam.

Eight inch seam.

Three feet two inch seam.

The last place examined, in the further extension of the rocks of this division, is at the Baynes Sound Coal Mine, on the River Sable, as it is written by some, being probably a corruption of Rivière aux Sables. The position of this mine is about five and a half miles from the base, section 5, on Bradley's Creek, in a bearing S. 53° E., and two miles and three-quarters due west from the mouth of the stream on Fanny Bay. Here, as stated last year (Report of Progress 1871-72, p. 78), in a deep ravine through which the river finds its way, the following section occurs, resting on a black dioritic rock, the beds being given in ascending order, and their average dip being N. 76 E. < 10°—25°:

Baynes Sound Coal Mine.

SECTION 7.

	Ft.	Ins.
Yellowish-weathering, dolomitic-looking conglomerate, with pebbles derived from the crystalline rocks and varying in diameter from half an inch to two inches, filling depressions in the black dioritic rock beneath	3	0
Brownish-grey or drab sandstones, moderately fine-grained, and slightly calcareous, with scales of white mica	19	0
Black carbonaceous shale, showing numerous obscure impressions of plants, with nests of good coal, as well as beds of the same from two to eight inches thick; some parts of the whole thickness are half made up of coal	6	0
Black argillaceous shale, with nodules of iron ore, some of them flat and varying in length from six inches to four and five feet, and in thickness from six to eighteen inches, while others are round, with a diameter of eighteen inches: they all contain impressions of plants, difficult to be obtained in a perfect state. The thickness of the band is from two feet to	3	0
Brownish-grey sandstones as before	18	0
Coal (1.) Clean and bright; varying in thickness, being in some parts five feet two inches, and in others seven feet; the lowest two feet show thin seams of black calcareous argillaceous shale, with obscure impressions of plants, say	6	0
Brownish-grey sandstones as before	60	0
Coal (2.) Clean and hard	5	10
Brownish-grey or drab sandstones, forming the whole height of the cliff, and estimated to be about	100	0
	220	10

A partial section of these beds was given last year, from which it will be perceived that the present differs a little in some of the beds; but, as then stated, the two coal-seams are seen descending both sides of the ravine, and the edges of the lower one meet in the bottom of the stream; but while those of the upper one are still about twenty feet above the water, a fault occurs cutting them off, the underlie of the fault being S. 62° W. < 38°. The dip of the arenaceous strata which occur immediately on the eastward side of the fault is obscure. The coal-seams occupy two chains and then the dip becomes N. 64° E. < 38°—43°. The following is the section of the whole of the measures on the eastward side in ascending order: Fault.

SECTION 8.

	Ft.	Ins.
Brownish-grey sandstones	99	0
Brownish-black, soft, argillaceous shale	22	0
Light-grey sandstones	25	0
	146	0

This is a greater volume of sandstone than was ascertained in this position last year, but as then stated the fault appears to be a downthrow to the north-east, the amount of which has yet to be determined.

From the facts displayed in these various sections, it will readily be seen that workable seams of coal occupy a belt of pretty uniform breadth along Position of the workable coal-seams.

the south western rim of the Comox field, associated with brownish-grey false-bedded sandstones, interstratified with black carbonaceous and argillaceous shales at the base, and overlaid by light-grey, even-bedded, fine-grained sandstones at the summit. In all the sections a constant character is easily enough recognisable in Division A as a mass; but the notable differences in the thickness of the coal-seams, and their distances from one another when in proximate sections, make it very difficult to establish the identity of individual seams over a very considerable area. This must be the work of practical explorers of the seams, by trial pits along the outcrops. But these irregularities and the occasional sudden interruptions in the continuance of the coal-seams constitute a remarkable distinction between them and the more regular beds of the true Carboniferous era, and may often occasion perplexities in working them. In no part of the exposures of division A were any fossil shells met with.

Difference in the thickness of the coal-seams in proximate sections.

DIVISION B.—*Lower Shales.*

Division B.

Immediately overlying the light grey sandstones which have been given as the summit of Division A on Brown's River, there occurs a series of brownish-black, argillaceous shales, interstratified at considerable intervals with layers of soft grey sandstone and arenaceous shale, which vary in thickness from one to six inches. They have a dip of N. 82° W <10° and continue with a very uniform character to the junction of this tributary with the Puntledge River, the inclination varying from 3° to 11°. In the beds comprised in this distance, which may have a thickness of 379 feet, the following fossils were met with in the argillaceous deposits:

Fossils.

Locality 1.	*Ammonites*	2	Species.
	Ancyloceras	1	"
	Natica	1	"
	Lamellibranchiata (undetermined)	5	"

Similar masses, in similar attitudes, occupy the Puntledge, from the light grey sandstones of Division A to the confluence of Brown's River, and continue further along the main stream, with some intervals of concealment, to within half a mile of the Kootenay, at the mouth of which they are concealed.

On the proposed line of the Union tramway these deposits are covered by drift; but on the Trent River they are exposed almost continuously, from the light grey sandstones to Comox Harbor, and are also displayed for over a mile up Bradley's Creek. On these two streams they afford the means of establishing their thickness and their attitude beneath the surface.

Exposures on the Trent River and on Bradley's Creek.

In the general downward bearing of the Trent the dips are to the north-eastward at inclinations varying from 10° to 0°, for three miles and three-quarters; beyond this they dip in a contrary direction for fifty-five chains, with inclinations varying from 0° to 26°, thus constituting a trough, in the centre of which the shales have a thickness of about 660 feet. The shales

Anticlinal axis.

thus fold over an anticlinal axis, the position of which is about twenty-eight chains from the coast, and the dips they display enable us to add a few feet to the thickness, making it 875 feet. At the north-eastern rise of the measures of the trough, about fifty-eight chains from the coal, the shales present what appear to be cracks intersecting them in various directions and which have become filled up with dark grey sand composed of quartz and feldspar grains, with a little mica and many small flakes of black carbonaceous and argillaceous shale. This sand has been converted into a compact rock scarcely distinguishable from the arenaceous layers interstratifying the shales, except through its superior hardness.

Dyke-like sandstones.

The thickness of these dyke-like sandstones varies from one to eight inches, and gives a very striking aspect to the cliff on each side of the Trent, and to the bottom of the intermediate stream, in the former of which they stand out in high relief, sometimes to the extent of two or even four feet.

Fossils.

The more argillaceous portions of the shales on the Trent are occasionally characterized by the presence of fossils, and the following is a list of those collected.

In the lowest 264 feet above the Falls,

Locality 2.	*Ammonites*	3	Species.
	Ancyloceras	1	"
	Inoceramus	1	"
	Lamellibranchiata (undetermined)	4	"

In the succeeding 528 feet below the Falls,

Locality 3.	*Ammonites*	3	Species.
	Inoceramus	2	"
	Lamellibranchiata (undetermined)	3	"

In a repetition, lower down the river, of 198 feet of 3 and 132 feet in addition.

Locality 4.	*Ammonites*	3	Species.
	Inoceramus	2	"
	Lamellibranchiata (undetermined)	3	"

Of the *Ammonites*, 1 species is common to localities 1, 3 and 4, 2 species to localities 3 and 4, and 1 species to localities 1 and 4. Of *Inoceramus*, 1 species is common to localities 3 and 4.

Thickness of Division B.

On the Sable River, the breadth of these shales is about a mile and three-quarters, in which the dips are very moderate, and there is a small undulation in the distance. It is computed, however, that their thickness to the mouth of the stream is 200 feet. They are seen immediately opposite on Denman Island. The width of Baynes Sound is here about a mile and a quarter, and the average dip of the shales under it, judging from the dips on each side, would be about 6°. This would give an additional thickness of 660 feet, making the whole, up to the shore of the island, 860 feet. Between the shore and the base of the succeeding Division there is a breadth of a quarter of a mile yielding 132 feet. So that the total thickness of Division B would thus be about 1,000 feet.

Fossils.

On the River Sable, the following fossils were collected from the lowest 200 feet of the shales:—

Locality 5.	*Ammonites*	3	Species.
	Anclyoceras	1	"
	Inoceramus	1	"
	Lamellibranchiata [undetermined]	2	"
	Gasteropoda	1	"

On Denman's Island these deposits occupy a narrow strip, in some places a quarter of a mile across, but occasionally widening to one half or three-quarters of a mile, extending about ten miles and a half along the coast, and presenting a greater amount of arenaceous layers than in the parts lower down. In this part they contain also frequent seams of coal, varying in thickness from a mere film to half an inch, and running in the strike for lengths varying from a few inches to several yards. Cracks filled with solid sandstone, similar to those on the Trent, are seen more or less for the whole distance, and they become remarkably prominent for about two miles at the south-eastern end of the strip. These dyke-like sandstones vary in thickness from two inches to two or three feet, and, occasionally, they lace the beach in such numbers and so close together that they predominate in mass over the shale. This strip of shales is limited on the north-west side, in the whole of the distance, by a conglomerate which constitutes the base of the succeeding Division.

Thin seams of coal.

Fossils on Denman's Island.

On the south west side of Denman's Island, the following fossils were collected from the upper part of the Division:

Locality 6.	*Ammonites*	2	Species.
	Baculites	7	"
	Inoceramus	1	"
	Gasteropoda [undetermined]	2	"
	Lamellibranchiata	3	"

DIVISION C.—*Lower Conglomerate.*

Division C.

This conglomerate runs through the whole length of Denman's Island, from Henry Bay on the north-west, to Boyle's Point on the south-east, a distance of eleven miles, and it often shews a very bold escarpment, rising into prominent points, three of which are conspicuous. One of them is behind Village Point, and two others occur to the south-east of it, each of them, according to the Admiralty chart, about 400 feet above the waters of the sound. The rock probably underlies the whole breadth of the island to Kamas Bluff, but it comes above the surface of the drift for a width of only a mile and a quarter, and the cliffs on the north-east side of the island, which sometimes rise to nearly 300 feet, appear to be composed of interstratified sand and clay.

Prominent points.

Cliffs of sand and clay.

The pebbles of the conglomerate consist chiefly of white and brown vitreous quartz, mixed with many of diorite and other crystalline rocks, as well as some of limestone. They vary in diameter from a quarter of an inch to six or seven inches and are contained in a dark brown or

Conglomerate holding fossils.

brownish-grey sandy matrix, which holds also fragments of fossil wood and occasional fossil shells.

In the promontory which forms the south-east end of the island, and runs out into Boyle's Point, they present bold cliffs of 200 feet in height, washed by the waters of the sound for nearly a mile on the south-east side, and for about three miles on the north-east. About the third of a mile south of Boyle's Point they are present in Yellow Island, which lies in the run of their base. They form also Norris Rock, an island about a mile S. 60° E. from Norman Point, which is the most southern part of Hornby Island.

Norris Rock is probably at the summit of the band, of which the direct transverse breadth in this part would be about a mile and a quarter. To arrive at the thickness we must estimate the average dip, which, in consequence of the false-bedding which seems everywhere to prevail, is not easy to do. But, guided by dips at the base and at the summit in the vicinity, it may be taken as about eight degrees, which would yield a thickness of between 900 and 1,000 feet. On the south-east end of Denman's Island, and on Norris Rock, the following fossils were obtained from this band of conglomerate. Fossils.

Locality 7. { *Ammonites* .... 1 Species.
Arca .... 1 "

DIVISION D.—*Middle Shales.*

Succeeding the conglomerate which has just been described, there occurs a series of shales much resembling those at the summit of the Lower Shales, but somewhat more arenaceous. A partial section of them is seen on Hornby Island, proceeding along the coast eastward from Norman Point. Division D. Section on Hornby Island.

The following are the beds in ascending order:

SECTION 9.

	Ft.	Ins.
Light brownish-grey sandstones	5	0
Dark grey argillaceous shale	1	3
Light brownish-grey sandstone in one bed	4	6
Dark grey arenaceous and argillaceous shale	2	0
Light brownish-grey sandstone in one bed	2	0
Black argillo-arenaceous shale with some coal	0	4
Brownish-grey arenaceous shale	2	6
Light brownish-grey sandstones	3	9
Black arenaceous shale with some coal	0	5
Light brownish-grey sandstone, in beds of from two inches to two feet	6	0
Black arenaceous shale	0	2
Brownish-grey arenaceous shale	0	6
Black arenaceous shale	0	4
Brownish-grey sandstone	1	0
Brownish-grey arenaceous shale	0	6
Black arenaceous shale	0	2
Light brownish-grey sandstone	1	2
Black and grey arenaceous shale	1	0

Light brownish-grey sandstone	0	6
Black argillaceous shale	0	4
Light brownish-grey sandstone	4	7
Black arenaceous shale, and brownish-grey sandstones	5	0
Brownish-grey sandstones	4	6
	47	6

Beneath these beds, which come to the margin of the sound and are exposed between high and low water marks, a lower portion of the band is lost beneath the sea, but its entire breadth may be a little over half a mile. The general dip, however, appears to be so small, probably not above two degrees, that the total thickness would not exceed seventy feet.

Thickness of Division D.

This band of shales, like the lower one, is limited on the north-east by a great mass of conglomerate; and at the foot of the cliffs formed of this, the shales, after leaving the vicinity of Norman Point, run to the north-west, in a very narrow strip, along the shore to Shingle Spit, a distance of two miles and a half. Their course then becomes north, and they gradually widen out until they reach Point Phipps, which is a mile and a half further. Here they have a direct transverse breadth to the foot of the conglomerate escarpment of about half a mile on the land, while about the same breadth is occupied by them between high and low water marks.

From this their strike gradually rounds to north-eastward, while their breadth again diminishes, and their summit comes upon the north shore of the island a mile and three-quarters further on, their strike here becoming nearly west. In its course from Norman Point, the band gradually becomes more and more argillaceous, displaying fewer interstratified arenaceous beds, while occasional lenticular patches of limestone, with a length of two feet, and a thickness of from one to six inches, and marked by the presence of fossils, occur. Among those obtained are the following:

Lenticular patches of limestone holding fossils.

Locality 8.	*Ammonites*	1	Species.
	Baculites	1	"
	Nautilus	1	"
	Inoceramus	1	" perhaps 2
	Ostrea	1	"
	Nucula	1	"
	Arca	1	"

Besides these, numerous fragments of undetermined *Gasteropoda* and *Lamellibranchiata*, probably ten or fifteen species, were met with.

Division E.

DIVISION E.—*Middle Conglomerate.*

This conglomerate is largely made up of well rounded pebbles and boulders of white, yellowish and brownish quartzite, with diameters of from one inch to a foot, together with rounded masses of limestone of from one to six inches in diameter, and sometimes more, and containing occasional indications of fossils. The pebbles and boulders are held in a matrix of brownish-grey arenaceous grains. In some parts of the vertical thickness there are masses of conglomerate of 300 feet, with rare indications of bedding; while in others massive sandstones occur up to a thickness of 100 feet, in which no individual bed was observed of less than ten feet.

A transverse section of the whole band occurs at the south-east end of Hornby Island, between the position where the base comes in above the middle shales eastward of Norman Point, and where the summit occurs at a cove which may be called Middle Cove, half-way between Downe's Point and Dunlop Point. The direct breadth of this is about a mile, and it has a dip of about N. 10° E. < 12°, which gives a thickness of about 1,100 or 1,200 feet. The base of it follows the sweep which has been given to the summit of the previous division, and in this it presents a bold escarpment, affording nearly perpendicular cliffs, rising in some places to 200 or 300 feet, and forming a conspicuous ridge, a short distance removed back from it. Nearly west of Shingle Spit, at a distance of about two-thirds of a mile from the base, this ridge towers up into Mount Geoffrey, the height of which is given in the Admiralty map as 1,076 feet above the sea. Mount Geoffrey must show nearly the full thickness of the Division. From the ridge the surface gradually slopes eastward, and dies away into a plain with good agricultural surface.

Section on Hornby Island.

Mount Geoffrey.

Bounded by this plain to the right, and in uniformity with the base, the summit strikes to the north-westward from Middle Cove, and gradually curves round to the north-east coast of the island, coming out upon it at a position nearly due west, about three miles from Point Phipps. On this coast there is displayed another complete section of the band, stretching obliquely to the dip for a mile and a half along the water line, and presenting bold cliffs to the sea.

The direct transverse breadth here, however, may not exceed that already given. The curved form in the distribution of the band of course indicates the occurrence of a trough in the measures.

Division F.—*Upper Shales.*

In Middle Cove the lower beds of this division are pretty well seen, and the following section, in ascending order, occurring between that cove and the north-eastern side of Tribune Bay, gives the whole thickness of the band as far as it can be made out, after allowing for two considerable intervals of concealment:

Division F.

Section 10.

Section between Middle Cove and Tribune Bay.

	Ft.	Ins.
Black and grey, argillo-arenaceous shale, interstratified with layers of sandstone, varying from one to two inches in thickness	40	0
Brownish-grey or drab sandstone, in some places showing but one solid bed, but in others separated into two or three beds by partings of black argillo-arenaceous shale	5	0
Black and grey, argillo-arenaceous shale, with thin layers of sandstone	16	0
Brownish-grey or drab sandstones	4	0

Black and grey, argillo-arenaceous shale, with layers of sandstone of from one to two inches thick. This reaches Dunlop Point, where the dip is N. 14° E $<$ 9°	120	0
Black and grey, argillo-arenaceous shale, interstratified with drab sandstones of from one to three inches thick, which would yield good flag-stones; and also patches of limestone, varying in size up to twenty feet long and wide, and from one to three inches thick, without any indication of fossils. This reaches half way up the south-west side of Tribune Bay, where the dip is N. 64° E. $<$ 8°	82	0
Black and grey, argillo-arenaceous shale, interstratified with beds of grey sandstone from two to four inches thick, and occasional lenticular patches of impure grey limestone, up to twenty feet in diameter, and from one to three inches thick. In many parts the sandstones are well adapted for flagging. Some of the slabs lying loose on the surface of the shale measured twenty feet square, and from three to four inches thick, without any joints or flaws	45	0
Grey, thin-bedded sandstone. This reaches to the north-west corner of Tribune Bay	7	0
Measures concealed in the south-west half of the bight of Tribune Bay	200	0
Black and grey, argillo-arenaceous shale, interstratified with grey sandstones in beds of from two to eight inches thick	30	0
Grey sandstones, moderately fine-grained, in beds of four and five feet thick, and constituting a long tongue projecting from the middle of the bight of Tribune Bay	28	0
Measures concealed, forming nearly all the remainder of the bight of Tribune Bay	150	0
Grey arenaceous shale, with layers of coal from a quarter to half an inch in thickness, sometimes running on the strike for eight or ten chains. Some of the beds are crowded with fragmentary remains of compressed plants, which are too obscure for determination; there are also fragments of fossil wood, which shew distinct structure in transverse sections, and seem to be infiltrated with calcareous matter	50	0
	777	6

These shales sweep round in a curve, following the previous division, to the north-east side of the island, where they occupy the coast for probably about a mile and a-half, and run in a line oblique to the dip.

Division G.—*Upper Conglomerate.*

Division G. Like the previous conglomerate, this division contains pebbles and boulders of white, yellowish and brownish, vitreous quartzites, varying from an inch to a foot in diameter, and well rounded. It contains in addition, however, dioritic pebbles, but no observed masses of limestone. The matrix is fine-grained and arenaceous, but displays no bedding.

This rock forms the promontory which limits the north-east side of Tribune Bay, and terminates in St. John's Point. It has a breadth in some parts of half a mile, and in others three-quarters of a mile, in which the measures appear to be flat, as far as could be determined. On the north-east side the promontory presents an abrupt rise from the sea, showing cliffs of from ten to twenty feet high; but on the opposite side, overlooking

Tribune Bay, vertical precipices attain a height of 100 and even 300 feet; and this last measure may be considered the thickness of the division. The following is a vertical section in ascending order of the mass as seen in Tribune Bay: Section in Tribune Bay.

SECTION 11.

Grey and brownish sandstone, assuming in many places a conglomerate character, and containing occasional seams of coal from half an inch to sometimes an inch thick, and holding in such parts an occasional *Belemnite*, the only fossil observed in this or the previous division	120	0
Conglomerate with rounded masses of quartzite and diorite as described above, without any masses of shale or limestone	200	0
	320	0

The out-cropping base of this mass of conglomerate, when it crosses from Tribune Bay to the north-east coast at the neck of the promontory, exhibits a very sharp curve; and this, with the horizontal attitude of the mass, and the corresponding curves in the lower divisions to the north-west, shows that it occupies the very centre of the trough, the axis of which would run through the length of the promontory. The bearing of such an axis, N. 60° W., would pass through the trough which has been described in division A, as occurring on the lower part of Trent River; and the anticlinal which there occurs between the trough and the coast leads us to suppose that a corresponding form would occur outside of Hornby Island, which would be the south-west side of another and deeper trough still further to the north-east. It would not be extravagant to suppose that the rise of the measures on the north-east side of this would be something like the rise to the south-west on the Comox side of the Strait of Georgia, and that as great a breadth of the coal-bearing formation would occur on the one side of the anticlinal axis as on the other. If such were the case, the measures would spread out under the Strait of Georgia to the near vicinity of the crystalline rocks on the shore of Texada Island, and establish a breadth in the general trough of twenty miles, one half of which would be subaqueous.

From the description thus far given, it would appear that the total thickness of the rocks associated with the coal of Vancouver Island is the following in descending order: Thickness of rocks associated with the coal of Vancouver Island.

		Ft.	Ins.
G	Upper Conglomerate	320	0
F	Upper Shales	776	6
E	Middle Conglomerates	1,100	0
D	Middle Shales	76	0
C	Lower Conglomerates	900	0
B	Lower Shales	1,000	0
A	Productive Coal Measures	739	6
		4,912	0

This in round numbers may be called 5,000 feet.

CRYSTALLINE ROCKS.

The detailed exploration of the lower measures of the Comox coal-field has as yet been confined to the eighteen miles that lie between Brown's River and River Sable, and in this the crystalline series on which they rest has been seen only in three places. In these my inspection did not extend beyond the masses near the newer formation, or in positive contact with it. I cannot, therefore, pretend to give from these any connected view of the relation of the two series in age; but the exploration made for railroad purposes, at the request of Mr. Sandford Fleming, from the mouth of Qualicum River to Alberni on the upper extremity of Barclay Sound, having afforded me the opportunity of making a preparatory reconnaissance on a short line transverse to the strike of the crystalline series, has added to my information, and I propose here to give a brief description of the masses that were imperfectly observed in succession.

Qualicum River to Alberni.

The general bearing of the traverse, reduced to a straight line, is S. 28° W. It starts from the shore of Georgia Strait at a point a little under three and a half miles north-west from Qualicum River, and terminates at the upper end of the Alberni Canal, as this part of Barclay Sound is called, the whole distance being somewhat under fourteen miles.

On this the surface presents a plain with a very gentle inclination for about the first four miles. It then rises with increasing rapidity for nearly two miles, and culminates on the ridge of Mount Mark, at a distance of six and a quarter miles from the commencement.

Mount Mark.

The summit of this mountain is by the Admiralty chart 3,080 feet above the sea, and from this there is a precipitous fall of 2,723 feet, in less than a quarter of a mile, to the level of Horne Lake, which is 357 feet above the sea. A segment of the western end of Horne Lake occupies a little over two-thirds of a mile upon it. It then rises again with a few not very great undulations, for nearly three and a half miles, and attains a height of about 1,600 feet above high water mark. From this it falls rapidly for about two-thirds of a mile, and again reaches a gently inclined plain, over which it passes for two miles and two-thirds and attains the Alberni Canal.

Horne Lake.

The road travelled is a trail on the right bank of Qualicum River, and leaves the coast of Georgia Strait about a quarter of a mile from the mouth of the stream. For five miles it keeps about parallel with the river and with the traversed line, and reaches the lower end of Horne Lake. It then turns to the north of west, and runs close along the north side of the lake for about four and a half miles, crossing Qualicum River at its exit from the lake, which is about half a mile from its eastern extremity, and coming upon the traverse line, it still follows the margin of the lake, but in a southern direction for about two miles more, attaining its upper extremity.

Road travelled.

It then bears to the west of south for about two miles and a half, and winding round the foot of a hill called View Mountain, which attains an elevation of 1,600 feet over tide waters, on the right, it runs south-west for about three and a half miles in a straight line to the mouth of the Somass River, where this empties into the Alberni Canal at Stamp Harbor. View Mountain and Somass River.

The rock masses to be mentioned were all observed on or within a quarter of a mile of this trail, and none of them before reaching Horne Lake. The chief part of this nearly level intermediate plain is probably underlaid by the deposits of the Comox coal-field, and to these a space of four miles has been assigned on the traverse line. Coal deposits. The masses first seen at the lower end of Horne Lake are composed of crystalline limestone. Crystalline limestone. They were followed all along the north side, and partly round to the west side, in the whole of which distance they present an abrupt escarpment on the right hand. A quarter of a mile from the east of the lake, the dip is N. 48° E. < 41°, and three miles further on, it is N. 2° E. < 55°. Reaching the west side of Horne Lake, and looking northward to Mount Mark, a drift-covered surface rises up between 300 and 400 feet above the lake in a distance of about a quarter of a mile; and from this starts up a wall of limestone with an almost perpendicular face, presenting a thickness of probably 1,200 feet, which is again capped by a great mass of brown-weathering diorite, probably 1,000 feet thick, and constituting the summit of the mountain. Diorite.

The diorite is of a dark olive-green color, and has a ragged fracture, on the surface exposed by which, when fresh, small spots of dull greenish-white feldspar are observed. The rock has a felted kind of structure, and obscure parallel joints are observable, the walls of which are varnished with a brilliant black mineral, which Dr. Harrington supposes to be Delessite. The rock has something of the aspect of the masses observed in contact with the coal-bearing series at the Union Mine, and on the River Sable, and the intermediate distance between Mount Mark and this series may be occupied with this and allied diorites. The mass capping Mount Mark, however, after descending to the sea level in its dip on the traverse line, would leave a blank space of about a mile between it and the coal-series of which nothing definite can yet be said.

The limestones which underlie this diorite are of whitish, bluish, dove-grey, yellowish, greenish, and pinkish colors, the different tints running parallel conformably with the stratification. The greenish tints may perhaps be due to the presence of chloritic or epidotic matter. Character of limestones.

The calcareous masses are interstratified throughout the whole 1,200 feet with well defined bands of diorite of various thickness, from the eighth of an inch to two feet, as far as observed, but there may be beds of much greater thickness that have escaped observation. In these bands the dioritic character is well marked by the presence of crystals of black Interstratified diorites.

hornblende, some of which attain a length of half or three-quarters of an inch, with a breadth of from one-eighth to a quarter of an inch, all with well defined plains of cleavage. These diorites, at the junction of which with the limestone epidote is sometimes distinctly developed, are of various tints of grey, from dark to light, and some of them are of a speckled aspect similar to masses associated with the limestones in the vicinity of Victoria, mentioned in last year's report (Report of Progress 1871-2 p. 91.) Some of the diorite beds are of lenticular form while others are continuous; and they appear to be more abundant in the lower than the upper half of the calcareous mass.

The limestones appear to be highly crystalline throughout, sometimes coarsely and sometimes finely so, and in some parts, on being acted upon with acid, show multitudes of grains of silica. They are in many places crowded with fossils, which in the more coarsely crystalline bands appear to be chiefly encrinal columns. Many of the remains are replaced by silica, and are weathered out distinctly on the surfaces. Some of them have been obtained by dissolving the limestone in acid, while numbers have been observed in thin microscopic sections prepared by the skill of Mr. Weston since my return to Montreal. The following are Mr. Billings' remarks in respect to them :—

Fossils.

Remarks by Mr. Billings.

"The fossils from Mount Mark north of Horne Lake are,

1. Corals apparently of the genera *Zaphrentis* and *Diphiphyllum.*
2. Large crinoidal columns.
3. *Fenestella* or *Polymorpha.*
4. A large *Productus* and also a large *Spirifer.*

"They are so obscurely preserved that they cannot be determined specifically. They appear to be either Permian or Carboniferous, most probably the latter."

These limestones probably extend on the traverse line for three-quarters of a mile to its intersection with Horne Lake, which occurs about eight and a quarter miles from the coast. This, however, would give to their thickness about 500 feet more than actually seen.

For the next mile and three-quarters, including the portion which passes over the lake, there were no exposures on the traverse line. Further on, three-quarters of a mile are occupied by red ferruginous rocks, green diorites which are sometimes slaty and frequently amygdaloidal, and pale green epidotic rocks. These masses are interstratified with bands of bluish and greenish crystalline limestone in which no fossils were observed, and they are followed by green dioritic rocks, occupying about six chains, and dipping N. 13° E. $<$ 44°. Beyond this there is another interval of concealment of nearly a quarter of a mile. Then whitish, yellowish and bluish limestones present themselves, with a breadth of five chains, and beyond them seven chains hold red and green slates. These are followed by coarsely crystalline limestones of a yellowish-white color, occupying about twelve chains, and many of them crowded with crinoidal stems, some of which are three-quarters of an inch in diameter. The dip of the beds is N. 2° E.$<$32°, and their position on the traverse line is very nearly nine miles from the Georgia Strait coast. Red and green slates, limestones, etc.

Another interval of concealment here occupies about ten chains in width, and is succeeded by twenty chains of red clay slates, interstratified with harder red bands, to which green stripes parallel with the bedding give a ribband-like aspect, while both the harder and softer red slates are again interstratified with beds of red and pinkish limestone containing obscure fossils. In the next thirty chains red and grey clay slates prevail, interstratified with bluish and dove-grey limestones, varying from six inches to four feet in thickness. For half a mile beyond this the strata are vertical their strike at first being N. 31° W. and finally N. 61° W. They consist of bluish-grey and yellowish-white limestones, in beds varying from five inches to two feet. The larger part of this great calcareous mass shows obscure organic remains, on weathered surfaces, crinoidal columns being unmistakable at the end of the distance. These masses constitute the rocks of View Mountain, and beyond them there occurs a valley which is half a mile wide, and about 1,034 feet above sea level. In it the rocks are not well seen, but they appear to consist chiefly of grey clay slates, interstratified with grey sandstones. On the succeeding rising ground, and on the rapid fall of the flank beyond, three-quarters of a mile are occupied by green slaty diorites, dipping N. 87° E. $<$ 59°, underlaid by red and bluish-grey clay slates, which rest upon a green diorite. Here the height is only 578 feet above the sea. View Mountain.

We now come again upon the coal-bearing series; and about eighteen chains are occupied with a conglomerate belonging to it. It holds well rounded pebbles of white and brownish quartzite, of from one to three inches in diameter, in a matrix of sand, the whole forming a strong and solid rock. No dips were anywhere observed in it, and it is therefore impossible to state its thickness. Further on there are no exposures; but the drift is probably underlaid by a continuation of the coal-bearing series, and the ground falls gently for two miles to the margin of the sea. The crystalline rocks which thus occupy the space between the coal-bearing areas on each side, are no doubt those which constitute the Beaufort Range of mountains. With the exception of the vertical portion in View Mountain, they all dip in one direction, namely eastward. Whether they are affected by undulations producing repetitions, has not yet been determined. But in order to shew in one view the supposed thickness to be dealt with in the investigation, they are here given in succession in what would appear to be a Coal-bearing series. Eastward dip of crystalline rocks

Section of crystalline rocks.

descending order, although it is possible that a fold may have occurred causing a repetition of the beds :—

	Feet.
Measures concealed between the coal rocks and Mount Mark.......	2,240
Dark green diorites of Mount Mark..	1,000
Whitish, bluish, dove-grey, yellowish, greenish and pinkish, crystalline, fossiliferous limestones, interstratified with dark and light grey diorite..	1,700
Measures concealed...	3,332
Red ferruginous rocks, green diorites, which are often amygdaloidal, and epidotic rocks, with interstratified bands of bluish and greenish crystalline limestones	1,139
Measures concealed...	352
Whitish, yellowish, and bluish limestones................................	176
Red ferruginous rocks and slaty diorites, underlaid by yellowish, coarsely crystalline limestones, some of them crowded with crinoidal stems and with thin strings of what appears to be dolomite	308
Measures concealed...	154
Red clay slates, interstratified with hard red bands striped with green, all interstratified with red and pinkish limestones with obscure fossils..	880
Red and grey clay slates, interstratified with bluish and grey limestones..	1,320
Bluish-grey and yellowish-white limestones, shewing obscure fossils in most parts, but distinct crinoidal columns at the base. These beds constitute View Mountain......................................	1,760
Grey clay slates, interstratified with grey sandstones..................	968
Green dioritic slates, followed by bluish-grey clay slates resting on green diorite...	2,112

How far this great mass of rocks may descend in the series of geological formations, it would for the present be premature even to conjecture.

Coal-Bearing Rocks of the Queen Charlotte Islands.

The Queen Charlotte Islands.

The Queen Charlotte Islands consist of a group, situated between latitudes 51° 50′ and 54° 20′ north, and longitudes 131° and 135° 04′ west. With an east and west breadth of seventy-five miles on the north, it has a length southward, with a gentle curve to the east, of 175 miles, gradually tapering to a point, the different islands being separated by narrow channels running transversly. Of these islands the two principal ones, as has already been stated, are Moresby Island on the south, and Graham Island, the larger of the two, on the north of Skidegate Channel.

That part of the channel which runs continuously across the Queen Charlotte group, presents a curve which bears south-westward from the east entrance, and gradually turns west to Buck Point, situated on the open Pacific coast. Between nine and ten miles south-westward from the east entrance, at Dead-tree Point, are Alliford Bay and Leading Island. West of this is Maude Island with Lina Island north of it, and what may be called South Island on the other side.

Maude Island is the largest of the three, and between it and Lina

Island is the entrance to what may be called the north-west arm, along the north side of which are Anchor Cove, about twelve miles from the eastern entrance of Skidegate Channel, and Shallow Bay, a third of a mile further on. Separated from the latter by a bold volcanic promontory called Steep Point, is a deep narrow recess, which is termed Long Arm or Bay. It forms the extremity of the north-west arm, and the bight of it is seventeen miles from the eastern end of the channel.

That coal exists in these islands has been known for a long time, and several years ago the Queen Charlotte Coal Mining Company opened mines upon it at Cowgitz. On my way to this place I observed the outcropping edges of some of the coal-bearing strata at Cumshewas Harbour on the east side of Moresby Island. While staying at Cowgitz, coal was shown me from a place called Massett, on the north end of the island and about fifty-seven miles distant. Coal.

Between Cowgitz and Massett there is said to be spread out eastward towards the coast a level country well suited for agriculture, bounded on the west by a high range of volcanic rocks (some of the peaks being 3,000 and 4,000 feet above the sea). Under this it seems probable that the coal-bearing rocks may lie in the form of a north and south trough, prolonged a short distance southward into Moresby Island, the whole length being about eighty-four miles. The rocks in this trough, as far as a very superficial inspection has enabled me to ascertain, appear to be the following in ascending order :— Country suited for agriculture. Trough. General division of rocks.

1. Lower Shales with Coal and Iron Ore.
2. Coarse Conglomerates.
3. Upper Shales and Sandstones.

1. *Lower Shales with Coal and Iron Ore.*

In this division black argillaceous shales with a white streak are interstratified nearly throughout with dark grey sandstones, varying in thickness from six inches to a foot, and a mass of about 100 feet occupies a position apparently near the middle. The coal-seams and iron ores appear to characterize the base, but I have as yet seen these only in two localities, one of them being the claim of the Queen Charlotte Coal Mining Company at Cowgitz. Shales, coal and iron ore.

In this neighborhood, Hooper's Creek, which has its source on Seymour Mountain and meets the black shales at its foot, flows thence for nearly a mile south-eastward in the strike of the shales into Shallow Bay, about a third of a mile west of Anchor Cove. On the south-west side of the creek, the shales rise rapidly, leaning in a nearly vertical attitude against a spur of the volcanic rocks which have been mentioned as bounding the coal-trough. From the bed of the creek, at a point nearly a mile up its course, and 448 feet above the sea, an adit-level, called Hooper's Creek tunnel, has been driven in a bearing N. 69° W., for 190 feet, through vertical beds Hooper's Creek. Hooper's Creek tunnel.

of black shale, studded with nodules of clay iron-stone, which constitute perhaps a quarter of the mass, to a seam of coal. It then proceeds in the coal in a bearing N. 53° W., gradually turning to N. 29° E., in a distance of about 450 feet. Trap rock appears to form the western side nearly all the way. The coal is good anthracite, and where first struck in the tunnel its thickness was from two to three feet, but it soon increased to a little over six feet, and continued so for sixty or seventy feet. It then became mixed with black shale and iron-stone for seventy or eighty feet, and in this portion the coal had to be separated by hand picking. The tunnel continued for about fifty feet further, but I could not convince myself that any coal at all was present towards the extremity. This bed is called "the six feet seam."

Coal-seam.

About nine chains on the strike of the measures from where Hooper's Creek tunnel struck the coal, another tunnel had been driven at a lower level by seventy or eighty feet, and a third one about five chains further on the strike, and seventy or eighty feet still lower. On the mounds of *débris* excavated from these I could not find a trace of coal, which could not have been the case had but a small quantity been brought out. The inference is that no coal was met with, or so little as not to be worth working.

Second and third tunnels.

About nine chains across the measures in a bearing N. 35° E. from the coal-seam mentioned, and therefore above it stratigraphically, there occurs another seam. The following is an ascending section of the strata which are here vertical:

Coal-seam.

	Ft.	In.
Coal, good anthracite	0	6
Black argillaceous shale	4	6
Coal, good anthracite, called "the three feet seam"	2	5
Black argillaceous shale, with nodules of clay iron-stone	11	0
Grey trap, or it may be altered sandstone	8	0
	26	5

Shaft.

A vertical shaft had been sunk in the seam, and a good deal of good hard coal had been taken from it. The top of the shaft is 540 feet above the sea, but, at a lower level by 193 feet, an adit called Hutchison's tunnel had been driven to intersect it. The seam on being struck is stated by Mr J. J. Landale, a civil engineer and coal viewer, to have been thin. How thin is not mentioned. It is presumed, however, that it was not workable, and the excavation in the shaft having been abandoned before it reached the tunnel, it is supposed that the seam had diminished to an unworkable thickness in descending.

Hutchison's tunnel.

The strike of the measures immediately near the vertical shaft appears to be S. 18°E., and about eight chains in this bearing from it, there is another, which is said to have been sunk in coal, but I could not observe any interstratified in the shale at the top of the pit, and there were but

Second shaft.

small indications that any had been landed on the surface. A third shaft is situated about three chains further on, and said to be forty feet deep. Here several tons of dull, earthy, impure coal lay on the surface, and I was informed that some bright, good coal had been carried away; but I could perceive no fragments of it remaining intermixed with the other. Both of these shafts had been abandoned. Third shaft.

Towards the last mentioned shaft, and upwards of 300 feet lower in level, an adit called Wilkes' tunnel, has been driven from Robinson's Creek (a tributary of Hooper's Creek) sufficiently far, apparently, across the measures to have reached this coal, but the seam was not met with in it. At the extremity of the excavation, however, there occurred a black, tough, carbonaceous shale, with a black powder, a conchoidal fracture and an earthy aspect when freshly broken. *In situ* it is traversed by irregular cracks, splitting it into smallish fragments, the surfaces of which were often slickensided, and presented a brilliant black polish, with an occasional thin film of a greenish, probably magnesian mineral. In some of the cracks there were veins of quartz having a coating of the same mineral.* This shale was marked by the occurrence of a bivalve shell resembling a *Unio*. A mere filament of coal was intersected in the tunnel near its mouth, and this may correspond with a three-inch seam occurring at the mouth of Hutchison's tunnel. The stratigraphical place of this would be about 200 feet above the three-feet seam, and the strike of the three-inch seam in Hutchison's tunnel is N. 10° W., which would sufficiently correspond with that of the three-feet coal. The whole band of strata from the six-feet seam, comprehending a thickness of more than 800 feet, would thus appear to be running for a spur of volcanic rock, thrown eastward from Mount Seymour, while the three-feet seam reaches without any deflection to within four chains of it. This appears to me a pretty strong evidence of the existence of a fault, which seems to be farther corroborated by a sudden change in the strike of the measures. Wilkes' tunnel. Carbonaceous shale. Coal. Fault.

From a report by Mr. Landale to the Queen Charlotte Coal Mining Company, it appears that some exploratory work had been done on Robinson's Creek, above Hutchison's tunnel. Trials were made in three places of poor, soft, dirty coal, nine and seven feet thick, and in two where coal of a fair quality occurred in a seam of two feet. But, unfortunately, not having been made aware of this at the time I was on the ground, I can only avail myself of it to show that the strike of the measures immediately beyond the mouth of Hutchison's tunnel changes to north-east, and Mr. James Deans, my assistant during the summer, having been employed by the Queen Charlotte Company to undertake explorations on their behalf Mr. Landale's report.

* Mr. Hoffmann has since the above was written ascertained the mineral to have the following composition:—Silica 36.54, alumina 28.76. protoxide of iron 16.677, lime 1.82, megnesia 2.667, water 13.733=100.197.

during the months of October and November, succeeded with much difficulty, owing to continued rains, in cutting trails through the heavily timbered lands, and in tracing these north-eastward seams as far as Slaty Creek, a distance of between three and four miles. In this distance coal-seams were observed on most of the streams he crossed, showing that whatever variation there may occur in their quality and thickness, they are at any rate continuous. The strata for the whole distance preserve their vertical attitude, and they are all along backed to the north-west by lofty escarpments of volcanic rock.

Slaty Creek.

Continuity of Coal-seams.

In an opposite direction, that is to say south-eastward from Hooper's Creek tunnel, for about three-quarters of a mile, to Shallow Bay, but little is seen of the strata except at the pits and tunnels previously described as having been sunk and driven, with but indifferent success, in search of the three-feet coal-seam. On the west side of Shallow Bay, about twenty chains below the mouth of Hooper's Creek, the trap comes visibly in contact with the black shales, being apparently thrown forward a little to the eastward on the south side of a fault running about N. 73° E.

In a bearing S. 47° E. from this, there is on the south side of the north-west arm, about a mile S. 30° E., from the wharf in Anchor Cove, and about 200 paces inland, what is called "Number Two Coal Mine." It is an excavation of about twenty feet, bearing S. 67° E. on a seam between two and three feet thick of *culm*, holding lumps of anthracite. The black shale on each side of it is characterized by the presence of disseminated nodules of clay iron-stone similar to that at the Hooper's Creek seam.

Number Two Coal Mine.

My own examination did not extend further in this direction, but it is reported by the Indians that a well marked seam of coal occurs about fourteen miles hence in a south-easterly direction, apparently agreeing with the general strike, on the south side of Skidegate Channel. This would give an extent of at least twenty miles to the coal-bearing strata which have thus been partially examined, and the facts mentioned indicate a general presence of coal in it, however much what may be considered the same seams may vary in their distances from one another on the strike, in their thickness and their qualities. It is very probable that irregularities and interruptions may prevail here, similar to those which have been observed in the Vancouver Island deposits, and, according to the information you have given me, occur also in the mesozoic coal-seams in Australia.

Extent of coal-bearing strata.

It would require a much more detailed exploration than I had time to give to pronounce with any chance of accuracy upon the extent of these irregularities in the Queen Charlotte Islands, but the possibility of their occurrence should always be kept in view by those endeavoring to turn the seams to practical account, and some cheap but careful system of trials along the outcrops ought to be instituted in the first instance to ascertain the probable quantity before any great outlay is made upon works intended to be permanent. This is usual even on the very regular seams of the Carboniferous era, and it is certainly much more required in coal deposits of a more recent age, which may have had their origin from drift instead of growth *in situ*.

Nothing can be better or more substantially constructed than the wharf, the houses, tramways, inclines, dumping-sheds and tunnels of the Queen Charlotte Coal Mining Company, and it is much to be regretted that their efforts have not been more successful. **Wharf, houses, &c.**

On Slaty Creek near the base of the band of coal-bearing black shales now under description, and close by the volcanic rock, there occurs a quarry which has been excavated by the Indians. It has a depth of three or four feet, a breadth of four or five yards, and a length of between eighty and ninety yards. It has been worked for the purpose of obtaining masses of carboniferous shale similar to that occurring in Wilkes' tunnel. These the Indians carve into tobacco pipes, numberless grotesque images, and musical instruments resembling flutes, to all of which they give a good polish. The shale occurs in lenticular patches of two or three feet in the thickest part, and from eight to twenty feet long, which are interstratified with a light grey not very hard sandstone. In the patches occur an abundance of flattened stems and leaves, sometimes infiltrated with the greenish mineral already alluded to, and many thin irregular patches of anthracite sometimes a tenth of an inch thick. Whether this description of stone occurs at any other horizon in the shales of this division, or in other parts of its distribution has not yet been ascertained. With reference to it, Dr Harrington says: **Quarry of carbonaceous shales on Slaty Creek,** **Indian carvings.**

"This rock shows no tendency to cleave into laminæ until it is ignited, but breaks with a true conchoidal fracture. Its color is greyish-black upon fractured surfaces, and black when polished. The specimen given me for examination is slightly jointed, there being two series of joints nearly at right angles to one another, and nearly at right angles to the plane of the bedding. The joints are partially filled with a soft white mineral which has not as yet been analysed. **Note by Dr. Harrington.**

"The rock has a hardness of about 2½, a specific gravity of 2.88-2.89 and readily takes a fine polish. When fragments are heated in a crucible they decrepitate with considerable violence, and split up into numerous thin laminæ. These, upon removing the cover from the crucible and burning the carbonaceous matter, become reddish-grey in color. Before the blowpipe the rock decrepitates, turns reddish-grey, and fuses with difficulty on the edges to a black scoria which is attracted by the magnet.

It is partially decomposed by sulphuric acid.

The following analysis shows it to be a hydrated silicate of alumina and iron with several per cent of carbonaceous matter: **Analysis of shale.**

Silica	44. 78
Alumina	36. 94
Peroxide of Iron	8. 46
Lime	traces
Magnesia	"
Water	7. 15
Carbonaceous matter	3. 18
	100. 51

The disseminated carbonaceous matter appears to be the cause of its being susceptible of taking a fine polish."

On Slaty Creek the division has a breadth of perhaps three-quarters of a mile in a south-eastward bearing. From this the band runs southward to Anchor Cove, where its breadth is diminished to less than half a mile. The summit of it then sinks under a strip of conglomerate, and rising again runs along the coast to a point about half a mile north from Cowgitz. The summit here folds apparently over an anticlinal, and strikes eastward across the north-west arm to a point near Christie Bay, running in this direction about two miles. It has here a breadth in a south-western direction of about a mile and a half to the volcanic rocks in the neighborhood of "Number Two Coal Mine." From this the band has a southward trend to Skidegate Channel, on the south side of which it gradually turns to the eastward, and, folding under the axis of the general trough, comes upon the channel again with a breadth of about a mile and a half, the base reaching to within a short distance of Alliford Bay. In its northern course thence it composes South Island, all of Maude Island, except a small part of the west end, and the whole of Lina Island. The summit comes upon Graham Island again at the Narrows between it and North Island, shewing a breadth on the shore of the former of about two and a half miles: thence its course northward can for the present be only conjectured.

Organic remains.

The thickness of these shales has not yet been determined, but on both sides of the trough they are characterized by abundance of organic remains. These are met with in the interstratified sandstones, as well as in the shales, but they are more numerous in the latter, and particularly in the lower part of them. It is unnecessary for me to allude to them further as they are described in appended notes by Dr. Dawson and Mr. Billings, the plants by the former, and the shells by the latter.

2. *Coarse Conglomerates.*

Conglomerates.

These conglomerates are composed of well rounded pebbles, varying in size from a quarter of an inch to seven or eight inches, and appearing to consist chiefly of diorites, of light grey and yellowish-brown colors, held in a matrix of brown silicious sand with which they are well mixed up, the mass showing indications of very fine bedding. The base of the mass, however, becomes finer in some places than in others, presenting then the characters of sandstone. The country which these conglomerates occupy exhibits a broken surface, and a series of small islands immediately west of North Island rise abruptly from the water to heights of 100 and 150 feet. Where the band reaches Graham Island, on the east side of the trough, it presents a cliff of nearly 500 feet in height, and it must thus attain to at least this thickness.

On Graham Island the band comes southward towards Skidegate Channel, on both sides of the trough, with a breadth of about a quarter of a mile. The summit on the west side reaches the north-west arm of the channel at the mouth of Slaty Creek, and, after sweeping round under the water for three miles and a half, again reaches the coast, nearly north of the western extremity of North Island. The course of the base has been indicated in giving the summit of the lower shales. This part of the mass runs into a long spur as it approaches Anchor Cove, which seems to be prolonged with a curve to the eastward in a strip that occupies the shore between Cowgitz and what is called South Point. Further south these conglomerates fill an east and west breadth of seven miles and a half, occupying about a quarter of a mile at the west end of Maude Island, the remainder being on the promontory between the north-west arm and the western part of Skidegate Channel. On Moresby Island, along this channel, their breadth is about the same, but the distance they occupy to the south on this island, on the axis of the trough, must for the present be conjectured; it may, however, be between three and four miles.

3. *Upper Shales and Sandstones.*

These shales are by no means so black as the lower band, their darkest tint being a brownish or blackish-grey, and most of them are somewhat arenaceous. They are interstratified with sandstones, generally from three to six inches thick; but a band of about thirty feet occupies a position which is conjectured to be about seventy feet from the base. Upper shales and sandstones.

Approaching the conglomerates, some twenty or thirty feet are interstratified with beds of reddish-weathering, greyish-brown, argillaceous dolomite, varying in thickness from two to six inches, but constituting the chief part of the mass; and these seem to form a passage to the conglomerates, the tops of which hold a few of the magnesian layers. Only one fossiliferous bed was observed: it was at the top of the highest part seen, which may be about 200 feet from the base, though it has not yet been determined that this constitutes the summit of the band.

Soils, Vegetation, &c.

South and south-west of the prairie land described last year (Report of Progress 1871-72, p. 94) as extending eight miles from Comox up the Courtnay River, the country is heavily timbered on the Puntledge and its tributary, Brown's River; and the soil which supports the timber on the Soil.

lower parts of this, very much resembles that of the prairie, being of a rich snuff-brown when dry, and black when wet, and nearly destitute of pebbles. But on the more elevated portions, the color of the dry soil is of a duller brown, and it holds many well rounded pebbles of the crystalline rocks, not exceeding on an average the eighth of an inch in diameter, though a few up to seven inches may be occasionally met with.

Timber. The chief part of the timber seems to grow as large on the one soil as on the other. Beneath the brown soils on the Puntledge, from its junction with the Courtnay up to its junction with Brown's River, cliffs, in which clay and sand are interstratified with one another, are occasionally met with, varying in height from 100 to 150 feet.

On the line of the projected tramway to the Union Mine, the soil is well seen. It consists chiefly of the pebbly variety, but in a few parts openings occur, varying in extent from half an acre to seven or eight acres; and in these the soil resembles that of the Comox prairies. These soils prevail here for six miles from the coast, and reach for the same distance on the Trent River. On the Sable their breadth is limited to two miles; south-west from which the surface rises rapidly into rocky hills from 1,000 to 4,000 feet high, while two and a half miles further back the peaks of the Beaufort Range attain from 4,420 to 5,420 feet above the sea, according to the Admiralty Chart.

On the north-east side of Denman's Island, cliffs of interstratified sand and clay extend from Buck Point at the north to Kamas Point, and for two miles beyond, rising to heights of from 100 to 300 feet, as already stated. The interior of the island is generally covered with a thick growth of forest, and, excepting where the conglomerate rocks of Division C come to the surface, is well adapted for cultivation. Cliffs of sand and clay similar to those on Denman's Island occur on Hornby Island. From Shingle Spit to Point Phipps, and for about a mile and a half beyond, they rise to heights of from twenty to eighty feet. At the top of these a narrow strip of good brown soil prevails. It occurs also east of Point Norman, and at the head of Tribune Bay, extending to the north-east coast. On it there is some good prairie land.

In connection with these prairie soils it may be mentioned that Mr. George McFarlane of Comox shewed me a field of six acres from which he had just obtained nine tons of oats. This, allowing the ordinary rate of thirty-two pounds to the bushel, would be a yield of ninety-two bushels to the acre. From a turnip field of two acres which I saw before leaving the neighborhood, Mr. George Robb, at my request, sent me in November last to Victoria a Swedish turnip weighing twenty-six pounds and a half. When I left Comox in the beginning of October there appeared to be a great number, judging by comparison, which would weigh at least twenty pounds. The soil of the oat field was of the rich prairie variety without pebbles. The turnip field possessed the pebbly variety.

Crops

My stay on the Queen Charlotte Islands was too short to enable me to gather many facts in regard to their fitness for agricultural settlement. The forest trees appeared to me to equal in size those of Vancouver Island. In several places spruce trees were measured, and at seven feet from the ground they were found to be thirty-six and a half feet in circumference, while they ran up straight without a branch for 100 feet. Cedar trees (*Thuja gigantea*) were observed of not less magnitude. The Indians raise potatoes in openings which occur in the woods not far from the coast, and, where I saw them, the crop, in every case, appeared to be a good one. In one place near the company's tramway, where seed had been accidently dropped, timothy grass had sprung up to a height of six feet three inches. Fitness of the Queen Charlotte Islands for agricultural settlement.

The general surface of the Islands, though in some places mountainous, is not what might be termed rocky, the hills being for the most part, as the Indians informed me, covered with soil, and in the northern part of Graham Island there is said to be a good deal of level land.

The rain-fall appears to be greater than on Vancouver Island, and in this respect the country might be compared with the United Kingdom. There is, however, on the volcanic range, which bounds the coal-field to the west, occasionally an excess of wet weather. Rain-fall.

Erratic blocks, generally well rounded, and consisting chiefly of gneiss and granite, were occasionally met with in all parts of the country examined, but usually at distant intervals. But on the Union Mine tramway road, a little beyond the third mile from the coast, a quick rise takes place in the surface, and here the ground for a short distance is closely packed with well rounded boulders, varying in diameter from one to three feet. Erratics.

The only places where ice-grooves were observed, were in the neighborhood of Victoria. On the outside of the harbor they run S. 15 W. On the south side of James Bay, at the end of the bridge, they run S. 19° W., and at the upper end of Fort Street they are S. 13° W. Ice-grooves.

I have the honor to be, Sir,

Your most obedient servant,

(Signed,) JAMES RICHARDSON.

APPENDIX I. TO MR. RICHARDSON'S REPORT.

BY

PRINCIPAL DAWSON, LL.D., F.R.S.

Note on the Fossil Plants from British Columbia, collected by Mr. James Richardson in 1872.

McGILL COLLEGE, MONTREAL, May 8, 1873.

MY DEAR SIR,—I beg leave to send herewith notes on the specimens from British Columbia which you were so kind as to submit to me. I have felt much interest in these plants, many of them so well preserved, and only regret that the want of complete series of the modern trees of British Columbia and other parts of the West coast, has prevented more detailed comparisons of the fossils with their modern successors, which in some respects they so much resemble. I hope, at a future time, that this desideratum may be supplied.

I remain,

Your obedient servant,

J. W. DAWSON.

A. R. C. Selwyn, Esq., F.G.S.,
Director of the Geological Survey of Canada.

In my note of last year on the plants collected by Mr. Richardson in 1871, I referred to specimens of fossil coniferous woods from the coal-field of Nanaimo, Vancouver Island. Mr. Richardson's collections of 1872 include a much larger number of specimens of fossil wood from the Queen Charlotte Islands, Norris Island and Hornby Island, all of them apparently from Mesozoic rocks, and many of them associated with characteristic marine shells of Cretaceous or Jurassic Genera. They are principally drift trunks, though probably from not very distant land, and some of the specimens have been bored by Teredine mollusks.

Mr. Weston, the lapidary of the Survey, has prepared upwards of a hundred excellent slices of these fossils, all of which I have carefully examined, with the following general results:—

I. CONIFEROUS WOODS.

These are by much the most abundant in the collection, ranging in age from the probably Lower Cretaceous or Jurassic beds of the Queen Charlotte Islands to the probably Middle and Upper Cretaceous of Vancouver Island and Hornby Island. They may all be referred to the genera *Cupressoxylon and Taxoxylon*, or in other words are allied to the modern Cypresses and Yew trees, which range with very little modification of type from the Mesozoic to the modern period.

Genera of coniferous woods.

Cupressoxylon.

This genus is characterised by distinct concentric rings of growth, round discs or bordered pores on the walls of the fibres in one or two series, resin cells (which are, however, often very obscure in the fossil specimens) and simple medullary rays. Characters of genus *Cupressoxylon.*

One of the most common woods of this type in the collections from the Queen Charlotte Islands, Vancouver Island and Hornby Island, is of the same character with the wood of the modern *Sequoia gigantea* of California, and probably belonged to an allied tree.

Another from Vancouver Island, with two rows of pores on each fibre, is scarcely distinguishable from specimens of the ordinary California Redwood, in the collection of Prof. Gray, of Cambridge, who has kindly given me specimens for comparison.

Another species differing from the above in its very short medullary rays, and having one row of pores on the walls of the fibres, occurs at Queen Charlotte and Vancouver Islands.

Two others, with well developed resin cells, and one row of pores on the fibres, are found at Vancouver Island alone.

I do not think it necessary to attach specific names to these trees, at least until I can compare them with more complete series of woods from the west coast. It is sufficient to know that they indicate several species of Cypress-like trees not very dissimilar from those at present existing in the region. Cypress-like trees.

Taxoxylon.

This genus is characterised by concentric rings of growth, by wood-cells with spiral fibres, in addition to the bordered pores, and by simple medullary rays. Genus *Taxoxylon.*

There appear to be in the collection three species of this genus, two from Vancouver Island and one from the Queen Charlotte Islands. They have the characters of modern taxine woods, modified a little probably by the long maceration in water which they have sustained. Many of the modern taxine trees are remarkable for the toughness of their fibre, arising apparently from a less firm lateral adhesion than usual of the woody fibres to each other, and, also, perhaps, from the peculiarities of their ligneous lining. This laxity of the tissue becomes exaggerated in the water-soaked fossil specimens, so that in cross section the wood-cells appear as if round within, and separated by intercellular spaces, the appearances recalling those in the Devonian *Prototaxites*, which, however, presents them in a still more exaggerated form. The study of these more modern taxine trees has served to confirm my belief in the interpretation I have given of the Devonian prototype of Taxineæ.

II. Angiospermous Exogens.

Wood of this class is not so abundant in the collection as coniferous wood; but it is of much interest as exhibiting the existence in the Cretaceous period of the same modifications of wood which exist at present, and as corresponding with the leaves of exogenous trees found in the coal formation of Nanaimo.

Quercus.

Two species of oak.

Two species of oak occur in the collection. One is from the Upper Cretaceous shale of Hornby Island. The other is from the Cretaceous coal-field of Vancouver Island, at Trent River below the Falls, or according to Mr. Richardson's sections, about 3,000 feet lower than the Hornby Island beds.

Quercus, No. 1. Hornby Island.—This has very large medullary rays of many series of cells, the ducts small, uniformly scattered and annular. Of the species with which I have means of comparison, it most nearly resembles *Q. ilex* of the south of Europe, but has larger medullary rays. The specimen is a fragment of a decorticated stem about six inches in diameter, and to the naked eye has much the appearance of a blackened fragment of the wood of *Q. suber.*

Quercus, No. 2, Vancouver Island.—The medullary rays are narrower than in the last, and more dense. The ducts are more collected in the vicinity of the rings of growth, and are apparently dotted. The specimen is a fragment of wood in a nodule.

Resemblance to European oaks.

Both the above species have more resemblance to European oaks than to those of Eastern America; and unfortunately I have not yet been able to procure specimens of the wood of the modern oaks of British Columbia for comparison.

Betula.

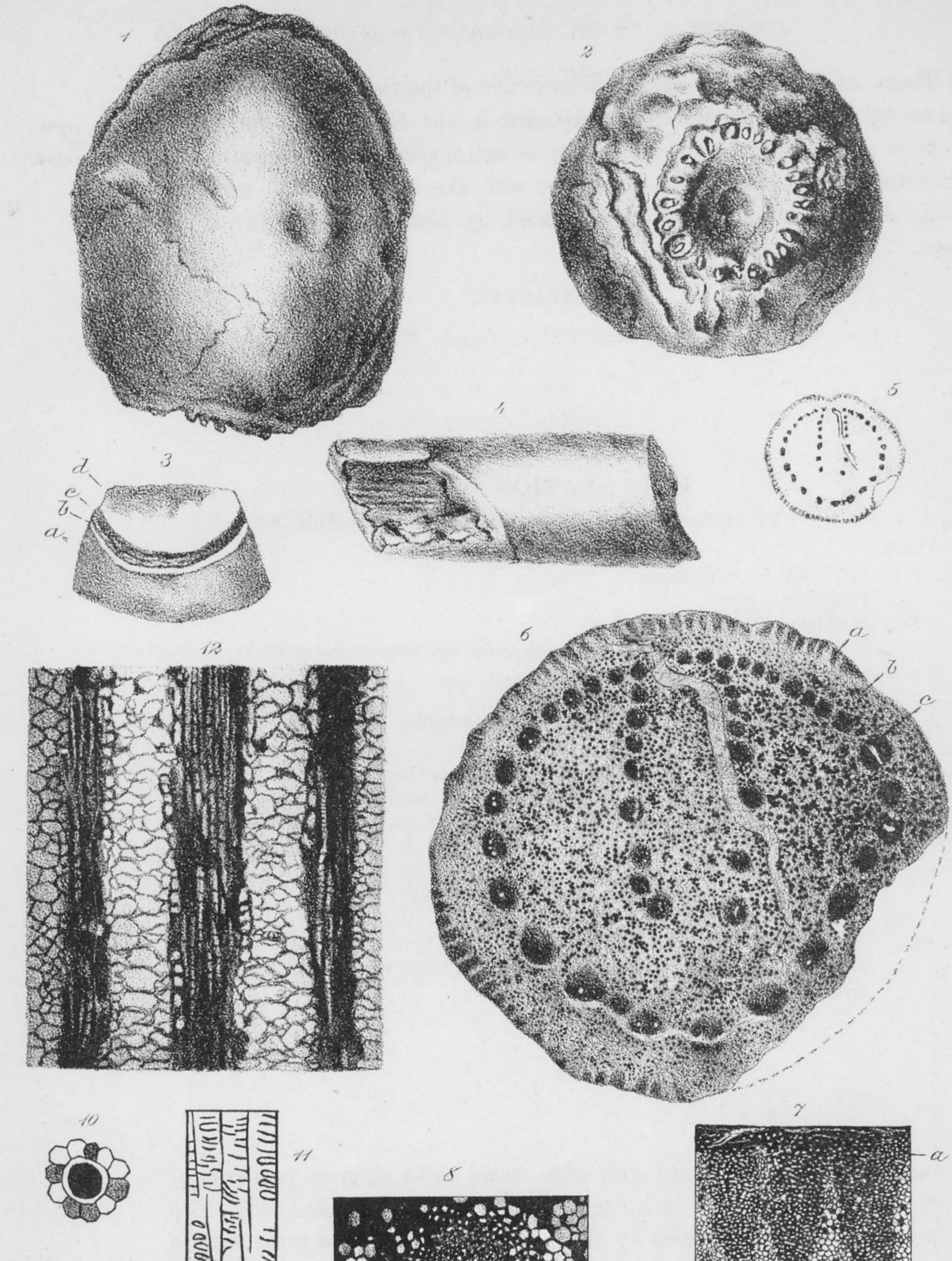
Birch-wood.

One specimen from Vancouver Island, a fragment of a stem about three inches in diameter, and with a very smooth external surface, presents the characters of Birch wood, and is not very dissimilar from the modern *Betula papyracea.* It has clustered ducts, evenly disposed and dotted on the walls, and thin-walled wood-cells. The medullary rays are narrow and frequent, of about three rows of cells.

Populus.

Poplar.

This is also a specimen from Vancouver Island. It is a small knot or base of a branch, imbedded in a nodule. Its structure is not dissimilar from that of *Populus balsamifera.* The wood has infrequent scattered ducts and delicate medullary rays of one series of cells. Its growth rings are distinct.



A. H. Foord, del et lith.   Roberts & Cº impt.

CYCADEOCARPUS (DIOONITES) COLUMBIANUS.

CRETACEOUS OF QUEEN CHARLOTTE ISLANDS.

EXPLANATION OF PLATE.

CYCADEOCARPUS (DIOONITES) COLUMBIANUS, N.S.

FIG.

1. Fruit, side view, natural size.
2. Fruit, basal view "
3. Section of Fruit "

    (a) epicarp, or testa; (b) space occupied by structureless calcite; (c) endocarp or tegmen (d) nucleus.
4. Petiole, natural size.
5. Cross section of the same, shewing bundles of fibres.
6. The same magnified.

    (a) cortex; (b) cellular tissue; (c) bundles of fibres.
7. Portion of the same more magnified. (Reference letters the same.)
8. Transverse section of one of the bundles, highly magnified, shewing lacunæ and fibres.
9. Longitudinal section of portion of petiole magnified.

    (Reference letters as in fig. VII.)
10. One of the "gum-cells" magnified.
11. Fibres shewing transverse markings.
12. Portion of a leaf magnified, shewing bundles of fibres with transverse markings, and intervening cellular tissue.

These woods afford an additional evidence of the fact already commented on by Lesquereux and Newberry, that in the Cretaceous period the generic types of American trees were as well marked as at present; and they are further curious in connection with the occurrence of workable coal, which must have been accumulated by plants thus modern in aspect.

Generic types of the Cretaceous period.

III. Cycadeae.

Cycadeocarpus (Dioonites) *Columbianus*, N.S. (Plate I.)

This is a large and beautiful fruit, showing its internal structure, and associated with fragments of petioles and leaves, which, from the similarity of their tissues, I regard as probably belonging to the same species. I shall, therefore, describe under this head these different organs, in the hope that future discoveries may make good my judgment as to their specific identity.

(1) *Fruit.* Broadly ovate or nearly oval. Surface smooth, but with traces of indented longitudinal bands. Apex rounded or obtusely pointed. Base showing a broad surface of attachment, with a ring of scars of about twenty-two fibrous bundles which probably passed upward on the outer rind. Length of largest specimen, 5.25 centim. Largest transverse diameter, 4.5 centim. Length of a smaller specimen, 4 centims. Largest transverse diameter, 4.25 centim. This smaller specimen has probably been vertically compressed.

Description of fruit.

When sliced, it shows an epicarp (or testa) of large and rather thick-walled hexagonal cells, without auy fibres or vessels. Within this is a narrow structureless ring filled with calcite, and probably a result of shrinkage. This encloses the endocarp (or tegmen,) which is thin and composed of fine cells, and apparently lined with a dense membrane. The nucleus, which was large, has entirely disappeared, its place being occupied by structureless calcite.

(2) *Petiole.* This is a slightly flattened cylinder, two centimeters in diameter. Externally it has a thin bark of small elongated cells, arranged in little groups in a radial manner. Within this is a continuous tissue of hexagonal cells, interspersed with what seem to be gum or proper-juice cells, darker in color, and each enclosed in a sheath of smaller cells. This cellular substance is traversed by about 45 bundles of fibres presenting in the cross section a somewhat hippocrepian arrangement. Thirty of these bundles, in the cross section, form a circle a little within the bark—the larger bundles being at the lower side. At the upper side is one bundle larger than those in its vicinity and of a round form, and from either side of this the remaining bundles form a deep loop extending considerably beyond the centre of the petiole. Each bundle consists of fine fibres radially arranged and coarser outside, and with these are from one to five

Description of petiole.

lacunæ, which in the longitudinal section seem to be oval intercellular spaces. The fibres show in places a delicate transverse or pseudo-scalariform marking similar to that in modern Cycads.

Description of leaves.

(3) *Leaves.* These have the structure well preserved, though in a fragmentary condition. The fragments are parallel-sided, about half an inch wide, thick, and traversed by strongly developed parallel fibrous bundles, imbedded in delicate cellular tissue. Each bundle is enclosed in a sheath of dense cells, and some of the fibres show the barred structure already mentioned. Between the principal bundles are secondary nerves, each consisting of a single, perhaps laticiferous, vessel. The epidermis is composed of dense irregular cells. The structures are similar on the whole to those in the pinnules of the leaf of *Dioon*, though they also remind an observer of the leaves of *Yucca gloriosa*.

General characters of plant.

On the supposition that the above described organs belong to one and the same plant, it had no doubt a thick though perhaps short stem, large compound leaves having their divisions thick and rigid, with parallel veins, fruits or large naked seeds, supported on massive peduncles, or sessile on a common peduncle, and when mature furnished with a thick and probably dry cellular coat. No true vascular structures are apparent in any of the specimens. These characters would point to the Cycads; and, perhaps, nothing of this kind more nearly approaches to the fossil than the modern *Dioon edule* of Mexico, of which this may be regarded as a cretaceous predecessor. It may, I think, very properly be placed in the genus *Dioonites* created to receive certain fossil cycadeous leaves from the Mesozoic of Europe. The fruit, if described by itself, would go into the genus *Cycadeocarpus*.

The specimens are from the Lower Cretaceous or Jurassic of Skidegate Channel, Queen Charlotte Islands.

IV. Filices.

Ferns.

Pecopteris.—The shales of Hornby Island along with many obscure vegetable fragments, contain pinnæ of a fern approaching in outline to *Pecopteris Phillipsi* of the English Oolite, though of much smaller size. As its venation is not preserved, I think it best not to give it a name.

Geological Relations.

Geological relations.

The fossils from the Queen Charlotte Islands, consisting entirely of Pines and Cycads, while decidedly Mesozoic, would indicate a somewhat older stage than the others, say the Jurassic or Lower Cretaceous.

The fossils from the coal-field of Vancouver Island, embracing, in addition to coniferous trees, both wood and leaves of several species of Angiospermous Exogens, coincide with those of the Cretaceous of other parts of America, for example of Nebraska.

The fossils from Hornby Island, in shales believed to overlie those of Vancouver Island, are also Cretaceous, and there is nothing to preclude their belonging to the upper part of that system.

APPENDIX II. TO MR. RICHARDSON'S REPORT.

BY

E. BILLINGS, F.G.S., *Palæontologist to the Geological Survey.*

On the Mesozoic Fossils from British Columbia, collected by Mr. James Richardson in 1872.

The following table exhibits the geological horizons of the Mesozoic rocks of British Columbia, as compared with those of England, Nebraska and California, according to our present information :—

	England. *	Nebraska.	California.	British Columbia.
Upper Cretaceous	Maestricht beds......	Fox Hills Group	Tejon Group	Position of the rocks of Vancouver, Hornby and Denman Islands.
	White Chalk.........	Fort Pierre "	Martinez "	
	Grey Chalk...........	Niobrara "	Chico "	
	Upper Greensand...	Fort Benton "	....	
	Gault	Dakota "	....	
Lower Cretaceous	Lower Greensand...	....	Shasta Group	Queen Charlotte Islands. The fossils are partly Jurassic and partly Cretaceous.
	Wealden Clay.......	....		
	Hastings Sand.......	....		
Jurassic	Upper Oolite.........	....	....	....
	Middle "	....	....	....
	Lower "	....	....	....
	Upper Lias...........	....	....	....
	Middle "	....	....	....
	Lower "	....	....	....
Jurassic	Upper Trias..........	....	....	....
	Middle "	....	....	....
	Lower "	....	....	....

According to the researches of Mr. F. B. Meek and Dr. F. V. Hayden in Nebraska, and of Mr. W. M. Gabb in California, the fossils of the Cretaceous formations on the east side of the Rocky Mountains, are nearly all specifically distinct, from those that occur in rocks of the same age on the west side. This would seem to establish the existence of a land barrier, between the two regions, at an early period; and upon this land, most probably grew the plants, whose remains occur so abundantly in the rocks in question. Land barrier.

It appears also, that the five groups into which the Cretaceous rocks of

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* Lyell's Elements, 6th ed., 1865, p. 312.

Nebraska have been divided, when taken together as a whole, represent in a general way, the upper four members only, of the English series, as indicated in the above table. Neither the Gault, Lower Greensand, Wealden Clay, nor the Hastings Sand has been recognised on the east side of the Rocky Mountains. In effect, the whole of the lower half of the Cretaceous system is unknown in that region. But on the west side of the Mountains, a portion at least of the Lower Cretaceous is supposed to occur. The officers of the California Survey have placed their upper three groups (Tejon, Martinez and Chico) on a parallel with the upper three of the English Divisions. They consider that the Shasta group may represent the remainder of the Cretaceous from the Gault downwards.* If this view should be correct, and I have no doubt but that it is, then the Lower Cretaceous (as well as the Upper) is represented on the west side of the Rocky Mountains.

Absence of Lower Cretaceous on east side of Rocky Mountains.

In deciding the age of a rock in which all of the species are either new, or of forms whose geological horizon has not been determined, we are obliged to rely upon the known range of the genera. This is the case with regard to the fossils from the Queen Charlotte Islands. I cannot find that any of the species have been described. I sent ten of the species of Lamellibranchiata from this locality to Mr. Meek, who is one of the most experienced Mesozoic palæontologists on the continent, and he informed me that they were all new to him. My own observations have been confined chiefly to the cephalopoda, and may be thus briefly stated. There are sixteen species of ammonites which exhibit the following alliances:—

Sixteen species of ammonites.

No. 1.—A species closely allied to *A. Raquinianus*, d. Orb. Paléontologie Française, Terrains Jurassiques, Tome 1, pl. 106, Upper Lias. This species is from Skidegate Channel.

No. 2.—Allied to *A. coronatus*, Brug. d. Orb. op. cit., pl. 169, Upper Oolite. Occurs with No. 1.

No. 3.—This species is of the type of *A.* (*Perisphinctes*) *tyrannus*, Neumeyer. Jahrbuch der K. K. Geologischen Reichanstalt, Band XX., pl. 9., Upper Oolite, Germany. Occurs at Skidegate Channel west of Alliford Bay.

No. 4.—Same type as the former, but with more numerous ribs. Occurs at the same locality.

No. 5.—This also belongs to the same group. It has still finer ribs on the dorsum than No. 4, and approaches, in this respect, *A. Humphriesianus*, Sowerby, of the Inferior Oolite. It occurs with 3 and 4.

* Geology of California, Vol. 1, p. 19, and Vol. 2, p. 13.

No. 6.—This species apparently belongs to the group LIGATI, which ranges from the Middle Oolite up to the White Chalk. It is from Skidegate Channel west of Alliford Bay.

No. 7.—A species of the group DENTATI. It resembles *A. Stoliczkanus*, Gabb, Pal. Cal. 2, p. 135, pl. 23, in size and form. It is, however, quite distinct therefrom. *A. Stoliczkanus* has only three tubercles on the ribs on each side, but this has six or seven. Occurs with No. 6.

No. 8.—A compressed discoid species with a very small umbilicus, of the group HETEROPHYLLI. It is allied to such forms as *A. semisulcatus* and *A. Tethys* d'Orbigny, Op. cit. pl. 53. Lower Cretaceous. Occurs with Nos. 6, 7.

No. 9.—A species allied to the last, but with a larger umbillicus. It resembles *A. Beudanti* d'Orb, Op. cit. pl. 34. Gault. Occurs with the last.

No. 10.—This species is closely allled to *A. macrocephalus*, Lower Oolite, but has a smaller umbilicus. Occurs with the last.

No. 11.—Another species of the same type, but with larger ribs. Same locality.

No. 12.—A species with large rounded ribs separated by deep narrow grooves. With the last.

Besides these are four other species, represented by very imperfect specimens. The genus *Belemnites* furnishes two species. One specimen consists of a portion of a large phragmocone, 2½ inches in length, 1½ inches across the larger extremity, and 13 lines across the smaller. The septa are moderately convex, and there are twelve chambers in the specimen. The second species is much smaller, the guard being only about 2½ inches in length, and nine lines in diameter at the margin of the alveolus. In one of the specimens the phragmocone is preserved, and exhibits at the upper extremity five chambers in the length of six lines. There are three specimens of the guard, which taken together exhibit all the parts, except a small portion of the apex and of the alveolar margin. From what may be seen in these three specimens of the guard, this species belongs to the section ACŒLI (Bronn), as it has neither dorsal nor ventral grooves. There is a short groove which extends from the apex upwards about nine lines. The materials are not sufficient to establish the position of this species with certainty, but the absence of furrows on the body of the guard and the presence of the small furrow at the apex, indicates that it belongs to the sub-section *Acuarii*. It is closely allied to *B. Russiensis* and *B. Kirghisensis*, d' Orb., (Palæontology of Russia, pl. XXIX.) both of which occur in the Middle Oolite.

Two species of *Belemnites*.

The only other Cephalopod in the collection besides the above, is a large *Nautilus*, with an aperture nearly six inches in width, and with coarse

***Nautilus*.**

somewhat transverse ribs meeting on the median line of the ventral side at an angle of about 110°. We have, thus, only three genera of Cephalopoda, in the Queen Charlotte Islands collection.

The genus *Ammonites* is found in all the Mesozoic formations from the Trias to the Upper Cretaceous. It has, however, been sub-divided into a number of groups, each of which has a definite range. The first five species above noticed belong to the group PLANULATI, nearly all of which are Jurassic. Thus in India, where the ammonites have been well described and figured, out of 93 Cretaceous species, only one belongs to this group.* No. 6 may be referred to the LIGATI, a group which includes some Jurassic species, but is most prolific in the Cretaceous. No. 7 belongs to the DENTATI, both Jurassic and Cretaceous. The group HETEROPHYLLI, to which 8 and 9 belong, is Jurassic and Cretaceous. Nos. 10 and 11 are of the group MACROCEPHALI, nearly all of which are Jurassic. No. 10 is very closely allied to the type of the group. No. 12 may be referred to the LIGATI, but it is doubtful to which of the sections it belongs.

The genus *Belemnites* ranges from the Trias upwards into the lower part of the Upper Cretaceous. Our two species are more like those of the Jurassic than the Cretaceous forms. If the smaller of the two be, as I suppose, truly a member of the sub-section *Acuarii*, then it belongs to a group never known to ascend above the Neocomian rocks, or the base of the Cretaceous.

The genus *Nautilus*, as represented in the Mesozoic rocks, consists of two groups, one longitudinally sulcated and the other with transverse curved ribs. The former is Jurassic while the latter is said to be exclusively Cretaceous. Our species is closely allied to if not identical with *N. pseudo-elegans* d'Orbigny, a widely distributed form which occurs in the base of the Cretaceous in England, France and Switzerland, and in the lower part of the Upper Cretaceous in India.

Age of Queen Charlotte Islands rocks.

According to the above, the *Ammonites* and *Belemnites* tend to prove that the Queen Charlotte Islands rocks are Jurassic, while the *Nautilus* would place them in the Cretaceous.

Gasteropoda.

There are four species of Gasteropoda in the collection, all from Skidegate Channel west of Alliford Bay. Two of these belong to the genus *Acteonina*; the other two are not determinable generically. The genus *Acteonina* is, in Europe, Jurassic, but two species have been described in the Palæontology of California from the Shasta group.

Lamellibranchiata.

The Lamellibranchiata from Skidegate Channel west of Alliford Bay, belong to the genera *Cucullæa*, *Thracia*, *Cyprina*, *Pleuromya*, *Inoceramus*, *Astarte*, *Melina*, *Trigonia* and *Pholadomya*. I sent ten of the species to

* Palæontologia Indica, Vol. 1, p. 161.

Mr. Meek, and he says they are "undoubtedly Cretaceous or Jurassic most probably the former."

Three miles east of Cowgitz two species of *Inoceramus* were collected, both of which occur also on the south shore opposite Cowgitz, while one of them seems to be identical with one from Alliford Bay. *Inoceramus.*

The fossils above noticed do not appear to be Upper Cretaceous. My impression is that they belong to the base of the Cretaceous and the upper part of the Jurassic.

The fossils from Vancouver, Denman and Hornby Islands are, in general characters, of the Upper Cretaceous type. The geologists of the California Survey, have already referred a portion, at least, of the rocks at Nanaimo including the coal-bearing beds, to their Chico group. * In 1856, a paper on some fossils from Nanaimo and Comox, was read before the Albany Institute by Mr. Meek, in which he refers the rocks of these localities to the Fort Pierre group of the Nebraska section, or to the horizon nearly of the White Chalk of the English series. There can scarcely be any doubt but that these views are, in the main, correct. The occurrence of *Baculites* alone, goes far to prove that these rocks are Upper Cretaceous, since of all the species known of this genus, only one is Lower Cretaceous. The collection of fossils from the localities above named is not large, and most of the specimens are very imperfect. I could not at present venture to name any of the species. They are all, however, distinct from those of the Queen Charlotte Islands. Views of Mr. Meek.

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* Mr. J. D. Whitney says that the Chico group "includes all the known Cretaceous of Oregon and of the extreme northern portion of California, and is the coal-bearing formation of Vancouver Island." Geol. Cal., Vol. 2, Preface XIV.

APPENDIX III. TO Mr. RICHARDSON'S REPORT.

BY

Dr. B. J. Harrington, *Chemist and Mineralogist to the Geological Survey.*

The Coals of the West Coast.

In the Report of Progress for 1871-72, page 99, there appeared a series of analyses of coals from Vancouver and Newcastle Islands, by Dr. Hunt. Since these analyses were made, however, Mr. Richardson has brought other samples of the bituminous coals from Vancouver and Newcastle Islands, as well as of the anthracite from the Queen Charlotte Islands; and an examination of these has been deemed desirable, inasmuch as they are, for the most part, from different seams or different localities from those examined last year.

I have only made proximate analyses; and as most of the samples were weathered, and the pyrites converted into peroxide of iron, determinations of sulphur would have been but of little value, and have, therefore, been made in a few cases only.

I shall first give the analyses of the bituminous coals, and afterwards those of the Queen Charlotte anthracite.

Bituminous Coals.

Union Mine.

I. Lower seam, Union Mine, Comox.

Different character of upper and lower portion of seam.

On referring to Mr. Richardson's report, page 38, section 3, it will be seen that the Lower or 10 *feet seam* (1.) at the Union Mine consists of two and a half feet of a dull, earthy coal, and seven and a half feet of clean and bright coal. The sample examined by Dr. Hunt was from the earthy portion, and contained 21·60 per cent. of ash. That which I have examined was from the upper and better portion of the seam. Its analysis gave:

	Slow Coking.	Fast Coking.
Water*	1.70	1.70
Volatile combustible matter	27.17	32.36
Fixed carbon	68.27	63.08
Ash	2.86	2.86
	100.00	100.00
Coke	71.13	65.94
Ratio of volatile to fixed combustible.	1:2.51	1:1.95

* Loss at 115° C in all the analyses.

The sample was weathered, rather brittle, and stained with oxide of iron, though bright upon fresh fractures. The powder, when slowly heated in a crucible, did not agglutinate ; but, when rapidly heated, was converted into a tolerably firm coke. Ash brick-red.

II. Union Mine, Comox. Seam 11, section 3, page 38, of Mr. Richardson's report. Union Mine.

This sample, like the last, was a good deal stained with oxide of iron, though bright upon fresh fractures. It was, however, much firmer, and contained a little mineral charcoal.

When slowly heated the pulverized coal agglutinated slightly ; but when rapidly heated gave a firm though rather dull coke. Ash pale brick-red.

Analyses by slow and fast coking gave :

	Slow Coking.	Fast Coking.
Water	1.34	1.34
Volatile combustible matter	28.11	30.01
Fixed carbon	67.72	65.82
Ash	2.83	2.83
	100.00	100.00
Coke	70.55	68.65
Rate of volatile to fixed combustible.	1:2.41	1:2.12

III. Brown's River. Section 1, seam 7, page 36. Brown's River

A surface specimen, brittle and stained with oxide of iron. When slowly heated it swelled up into a light porous coke. Ash reddish-grey.

	Slow Coking.	Fast Coking.
Water	0.95	0.95
Volatile combustible matter	21.57	23.35
Fixed carbon	73.14	70.86
Ash	4.34	4.34
	100.00	100.00
Coke	77.48	75.10
Ratio of volatile to fixed combustible.	1:3.39	1:2.55

Mr. Robert Brown, F.R.G.S., referring to the coal of Brown's River, says that it "is of a better quality than that of Nanaimo, and produces excellent coke."*

IV. Trent River, Seam 9 (3 feet 8 inches), section 5, page 40. Trent River.

This sample was somewhat weathered, but still firm and clean. It contained occasional thin leaves of carbonate of lime.

When slowly heated the powder swelled up to a light porous coke, occupying more than twice the volume of the powder. Rapid heating gave a firm coke. Ash reddish-grey.

* Trans. Edin. Geol. Soc., Vol. I., Part III., p. 315.

Analyses by slow and fast coking gave :

	Slow Coking.	Fast Coking.
Water	0.92	0.92
Volatile combustible matter	28.50	32.94
Fixed carbon	62.76	58.32
Ash	7.82	7.82
	100.00	100.00
Coke	70.58	66.14
Ratio of volatile to fixed combustible.	1:2.20	1:1.77

Trent River.

V. Trent River. From the same seam as No. IV., but from a different depth.

The sample was firm and bright, and had an irregular fracture. Like the last, it contained thin veins of carbonate of lime.

When slowly heated, the powder was only partially agglutinated. Rapid heating, however, gave a firm coke. Ash pale reddish-grey.

The following analyses illustrate its composition:

	Slow Coking.	Fast Coking.
Water	0.97	0.97
Volatile combustible matter	25.09	29.95
Fixed carbon	66.42	61.56
Sulphur	1.57	1.57
Ash	5.95	5.95
	100.00	100.00
Coke	73.16	68.30
Ratio of volatile to fixed combustible...	1:2.65	1:2.05

Newcastle Island.

VI. Newcastle Island. Upper seam, from three to four feet thick. (See Report of Progress 1871-72, p. 84.)

A bright and clean coal, exceedingly tough and breaking with an uneven fracture. The sample showed two planes of cleat at right angles to one another, and also to the plane of bedding; one of them, however, being much more distinct than the other. On account of its toughness this coal would appear to be eminently adapted for stowage.

The pulverised coal, when slowly heated, did not agglutinate at all; and, even when rapidly heated, the grains were but slightly sintered together. Ash bulky, and of a reddish-grey colour. Analysis gave,

	Slow Coking.	Fast Coking.
Water	1.57	1.57
Volatile combustible matter	30.95	38.14
Fixed carbon	58.03	50.84
Sulphur	0.82	0.82
Ash	8.63	8.63
	100.00	100.00
Ratio of volatile to fixed combustible...	1:1.87	1:1.33

Saaquash or Sukwash.

VII. Saaquash or Sukwash.

Upon this stream, at a point about two miles south of Fort Rupert, coal is said to crop out, and to have been worked at different times. Mr. Richardson does not allude to it in his report, but has given me a specimen, of which I have made the following analyses:

	Slow Coking.	Fast Coking.
Water	2.84	2.84
Volatile combustible matter	33.56	39.23
Fixed carbon	52.03	46.36
Ash	11.57	11.57
	100.00	100.00
Ratio of volatile to fixed combustible	1:1.55	1:1.18

The specimen consisted of alternate bright and dull layers, and was the poorest of all those examined. It can scarcely be classed with the *brown coals,* although not far removed from them in its characters.

The powder did not agglutinate at all, even when rapidly raised to a bright red heat. When boiled in a solution of caustic potash, it communicated a *pale* brown color to the solution.

If now we take the average of all the preceding analyses (including the sulphur with the volatile combustible matter) we get, Average composition of Vancouver coals.

	Slow Coking.	Fast Coking.
Water	1.47	1.47
Volatile combustible matter	28.19	32.69
Fixed carbon	64.05	59.55
Ash	6.29	6.29
	100.00	100.00
Ratio of volatile to fixed combustible	1:2.37	1:1.85

The average composition deduced from the analysis of eight samples of Vancouver coal by Dr. Hunt is,

	Slow Coking.
Volatile matter	31.00
Fixed carbon	56.41
Ash	12.59
	100.00

Again, combining Dr. Hunt's results with my own, we obtain as the average composition of Vancouver coal, deduced from the examination of fifteen samples,

	Slow Coking.
Volatile matter	30.33
Fixed carbon	60.23
Ash	9.44
	100.00

Mr. Robert Brown, in the paper already referred to, gives eight ultimate analyses of Vancouver coals, one sample of which was from Nanaimo and the rest from Koskeemo.

The average composition deduced from these analyses is,

Carbon	67.144
Hydrogen	5.530
Oxygen	10.623
Nitrogen	1.279
Sulphur	.843
Ash	14.642
	100.061

Remarks by Mr. Brown.

The same writer, speaking of the Nanaimo coal, says: "The coal itself is bright, tolerably hard, and not unlike some of the best qualities of English or Welsh coal in appearance. It burns freely with a good heat, but produces a great amount of ash. It is universally used by all Her Majesty's ships on the coast, and by all of the Colonial and other steamers plying on the coast. It is highly valued as fuel for domestic purposes. both in Victoria, San Francisco, and other towns. Gas is manufactured from it in Victoria of good illuminating quality." Referring to the Koskeemo coal-fields he says, "My opinion is decided that the Koskeemo coal-field is the best yet discovered in Vancouver Island, though unopened out, not only on account of the superior quality of the coal, but the ready accessibility of the mines from the Pacific, without the tedious inland navigation requisite for reaching the mines on the eastern seaboard of the island."

Character of Vancouver coals.

The Vancouver coals are for the most part *true bituminous coals,* and the name of "lignite" which has been applied to them by a number of writers, is altogether a misnomer. The principle of applying the term lignite to all coals of more recent age than the true Carboniferous is also unwarrantable. According to this view the Jurassic anthracite of the Queen Charlotte Islands would be called *lignite.*

It is true that the so-called lignites pass by insensible gradations into bituminous coals, so that cases arise in which it is a matter of doubt to which class a coal should be referred; but when we find a series of coals like those which I have examined from Vancouver Island, in which the average percentage of hygroscopic water is only 1.47 and that of the fixed carbon over 60, while at the same time their powder is black, in many cases agglutinates on heating, and communicates little or no color to a boiling solution of caustic potash, we surely need not hesitate to call them bituminous coals.

Unfortunate terms.

The names bituminous coal, brown-coal, lignite, have become so firmly rooted that we cannot well do away with them, although they are, to say the least, unfortunate; for bituminous coals contain little or no bitumen, brown-coal is often black, and the term lignite is often applied to coals which have lost their lignitic or woody structure. Some writers make brown coal and lignite synonymous, while others, and I think wisely, restrict the latter term to such varieties of coal as "manifestly present the appearance of woody tissue."

ANTHRACITE.

Until quite recently the coal of the Queen Charlotte Islands has been regarded as of Palæozoic age. Mr. Richardson's discoveries, however, appear to have proved that it belongs to a horizon high up in the Jurassic, or low down in the Cretaceous. It is in either case interesting, as being one of the many evidences of metamorphic action which has so largely affected the rocks of the west coast in comparatively recent times. Age of the coal rocks of the Queen Charlotte Islands.

The only analysis of this coal which I have seen published shows 71.28 per cent. of fixed carbon and 17.27 per cent. of volatile combustible matter, a composition making it scarcely worthy of being dignified with the name of anthracite. I have, however, recently examined specimens collected by Mr. Richardson, and found them to be true anthracites. Previous analysis of coal from the Queen Charlotte Islands.

One of Mr. Richardson's samples was from Nicholson's Creek, Skidegate. It was clean and bright, had a sub-conchoidal fracture, and contained occasional thin seams of carbonate of lime.

The powder after being rapidly raised to a bright red heat in a covered crucible, was unaltered in appearance. Ash reddish-white.

An analysis by fast coking, gave,

Analysis of sample one; collected by Mr. Richardson.

Water	1.60
Volatile combustible matter	5.02
Fixed carbon	83.09
Sulphur	1.53
Ash	8.76
	100.00
Ratio of volatile to fixed combustible	1:16.55

A second sample was taken by Mr. Richardson from a three feet seam, about 100 yards from Nicholson's Tunnel. It was brighter than the last, and had a conchoidal fracture.

An analysis by fast coking, gave,

Analysis of sample two; collected by Mr. Richardson.

Water	1.89
Volatile combustible matter	4.77
Fixed carbon	85.76
Sulphur	0.89
Ash	6.69
	100.00
Ratio of volatile to fixed combustible	1:17.98

IRON ORES.

According to Mr. Richardson, clay iron-stones are of frequent occurrence in the coal rocks of Vancouver and Queen Charlotte Islands. They might, no doubt, in some cases, be profitably worked in conjunction with Clay iron-ores.

the coal-seams, as they occur at but slight distances beneath them, and in some instances are even associated with the coal. The nodules vary in weight from a pound or less up to many tons, and Mr. Richardson says that at the Baynes' Sound Mine a sufficient quantity could probably be obtained for the regular supply of a blast furnace. With regard to other localities the question of quantity is one requiring investigation.

Iron-ore at Baynes' Sound Mine.

Analyses of iron-ores by Mr. Hoffmann.

Mr. Hoffmann has determined the percentage of iron in two samples brought by Mr. Richardson from the Baynes' Sound Mines. One of them gave 36.83, and the other 29.78 per cent. of iron. They both effervesced strongly with hydrochloric acid, leaving a large quantity of insoluble matter, which was perfectly white after ignition.

Rich magnetic iron-ore from Queen Charlotte Sound.

Mr. Hoffmann has also determined the amount of iron in a finely-granular magnetite from an island near the Walker Group, in Schooner Passage, Queen Charlotte Sound. His determination gave 71.575 per cent. of iron, showing the ore to be an exceptionally rich one. The deposit is reported to be one of importance, but has not been visited by Mr. Richardson.

Brine.

Mr. Hoffmann has recently analysed the water of a "salt-spring" from Nanaimo. It had a specific gravity of 10.39, and contained, in 1,000 parts:

Analysis of brine from Nanaimo.

Chloride of sodium	39.117
" potassium	.627
" calcium	10.049
" magnesium	.135
Sulphate of lime	1.803
Carbonate "	.347
" iron	traces.
Silica	.038
Alumina	.038
	52.154

Strontia.

Traces of strontia were also detected by means of the spectroscope.

According to Mr. Richardson, the spring issues from the coal-bearing strata near the Douglas seam, and has a flow of probably two to three gallons a minute. Some years ago the Hudson Bay Company erected a building near the spring, with the intention of manufacturing salt, but the enterprise was soon abandoned.

Crystalline Rocks.

Specimens of crystalline rocks.

The rocks collected by Mr. Richardson on his line of traverse from the mouth of Qualicum River to Alberni, form a most interesting series; but have as yet been only imperfectly studied.

Limestones.—Most of the specimens of limestone are highly crystalline, but vary much in texture as well as in colour. Some of the greenish ones contain chlorite; but others appear to owe their green tints to a soft pale green mineral, which weathers to a yellowish-brown, and is not far removed from pyrophyllite in composition. An analysis of this material, after removal of the carbonates with dilute nitric acid, gave:

Silica	66.54
Alumina	16.02
Protoxide of iron	5.32
Lime	.16
Magnesia	4.60
Loss on ignition	5.36
	98.00

The iron is calculated as protoxide, though its state of oxydation was not specially determined. A few small splinters, apparently homogeneous, were obtained, and found to be readily fusible before the blowpipe. Though approaching pyrophyllite in appearance and composition, it differs from it in fusibility and mode of occurrence. The limestone in which it occurred was fossiliferous, and it was thought that the fossils might be injected with the green mineral. Principal Dawson has, however, examined a section under the microscope, and found that such was not the case. Speaking of the limestone he says: "It contains numerous fragments of crinoids, Bryozoon corals and shells, imbedded in a green paste. There is nothing certainly to prove their geological age, but they may be Upper Palæozoic. The forms do not seem to be injected with the green paste." Fossiliferous limestone.

Epidotic Rock.—The specimens of epidotic rock consist principally of yellowish-green epidote and white quartz (a combination to which the name of epidosite or pistacite rock is generally given,) but contain in addition a considerable quantity of crystalline carbonate of lime. On removing the latter from fragments of the rock with an acid, the quartz, and more rarely the epidote, is left in curious skeleton forms. Epidotic rock, with carbonate of lime.

Diorite.—The specimens of diorite vary much in the relative proportions of their constituents, and, like the limestones, in colour and texture. In some the hornblende is black and the feldspar white, so that the rock has a grey colour; in others both the hornblende and feldspar are green. The green colour, moreover, may, in some cases, be due to the presence of epidote, which is a frequent accessory in hornblendic rocks, and is supposed by some to be a product of the decomposition of hornblende. As regards texture, the diorites present all the following varieties: they are granular, fine-grained, amygdaloidal, porphyritic and slaty. Character of diorites.

APPENDIX IV. TO MR. RICHARDSON'S REPORT.

Copy of Correspondence relating to the Anthracite of the Queen Charlotte Islands.

OTTAWA, 20th March, 1872.

Letter from the Secretary of State for the Provinces.

SIR,—I have the honor to submit for your consideration a copy of a despatch from the Lieut.-Governor of British Columbia, covering a memorial (copy of which is enclosed) from certain of the residents of Victoria, interested in the Anthracite coal seam on Queen Charlotte Islands.

I have the honor to be,
Sir,
Your obedient servant,
(Signed,) JOSEPH HOWE,
Secretary of State for the Provinces.

ALFRED R. C. SELWYN, Esq.,
Director Geological Survey,
Montreal.

GOVERNMENT HOUSE, BRITISH COLUMBIA,
20th February, 1872.

Letter from Governor Trutch, British Columbia.

SIR,—I have the honor to enclose herewith a memorial from certain residents of Victoria interested in the Anthracite coal seam which has been partly opened on Queen Charlotte Island, asking that the Geological Survey, the direction of which is included under your charge, may this year embrace an examination and report upon this measure.

As it is a matter of public importance to this province, that the real value of this coal basin should be determined at as early a period as possible, I should be glad if you would favorably consider this application which has been handed to me for transmission.

I have the honor to be,
Sir,
Your most obedient servant,
(Signed,) JOSEPH N. TRUTCH.

To the Hon. JOSEPH HOWE,
Secretary of State for the Provinces.

VICTORIA, B. C., February 7th, 1872.

ALFRED R. C. SELWYN, Esq.,
Director Geological Survey,

Memorial of persons interested, for a report on the anthracite coal seam of the Queen Charlotte Islands.

SIR,—The undersigned are interested in mining for Anthracite coal in Queen Charlotte Islands.

We believe it unnecessary to bring any facts before you to illustrate the great advantage to the Province (and therefore to the Dominion,) which will result from the development of this branch of its resources.

We therefore confine ourselves to the request, that you will take into consideration the injury that is occasioned by the want of a report by a competent and disinterested surveyor of the extent and economic value of the Anthracite-bearing seams in Queen Charlotte Islands, the only locality on the coast, where these are known to exist, and will instruct the surveying party to be sent out by your department during the coming season to examine Queen Charlotte Islands at the earliest possible opportunity.

We are, Sir,

Your most obedient servants,

(Signed,) JOHN N. ASH,
SETH B. JOBSON,
S. WHITBY,
and seventeen others.

MONTREAL, March 30th, 1872.

Letter from Alfred R. C. Selwyn.

SIR,—I have the honor to acknowledge the receipt of your letter of the 20th inst, submitting for my consideration a dispatch from the Lieut.-Governor of British Columbia, covering a memorial from certain residents in Victoria interested in the Anthracite coal, on one of the Queen Charlotte Islands, setting forth the injury which is occasioned by the want of a report by a competent surveyor of the extent and economic value of the said Anthracite coal-seam, and requesting that instruction may be given to the Geological Survey party to be sent next summer to British Columbia to examine the Queen Charlotte Islands at the earliest opportunity during coming season.

Difficulty of making the examination.

In reply, I beg to state that I have already had under consideration the possibility of taking steps to obtain some definite and reliable information respecting the probable extent and value of these anthracite deposits. There are, however, difficulties in the way, which, unless the local government is prepared to co-operate, would, I fear, render it impossible for the geological party to effect the desired examination at present. So far as I can ascertain, there are no white settlements on either of the Queen Charlotte Islands, and they are inhabited by a warlike and treacherous race of Indians, so that only a strong and well armed party could carry out the requisite exploration with safety.

Distance from Victoria to the Queen Charlotte Islands.

The Islands are nearly five hundred miles from Victoria, and from eighty to one hundred miles from the mainland, and as there are no established means of communication with them, a special vessel would have to be chartered and equipped to convey the party to the islands, and to attend on them while there. Under these circumstances, and also considering that almost nothing has yet been done towards ascertaining the extent and value of much nearer, and probably for present purposes more available, coal basins of Vancouver Island, I think it would not at present be advisable to incur the large outlay which from the circumstances above stated would be required for the exploration of these remote islands.

Means of transport for the Geological Survey party.

If, however, the local government, or the persons immediately interested, are prepared to furnish the requisite means of transport for the party, and likewise to secure them from molestation while conducting the examination, there would then perhaps be no serious objection to granting the request of the memorialists.

I have the honor to be,

Sir,

Your most obedient servant,

ALFRED R. C. SELWYN.

The Hon. JOSEPH HOWE, M.P.,

Secretary of State for the Provinces,

OTTAWA.

REPORT

ON THE

COUNTRY BETWEEN LAKE SUPERIOR AND LAKE WINNIPEG,

BY

MR. ROBERT BELL, C.E., F.G.S.,

ADDRESSED TO

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

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 24th February, 1873.

SIR,—Herewith, I beg to submit my report of the results of the exploration of last summer, which I endeavoured to carry out in accordance with the instructions I had the honor to receive from you.

Since my return to Montreal I have completed the maps, showing the explorations of myself and party during the season. Most of the work is laid down on a scale of one mile to the inch, but some of it on double that scale; and I have reduced all to four miles to an inch.

I have included with the accompanying report, an account of the results of the last exploration of the season, for the reason that, although for a portion of the time you were with the party yourself, our observations were made independently of each other.

I have the honor to be,

Sir,

Your obedient servant,

ROBERT BELL.

REPORT.

The explorations of myself and party during the past season constituted a continuation of those of the three preceding years, the results of which are published in the annual reports of the Geological Survey. They extended from the shores of Lake Superior, westward to the Red River. My party consisted of Messrs. George F. Lount, (who had also assisted me the previous year), Alexander Barnston, B.A., Alfred S. Ball, William Maynard and J. C. Young, with a variable number of Indians.

Region explored.

Party.

Duration of field-work.

We arrived at Thunder Bay, which we made our head-quarters for the season, on the 17th of June and left it on our return home on the 1st of November. I must here acknowledge our indebtedness for various kinds of assistance to Mr. S. J. Dawson, C.E., the chief superintendent of the Red River Route and some of the members of his staff, to Mr. Jarvis, one of the engineers of the Canada Pacific Railway Survey, and to Mr. E. B. Borron, the Inspector of mines. We are also under many obligations to the Hon. Donald A. Smith, M.P., chief commissioner of the Hudson's Bay Company, John McIntyre, Esq., of Fort William, and other officers of the Company for courtesies extended to us on various occasions.

Acknowledgment of aid.

The various explorations of the season.

The early part of the season was devoted to further examinations of the mining district around Thunder Bay, of the Huronian rocks lying to the north and west of it, and of the peninsula lying between Black Bay and Thunder Bay. Some parts of the coast and adjacent islands between the Kaministiquia and Pigeon Rivers were next visited. The rocks were examined along the chain of lakes, streams and portages, which constitute the boundary between the Dominion and the United States, from Lake Superior to Whitewood Lake; also along the Canadian route to Red River from Thunder Bay as far as "Sturgeon Lake" and between Whitewood Lake and "Sturgeon Lake." Explorations of the Black Sturgeon River and of the country lying to the west of it were made in continuation of the work begun in that region in 1869. The last exploration of the season was that made with yourself from Thunder Bay to Red River, by the Dawson Route to Lac des Mille Lacs, and thence by way of (the Great) Sturgeon Lake and Lonely Lake as far as Separation Lake on the English River. At Separation Lake it was considered advisable that two routes should be examined; and while you pursued your journey with one section of the party, I, with the other, crossed the country from Separation Lake southward to Sandy Bay on the Winnipeg above its junction with the English River. From this bay we ascended the Winnipeg River to its source in Lake of the Woods and made such an examination as our time allowed, of the rocks on the islands and shores of this lake, between its outlet and the North-West Angle, from which the Government Road starts to Fort Garry. From the latter point one of my assistants was sent to Fort Frances for letters, and on the trip he collected what geological notes and specimens he could. At the same time I walked to the Red River settlement, and examined the rock-exposures which occur by the way. While waiting for the steamer, which was to take us up the Red River, a few short geological excursions were made in the vicinity of Fort Garry. At the time of our return the steamers from Fort Garry connected with a branch of the Northern Pacific Railway, where the latter crosses the stream which discharges Red Lake into Red River. Here we took the train to Duluth and thence proceeded by steamer to Thunder Bay.

Winnipeg River and Lake of the Woods.

Fort Frances to Red River.

Vicinity of Fort Garry.

Return home.

In regard to the topography of the region examined, we availed ourselves of every source of information, besides adding considerably to what had been previously known. The Crown Lands Department of Ontario have lately been extending their surveys of the lands in the Thunder Bay region, and their maps, as well as all others available, were used for our work in this region, the only addition which we made to the topography, having been such as we were enabled to lay down from pacing. In the valley of the Black Sturgeon River, in addition to our paced lines, we had our own plan of the river, made in 1869, and the trial-lines since run for the proposed Canada Pacific Railway. Along the boundary line I made use of the map of the Commissioners under the treaty of Ghent. For the Red River Route, from Thunder Bay to "Sturgeon Lake," and between Fort Frances and Fort Garry, we had copies of the maps constructed for Mr. Dawson, the Chief Superintendent. Between Whitewood and "Sturgeon" Lakes I made a careful track-survey of the route, the plan of which will, I think, be found sufficiently accurate. Lac des Mille Lacs and the Seine River, which discharges it, are shown on Mr. Dawson's maps. The route of our final exploration of the season left the Seine by way of Brush Creek, a small stream from the north three or four miles below its junction with a branch called Fire-Steel River.

Topography and maps.

Thunder Bay region.

Black Sturgeon Valley,

United States Boundary line.

Red River Route.

Whitewood Lake to Red River Route.

Mille Lacs and Seine River.

Lonely Lake route.

Estimated and independent track surveys of the route were made by both of us while travelling together from the mouth of Brush Creek to Separation Lake; and thence similar surveys were made of the respective routes which we followed, yours being via the Winnipeg River to Lake Winnipeg and mine via Sandy Bay and the Winnipeg River to Rat Portage. The distance, according to my plan, from the mouth of Brush Creek to Rat Portage, by the course followed, is 360 miles.

This kind of survey was all that it was possible for us to make in the time and under the circumstances. As far as we are aware, portions of our route had never before been travelled by a white man. No reliable information could be obtained in regard to it, and it proved to be longer and more difficult than had been represented. We required the assistance of Indians as guides and canoe-men, but as they are not easily persuaded to work at all, and as we could not count on retaining their services for a single day, we suffered some inconvenience and loss of time in making our way through this unknown region; but we managed to take with us, from the start, to the end of the journey, all the provisions and camp outfit required for the party, which averaged fourteen in number. The plans of the route, as already stated, constructed independently of each other, agree so well, that they may be adopted for geological purposes and will form a complete guide and source of information for the use of others travelling over the same ground. My own method was to note every change in our course, no matter how short the distance

Difficulties of the journey.

Map of the route.

might be, and to take bearings constantly to the points, islands, bays, &c., to the right and left of us, recording these and the estimated distances on my sketch of the shores, to be afterwards plotted to a scale. The estimates of distance on these routes were mostly based on the speed of the canoes, which was pretty accurately known, and all the portages were measured by pacing.

Rocks of the route.

The rocks met with on the routes explored belong to the Laurentian, Huronian and Upper Copper-bearing series.

Arrangement of this report.

I purpose in the following pages to give a discription of the geology of each of the sections explored, to be followed by a general sketch of the character and distribution of each of the three great sections into which the rocks of the region are divided. The report will conclude with an account of the progress which has been made in mining in the Lake Superior region and a short sketch of the surface geology of the country between the Height of Land and Red River.

Thunder Bay Mining District.

Traverse N. W. from Amethyst Harbour.

A traverse was made from Amethyst Harbor for a distance of fifteen miles to the north-westward, and from this point south-westward to the mouth of Current River. Leaving Amethyst Harbor, the first two and a half miles of this traverse passed over the coarse reddish syenite or granite which I have referred to on page 328 of the Report of Progress for 1869. This rock is found to be cut in one place by a dyke of dark compact trap. Three other ridges of similar granite were crossed at about five, ten and twelve miles from Amethyst Harbor. But the prevailing rocks along the whole line were greyish, rather fine grained mica-schists with rusty partings, and greyish-green dioritic schists, with some grey silicious and feldspathic schsits. Returning towards the mouth of Current River, similar granitic rocks were crossed in four places, between which, schists like those just described were found, and, in addition, a band or grey dolomitic schists, occurring about seven miles north of the mouth of Current River. The prevailing strike was everywhere south-westward. These rocks are considered to be Huronian. The cherty slates of the upper copper-bearing series were met with near the forks of the Current River, about three miles north of Thunder Bay.

Granite or syenite. Micaceous and dioritic schists prevail. Dolomitic schists. Strike. Huronian age. Cherts.

The results of our explorations around the northern and southern shores of Thunder Bay; in the neighborhood of Thunder Cape, and in the township of McTavish, consisted of supplementary details in reference to the rocks described in my report for 1869, and which can only be shewn upon the maps, besides notes on the mines and mineral veins of the region.

Section of Huronian rocks on Kaministiquia River.

The banks of the Kaministiquia River between the junction of the Mattawa and the Grand or Kakabeka Falls, present an extensive section of the Huronian rocks. In addition to what is stated in reference to them in my report for 1869, Geological Survey Reports of Progress 1866-69, pp. 329-331, the following particulars, from our observations of last year, may be mentioned. At the second portage below the mouth of the Mattawa, which occurs at about six miles from that point, the rock consists of an olive-grey and light greenish-yellow fine-grained, nacreous mica schist, running S. 60° W. At the head of Knife Portage, which is met at about seven miles below the Mattawa, the rock is a dark grey compact quartzite, holding clear grains of the same mineral. Portions of the rock are micaceous. Some of the bands crossed on this portage have rusty surfaces, owing to the action of the weather upon the numerous small grains of iron pyrites which they contain. The dip is a little north of west at an angle of 70°. At the I-is-kapi-sing Portage, about thirty chains below Knife Portage, a fine-grained green mica schist is exposed in a cliff running some distance along the east side of the river. The cleavage, which runs diagonally across the cliff, strikes S. 55° W., the dip being north-westward at an angle of 60°. The schist contains elongated straggling white quartz patches and breaks up into large ligniform splinters. At the head of the Island Portage, about a quarter of a mile below the last, the rock is fine grained ribboned felsite schist, of a dark grey color with purplish and greenish layers. It dips N. 45° W. <70° and is underlaid, to the south, by greenish dioritic schist. At a portage about a mile further down, or about four miles above the Grand Falls, the granitic gneiss, referred to at page 329 of my report for 1869, is exposed for a distance of fifteen or twenty chains along the river. Between this point and Lost Portage, about three miles further down, the river runs about W. S. W., or with the stratification or cleavage of the green schist, which dips northward at an angle of 70°. Lost Portage is the first above the Grand Falls, or the second in ascending the river. It passes over a fine grained quartz and feldspar rock, which is usually light grey, but sometimes pinkish in color. Although its stratification is not distinct, it holds elongated schistose patches of a darker color than the rest, and, indeed, large portions of the mass have a schistone structure. The stratification of the hornblende schist, which occurs at the head of this portage is very regular and dips a little north of west at an angle of 60°. It is cut by veins and patches of rock of precisely the same character as that of the great mass lying to the south of it, which has just been described.

Knife Portage. I-is-kapi-sing Portage. Island Portage. Granitic gneiss. Lost Portage. Quartz and feldspar rock. Hornblende schist.

About a mile below the Grand Falls, the smoke-colored cherty slates of the Upper Copper-bearing series were observed on the west side of the river, to dip northward, or up stream at a very high angle, and a short distance further on, southward at decreasing angles, and finally to become nearly horizontal and they are then overlaid by the thinner black silicious shales.

Grand Falls. Anticlinal in cherty slates.

Three new townships.

Prevalence of slaty rocks capped by trap

Dyke of crystaline coarse diorite.

The surveys which have been made during the past year of the new townships, called Blake, Crooks and Pardee, lying between the Kaministiquia and Pigeon Rivers, have been of much service in giving us the natural features of that region. It appears that the greater part of the area is occupied by the slaty rocks of the lower portion of the Upper Copper-bearing series, and that the trap overflow crowns only the tops of the higher hills. Mr. Hugh Wilson, P. L. S., who made these surveys for the Crown Lands Department of Ontario, informs me that a band or dyke of coarsely crystalline diorite or syenite about twenty chains in width, running south-eastward or in the direction of Victoria Island, is seen in section 9, Concession IX township of Blake, and cuts the slate range lying to the north-westward in section 11, concession VII.

ruptive dykes.

Silver Islet dyke.

Although erruptive trap dykes are so numerous along the shore and among the islands in front of these townships, Mr. Wilson observed very few in the interior. This would correspond with our own observations to the north and north-eastward. The Silver Islet dyke, which is peculiar in its character and composition,and averages about eight chains in width, appears to run continuously through McKellar's, Thompson's, Spar, Jarvis's and Victoria Islands, to McKellar's Point. From this locality, it has been traced by reliable explorers for some miles inland, curving gradually to the west and finally north-westward.

International Boundary from Lake Superior to Whitewood Lake.

Grand Portage.

Soil.

Trap bluffs.

Dyke at Partridge Portage.

Mountain Lake.

Height of Land.

Gun-flint Lake.

Slate, dolomite and breccia.

Grand Portage, by means of which the rapids and falls in the lower part of Pigeon River are avoided, is about ten miles in length and lies wholly in American territory. No rock *in situ* was observed on the trail itself, which passes through a hilly country overspread with gravelly earth and brown clay with boulders; but the prevailing trap of the country rises in bluffs in a few places at no great distance from it. At Partridge Portage, where there is a beautiful fall on the Pigeon River, a large trap dyke cuts through green arenaceous slate of the Upper Copper-bearing series, disturbing it to some extent. On the upper side of the fall the slates dip south at an angle of about twenty degrees. On the portage at the east end of Mountain Lake, rusty silicious slates with thin layers of impure hematite are exposed, dipping south at an angle of from ten to fifteen degrees, and capped to the southward by the common dark grey trap of the country. The water of the next lake eastward of Rose Lake flows both ways, when high, but only to the Arrow River when low, so that the height of land may be considered as intersecting the portage which leads from it to Rose Lake. The hills along the south side of Gun-flint Lake consist of trap, but on the north side, near the western extremity, a silicious slate occurs, dipping N. $< 25°$. It is interstratified with beds of a bright yellow-weathering grey dolomite and others of a breccia, which is made up of fragments of chert and slate, lying at all angles to each other and resembling very closely the brecciated beds of the same formation which occur near the head of Thunder Bay. A short distance further west on the same shore, at the narrows where the canoe-route turns north-westward, a light pinkish-grey granite begins. It consists of feldspar and quartz, with a little mica, and is divided by natural joints into fine rectangular blocks which would be suitable for building. These rocks rise into a series of hills called the "Giant's Range," which runs for many miles in a N. E. and S. W. course. The same kind of granite continues to be largely exposed all along the route to near the western extremity of Seiganagah Lake where it becomes replaced by Huronian schists. At a point about a mile east of the place where the boundary line leaves Seiganagah Lake, a rusty brown altered sandstone is exposed, containing small white quartz pebbles, about the size of peas, very thickly disseminated in some of the beds, which vary from two to eight inches in thickness and strike N. 30° W. with an inclination to the south-westward of about 70°. At the small channel, by which we leave the western extremity of Seiganagah Lake and enter Poplar Lake, the rock consists of altered yellowish-brown sandstone with beds of soft green argillite, which, under the influence of the weather, become red, to a depth of half an inch. The strike is about N. N. W. At Poplar Portage which leads from Poplar to Otter Lake, and on the shores of Poplar Lake a short distance before coming to the portage, the rock is a massive dioritic schist, some portions being dark and others light greyish-green in color. It is of a conglomerate character in some parts, and is associated with compact brittle cherty felsitic slate of a drab grey color, and having a conchoidal fracture. Poplar Lake is the small sheet of water called "Swamp Lake" on the Boundary Commissioners' map. The next lake to the westward marked "Cypress Lake" on the map, is known in the country as Otter Lake. It is about five miles in length, and along its shores are exposed a variety of dioritic, argillaceous and silicious schists, running nearly north and south and dipping generally eastward at a moderate inclination, but in some places westward, at high angles. Little Knife Portage leads from the west end of Otter Lake to Knife Lake. It derives its name from the sharp edges of a dark colored splintery chert-rock, which here forms a considerable band dipping westward at an angle of 70° to 80° and rising into a cliff on the east side of the portage-trail. This rock resembles the dark cherty slates near the base of the Upper copper-bearing series, except that it does not separate like them, along the lines of stratification. At the Little Knife Portage the chert band is overlaid or followed to the westward, by light greenish-grey quartziferous dioritic schist, with bands of dark grey compact felsitic quartzite and altered sandstone. At short distances west of the portage

Granite begins.

Giant's Range.

Seiganagah Lake.

Huronian schists.

Altered sandstone and conglomerate.

Dioritic and cherty felsitic slates.

Poplar or "Swamp" Lake.

Otter or "Cypress" Lake.

Various schists.

Little Knife Portage.

Chert-rock.

Schists.

these rocks strike S. 15° to 30° W. and dip to the westward at an angle of about 80°. Knife Lake is about ten miles long. On the north shore at about a mile and a half west of Little Knife Portage, the rock is a light grey granular quartzite or altered sandstone, with small specks of iron pyrites thickly disseminated through it. At the Narrows of Knife Lake, three miles from the east end, a slightly calcareous dark green dioritic schist is associated with a light olive colored cherty or chalcedonic rock which is translucent on the edges. Two miles west of the Narrows or about the middle of the lake a very dark or nearly black chert-rock occurs with dioritic schist on either side. Between this point and the west end of the lake, the rock along the north shore consists of dark hard argillaceous slates with cubic crystals of iron pyrites. The strike is here nearly due west. At the Big Knife Portage at the west end of Knife Lake, argillaceous cherty, dioritic and grey finely granular silicious slates are met with. At the S. E. end of the portage the strike is S. 80° W. and at the N. W. end, S. 75° W. Near the north end of the portage, a dyke of dark crystalline trap, ten feet wide, cuts the slates and runs S. 50° W. Similar slates continue with a south-westward strike for the next two miles, when we arrive at Carp or Sucker Portage at the east end of Birch Lake. Here we meet with a dark greyish fine-grained glossy clay slate, approaching the character of roofing slate. It holds small lighter grey calcareous patches and strikes S. 55° W., the bedding or cleavage being vertical. My examination of Whitewood Lake only extended to the long point on the Canadian side, between six and seven miles from the eastern extremity. The only rocks observed around the lake consisted of rather fine grained, bright, light grey and reddish-grey syenite. It consists of crystalline white or red feldspar and black hornblende with more or less quartz in some parts.

Knife Lake.

Big Knife Portage.

Carp Portage.

Whitewood Lake.

Syenite.

Name of the Lake.

Basswood trees were not seen around this lake, nor indeed anywhere in this part of the country; and the lake is said to derive its name, Lac de Bois Blanc, or Whitewood Lake, from the whitewood or balm of Gilead, a kind of poplar, so that the name "Basswood Lake," which is sometimes given to it, would appear to be incorrect.

Eastern section of the Red River Route.

Kaministiquia River to Shebandowan Lake.

In the Report of Progress for 1869, pp. 321 to 331, I have described the geology of the country traversed by the Red River road from Thunder Bay to the crossing of the Kaministiquia River. From the latter point to the outlet or eastern extremity of Shebandowan Lake, greenish-grey, micaceous and dioritic schists are exposed at intervals all along the road. The general strike is west, varying to about ten degrees on either side of that course. Where the road crosses the Mattawa River, about five miles from its junction with the Kaministiquia, thin bands of fine-grained greenish-yellow nacreous mica schist occur in the greenish-grey dioritic schists, which here strike S. 80° W. About half way from this point to Shebandowan Lake the strike in the same kind of rock has changed to N. 80° W. Around the outlet of Shebandowan Lake, the rocks consist of soft glossy greenish argillaceous mica schist and greyish-green soft dioritic schist, all running S. 85° W., the cleavage or bedding being vertical. These schists continue along the shores of the lake for about three miles west of the outlet, beyond which, the shores for seven miles consist of a light colored syenite, composed of white, pink and green feldspar and green hornblend with grains of quartz in some parts. These rocks appear to form part of the Giant's Range, which presents a breadth of thirteen or fourteen miles of granite rocks between Gun-flint Lake and the northern part of Seiganagah Lake. From the west side of the syenitic belt on Shebandowan Lake to the Kashabowie Portage, a distance of six miles, the shores are occupied by greenish micaceous and dioritic schists. Some of the latter are of a conglomerate character, and many of the enclosed pebbles are of a large size. Patches of granite occur here and there among these rocks. At the Narrows, about three miles east of Kashabowie Portage, the strike of the schists is S. 65° W., and the dip north-westward at an angle of about 80°. In this neighborhood the vegetation has been burnt off the hills, and the stratification of the schists is rendered conspicuous by broad bands weathering to different shades. At the Kashabowie Portage the rock is a rather light greenish-grey, fine-grained dioritic mica schist with strings of quartz running with the strike of the cleavage or bedding, which is S. 60° W., corresponding with the general course of the north-west shore of Shebandowan Lake. We were given numerous specimens of quarts containing copper pyrites, said to have been taken from veins on the shore of the lake, about a mile and a half westward, and two miles eastward of the portage. After crushing all these together a sample of the average yielded 0.146 oz. of gold and 0.292 oz. of silver to the ton, according to an assay made by Mr. Hoffmann.

Schists at outlet of Shebandowan Lake.

Belt of syenite.

Schists of western part of Shebandowan Lake.

Conspicuous stratification of schists.

Kashabowie Portage.

Copper ore.

Around the shores of Kashabowie Lake, banded gneiss occurs in the central part, and what appeared to be Huronian schists for about two miles from the outlet, while around the northern extremity there is a variety of syenitic rocks, none of which show any stratification. The height of land passes between a pond near the head of Kashabowie Lake and the south-eastern bay of Lac des Mille Lacs. A portage, about a mile in length, over tolerably level ground, leads from one to the other. The rocks on this portage consist of moderately coarse grained greenish-grey mica schists. The strike of the bedding is west, and that of the cleavage west-south-west. At the north end of the portage the vertical edges of the schist show numerous small lumps and strings of white quartz. The latter are sometimes crowded closely together and, curving with the contortions in the

Kashabowie Lake.

Syenite.

Height of land.

Portage.

Mica schists.

No fossils. schists, have occasionally a skeleton-like appearance, which has given rise to reports of the discovery of fossils at this locality. Between the Height-of-Land Portage and Barrel Portage, at the south-western extremity of Mille Lacs, the rocks observed along the southern shore consist of rather soft massive greenish-grey diorite till we come to within about four miles of Barrel Portage, when Laurentian gneiss begins. In some places in this interval the bedding appears to run south-eastward, and in others south-westward, but it is difficult to distinguish the stratification from the joints and cleavage. At a point six or seven miles from the Height-of-Land Portage, the diorite is associated with a greenish and yellowish-grey quartz rock, having smooth-surfaced partings and holding clear grains of quartz. From the point on Mille Lacs above mentioned, (about four miles north-eastward of Barrel Portage) in going south-westward all the way to Sturgeon Lake, the only rocks met with are micaceous grey and red gneiss, sometimes passing into mica schist with veins of granite. In this interval the strike was ascertained in about twenty localities along the route, and found to be S. 80° W. except in a few instances, where it varied from S. 50° W. to S. 70° W., and has thus the same general course as the chain of lakes constituting the route. The dip is almost as frequently to the southward as to the northward, and the angles are generally high.

Diorites.

Gneiss begins.

Strike corresponds with chain of lakes.

From Whitewood Lake to Sturgeon Lake, on the Red River Route.

This route leaves the north-eastern extremity of the eastern part of of Whitewood Lake and joins the Red River route at a narrow place about three miles south of the head of Sturgeon Lake. Tne first two-thirds of our course lay nearly north to Pembina Lake, and the remaining third north-westward to Sturgeon Lake. The distance, according to my plan, is twenty-seven miles in a straight line, or forty by the canoe route.

Course of route.

Distances.

North Portage. Leaving Whitewood Lake, by what is called the North Portage, half a mile in length, we arrived at a lake three miles long, running in a north-easterly direction. A red granitic rock was exposed all around the shores of this lake. From the head of this lake, Burnt Portage runs east fifty chains to a pond, from which another portage twenty-eight chains in length, running northward, brought us to the south end of Lake Agnes. In the neighborhood of these two portages the rock assumes a gnessoid aspect, holding a few lenticular bands of grey micaceous and hornblendic schists, and others of fine-grained red quartzite, running S. 25° to 35° W., in a matrix of a reddish granitic character. Lake Agnes has a very straight northern course of thirteen miles, and varies from a few chains to a mile and a-half in breadth. A river from Seiganagah Lake enters the east side about a mile from the southern extremity, falling perpendicularly

Burnt Portage.

Lake Agnes.

River from Seiganagah Lake.

a height of about forty feet, almost directly into the lake. The outlet, which is said to flow to Whitewood Lake, leaves the western side about half way down the lake. The shores are high and bold, the rocks in some parts rounding abruptly down to the water's edge. The red gneiss which prevails all around the lake, has an average run of about S. 10° W., and dips westward at angles varying from 45° to 90°. On the portage from the northern extremity of Lake Agnes, a grey variety of gneiss dips S. 50° E. < 75°. Along the western shore of Pembina Lake a similar gneiss runs a little west of north. This lake receives the Ka-wa-wi-ai-ga-mog River, which flows south-westward from the height of land near the west end of Shebandowan Lake. At a sudden bend, or elbow, to the southward, in the outlet of Pembina Lake, we came upon a band, fifty chains in width, of fine-grained grey mica schist with garnets, running S. 35° W. and dipping north-westward at an angle of 70°. A vein of quartz occurs here, varying from one to two feet in thickness, and running more nearly south than the strike. It holds patches of yellowish bitter-spar on the west wall. A specimen from one of these, assayed by Mr. Hoffmann, yielded no trace of either gold or silver. From this point to "Sturgeon" Lake, massive gneiss prevails. It is sometimes reddish, bnt generally grey in color. At the Snake Falls, about half way between Pembina and Sturgeon Lakes, the stratification is distinctly seen, and runs S. 40° W., while on the western shore of the upper part of Sturgeon Lake, it runs nearly east and west.

Pembina Lake.

Band of mica schist.

Vein.

Gneiss to Sturgeon Lake.

Valley of the Black Sturgeon River.

The additional investigations in the valley of the Black Sturgeon River were performed by Messrs. Barnston and Lount, and consisted of a further examination of rock exposures near the main river as far up as Nonwatan Lake, a traverse from the neighborhood of that lake southward to Mud Lake, and thence to Lake Dufferin, a distance of eleven miles, and another traverse from the last lake south-eastward to Cranberry Bay, at the head of Black Bay, a distance of about thirty miles. These explorations resulted in confirming the correctness of the general geological description of the valley of the Black Sturgeon River contained in my report, 1869, (Geological Survey Reports of Progress 1866-69, pages 334-336,) and in extending our knowledge of that region. The Upper Copper-bearing rocks appear to extend to a distance of about twenty miles west of the Black Sturgeon River, all along the section below Black Sturgeon Lake. They consist of a great variety of reddish and greyish sandstones and marls, more or less indurated, and generally calcareous, together with dark silicious argillaceous and feldspathic slates, the whole lying nearly horizontally. They are cut by dykes of compact crystalline dark greenish-grey trap, and in the higher hills are capped by the great horizontal over-

Traverses made.

Results.

Character of rocks.

flow of trap. The latter is generally more friable and coarsely crystalline than the trap of the dykes, and has usually a yellowish shade, especially near the surface, and also a lighter color. As stated in my report for 1869, (Reports of Progress 1866-69, page 333,) there is a considerable tract of comparatively level land lying to the westward of Black Sturgeon Lake and the Nonwatan Lakes; but south of this region the country is much broken by bluffs of the sandstones, marls and overlying traps. The only Laurentian gneiss met with, consisted of a small ridge protruding through the red indurated marl at a point about fifteen miles north of Cranberry Bay.

Aspect of the country.

Route from Lac des Mille Lacs, via Lonely Lake, to Lake of the Woods.

As already stated, the southern shores of Lac des Mille Lacs are composed of Huronian slates. Proceeding through the lake from the Height-of-Land Portage, towards the Seine River, which constitutes the outlet, Laurentian gneiss was first met with a short distance north of the entrance to the narrow south-western arm of the lake, which constitutes a part of the Red River route. It was the only rock observed around the north-western shores of the lake, and down the Seine as far as we followed it. The gneiss in this region is of a massive character, with the bedding usually much contorted. A grey color prevails, but there are also some reddish bands. The average strike is about S. 70° W. In the neighborhood of the outlet of Mille Lacs the dip is mostly northward, at angles varying from 45° to 90°; but at Pike Lake on the Seine, ten miles below Mille Lacs, where the bedding is very distinct and less contorted than above, the dip is northward but at very high angles. At one place on the hills on the north side of Pike Lake, a beautifully banded, micaceous but massive variety of gneiss has a local strike, bearing N. 75° W., the bedding being vertical.

Gneiss Regions.

Pike Lake.

Brush Creek.

We left the Seine by way of a small brook from the north, named Brush Creek, which enters the river between three and four miles below the branch called the Fire-Steel River, which also enters on the north side.

First Lake.

Huronian schists begin.

The first small lake on Brush Creek occurs at about a mile and a-half in a straight line north-west of the Seine. The Huronian schists appear to begin near this lake. They are well exposed in the burnt hills about a mile to the north of it. Here they consist of fine-grained greenish argillaceous, micaceous and dioritic bands, in some parts quite calcareous, and holding numerous strings of calc-spar. In one place there is a band of yellowish-grey or drab earthy dolomite thirty feet thick. The weathered surface of this band becomes converted into a brownish-yellow ochre, indicating a large proportion of iron in the rock. The strata are here vertical, and run N. 60° W. They are cut by a vein of quartz six feet in width, which crosses Brush Creek about a mile and a-half above the first

Dolomite.

Quartz vein.

lake and runs N. 80° W. It contains crystals of calcareous spar and ochrey patches near the weathered surface. Seven specimens broken from different parts of the vein on being reduced together so as to represent an average, were assayed by Mr. Hoffmann, and found to yield neither gold nor silver. A band of yellowish-grey dolomite, which in one place is ten feet wide, accompanies this vein on the south side. Numerous smaller quartz veins, one of them two and a-half feet thick, were found in the hills near Brush Creek for a distance of five miles north of the one just described. At the third portage on Brush Creek which occurs at about two miles above First Lake, the dioritic schist is of a compact dark greyish-green character, holding numerous grains of common and magnetic iron pyrites, and looks promising as a matrix for copper-bearing veins. About three miles further on, or five miles north of First Lake, the greyish-green schists are very dolomitic, and among them a band of pure white quartziferous dolomite was observed. A fine-grained dark grey quartzite, with a westerly strike, was found in a hill about a mile west of Brush Creek, and seven miles north of First Lake. Huronian schists of the various kinds first described as occurring on this brook, prevailed as far as Pyramid Lake at its head, where they became replaced by fine-grained reddish granite; so that the breadth of this Huronian band would appear to be about eight miles at right angles to its strike.

Assay.

Other quartz veins.

Dioritic schists.

Dolomitic schists.

Quartzite.

Breadth of Huronian band.

Squirrel Portage, half a mile long, leads from the north-west bay of Pyramid Lake across the height of land separating the waters of the Seine from those flowing towards the English River, to a pond at the head of Carr's River, so called after Mr. Carr, C.E., whose section of the Canada Pacific Railway exploration line crosses this stream. The general course of Carr's River is about due north for upwards of thirty miles, in a straight line to Mattawa Lake, into which it discharges. The rocks of Squirrel Portage and of the country on our course for the next eight miles, consist of granite, varying from a light red color and fine texture to a light grey color and coarse texture. There is then an interval of about two miles of massive reddish gneiss with a north-westward strike. Continuing northward, the gneiss is followed by two or three miles of fine-grained green mica schist and slaty felsites with intercalated veins of reddish granite, running, first to the north-westward, and further on to the north-eastward and all dipping to the eastern side. These exposures appear to be near the western extremity of a bend in the Brush Creek band of Huronian schists, which probably corresponds with the bend in the Minnietakie band, which occurs at the Lake of the Woods, and will be described further on. The junction of these schists with the Laurentian gneiss to the north, appears to take place about the point where the Canada Pacific Railway trial-line crosses Carr's River, which is at about

A water-shed.

Carr's River.

Granite.

Gneiss.

Mica schist, felsite and granite.

Probable fold in strata.

Laurentian gneiss begins.

twenty-one miles north of the Seine. About four miles further north this river enters Selwyn's Lake. Massive grey micaceous gneiss, with very distinct bedding, running about S. 45° W. with a vertical dip, is well exposed around the shores of this lake. Similar gneiss, but with a general dip to the east-ward, is seen all along the lake-like expansion of Carr's River as far as Mattawa Lake. The canoe-route, which we followed, leaves the north-eastern part of Mattawa Lake by a short portage over a rocky ridge, and passing through Bell's Lake, reaches Sturgeon Lake, eight miles from its south-western extremity. The river which discharges Mattawa Lake flows from its western side, and appears to be identical with the stream I have called Drummond's River, and which joins the Sturgeon Lake River at Kitchi-sagi or Big-inlet Lake. I may here remark that Sturgeon Lake River is not the outlet of Sturgeon Lake, but another river, a part of which is followed by the canoe-route from Lonely Lake to Sturgeon Lake. The outlet of Sturgeon Lake is near its northern extremity. Around Mattawa and Bell's Lakes the strike of the gneiss, which is usually grey and micaceous, varies from S.W. to W.S.W.

Selwyn's Lake.

Gneiss dipping east.

Outlet of Mattawa Lake.

Sturgeon Lake River.

The Huronian schists again appear at the place where we came upon Sturgeon Lake, at eight miles from its head or south-western extremity. Here they consist of fine-grained shining grey mica schist, running S. 70° W., and dipping northward at an angle of 70°. They contain numerous irregular quartz veins holding ochrey patches. A specimen broken from one of these veins, about a foot thick, is found by Mr. Hoffmann to contain neither gold nor silver.

Huronian schists begin.

Quartz veins.

Assay.

The islands which we examined in the centre of the lake on our way to the south-western extremity consist of dark green, soft dioritic schist, running in the same south-westward direction as the lake itself. The portage at the head of the lake is forty-five chains long and runs west to Young's Lake. At this lake the rock has the same strike and consists of green dioritic schist, studded with small crystals of calc-spar and feldspar, which give it a finely porphyritic appearance. It also holds specks of copper pyrites.

Sturgeon Lake.

From the head of Sturgeon Lake our general course was due west by compass for about thirty-two miles in a straight line, at the end of which distance, we came to Minnietakie Lake. In the first half of this interval we passed through seven lakes, the waters of which flow westward, the one into the other, and all finally discharge by the Sturgeon Lake River into Minnietakie Lake. The exploratory line of the Canada Pacific Railway touches the south-west extremity of Sturgeon Lake and going westward passes between the third and fourth of the small lakes just referred to and crosses the Sturgeon Lake River at the outlet of the seventh of the chain. This lake receives the river which flows from Night Owl Lake, lying to the south-westward, and is said to be the

Sturgeon Lake to Minnietakie Lake.

Seven Lakes.

Canada Pacific Railway line.

beginning of the canoe-route to Fort Frances. Between this seventh lake and Minnietakie Lake the Sturgeon Lake River receives a considerable tributary from the southward, which we named Jarvis River, after the chief engineer of division L of the Canada Pacific Railway Survey. Huronian rocks were observed around all the seven lakes except the fifth or most southerly of the group called Kitchi-sagi or Big-inlet Lake, on whose shores various kinds of Laurentian gneiss occur. The Huronian rocks in the neighborhood of these lakes consist of green dioritic and glistening greenish mica schist. Light grey granite occurs on the fourth lake near the trial-line for the Canada Pacific Railway, and a finer-grained red variety of the same rock where the line crosses the outlet of the seventh. At the rapids, about two miles below the last named point, the rock consists of a dark green variety of diorite, thickly studded with crystals of black hornblende about the size of peas. In some parts it also holds scales of black mica. It appears to be bedded and to have an eastward dip. The Sturgeon Lake River is very rapid for about a mile before falling into the southern extremity of Minnietakie Lake. The rapids terminate in a perpendicular pitch of about seven feet, called the Minnietakie Fall, just at the head of the lake. Here the rocks consist of green dioritic and glossy greyish-green micaceous, argillaceous and chloritic schists. Some of the bands contain much calcareous spar, which, by dissolving away under the influence of the weather, gives rise to rough and pitted surfaces. The strike is S. 85°W., with a southward dip at an angle of 60°. The greatest length of Minnietakie Lake, according to Mr. Jarvis, is about twenty-five miles in a western course from the Minnietakie Fall. From this fall to the outlet, a distance of ten miles in a straight line, our course lay through an archipelago of islands which fills up the north-eastern part of the lake. In this distance the rocks consist of greenish Huronian schists mostly of a dioritic character. The strike, which was ascertained in numerous places, varies from S. 50° W. to S. 75° W., except at one spot, where it was N. 50° W. A narrow ridge of rock at the north-western extremity of Minnietakie Lake, separates it from Abram's Lake, into which it discharges through Abram's Chute, with a fall of three or four feet. The dioritic schists are here of a conglomerate character, being mottled by small hard reddish patches, which appear to be pebbles. They also contain quartz, epidote and feldspar, and specks of copper and iron pyrites and of specular iron. Abram's Lake has a breadth, on our course (which continued to be north-westward), of upwards of four miles. In this interval the average strike of the green schists is about S. 20° W. At the narrows which separate Abram's Lake from Pelican Lake, lying to the north-west of it, the rocks consist of green epidotic and dioritic schists, with large patches of fine-grained grey granite, The schists are cut by numerous quartz veins, from six inches to a foot

Route to Fort Frances.

Jarvis River.

Huronian rocks.

Granite.

Hornblendic porphyry.

Minnietakie Fall.

Various schists.

Minnietakie Lake.

Strike of dioritic schists.

Abram's Chute.

Metalliferous diorite.

Quartz veins.

thick, running south-south-west and holding specks of iron and copper pyrites. A sample, representing the average composition of two specimens from one of these veins, has been assayed by Mr. Hoffmann, and found to yield no trace of the precious metals.

Assay.

Pelican Lake and Falls.

Pelican Lake is four miles broad in a north-westerly direction. A strong rapid occurs at the outlet, called Pelican Falls. The rock at the head of the rapid consists of crystalline dark greenish-grey hornblende schist, which is cut by rectangular joints and splits into remarkably even slabs along the cleavage planes, which are vertical and strike S. 85° W. Laurentian gneiss, somewhat contorted, but having a general south-westward strike, begins at the foot of the rapids, only seventeen chains further on. Around the northern part of Pelican Lake, the rocks consist of reddish micaceous gneiss and mica schist, standing on edge and striking very regularly S. 80° W. These rocks form the commencement of the great Laurentian area of the Lonely Lake region.

Hornblende schist.

Gneiss begins.

Huronian band 30 miles wide.

The Huronian schists which have been described as continuing from the southern shore of Sturgeon Lake to the outlet of Pelican Lake, appear to have a breadth across the strike of about thirty miles. Although the course of the strike is somewhat sinuous, its general direction is about W.S.W., which would bring it to Lake of the Woods, where the Huronian rocks are again largely developed. They have also been noted at various places in the interval by Mr. Jarvis, Mr. W. W. Russell and others, and there appears to be no doubt that the Minnietakie and Lake of the Woods bands are identical.

Strike towards Lake of the Woods.

Canoe route to Lonely Lake.

Two miles below Pelican Falls, the Sturgeon Lake River turns off to the north-eastward, or at right angles, but the canoe-route continues north-westward. After passing over three lakes and two portages, we arrived by a stream called Canoe River at a point on the south shore of Lonely Lake, about thirty-two miles north-west of Minnietakie Falls. From the Pelican Falls to Lonely Lake the only rocks seen were massive Laurentian gneiss, all striking south-westward.

Gneiss.

Hudson's Bay Co's Post on Lonely Lake.

The Hudson's Bay Company's post on Lonely Lake is situated on the north side of the White Pine Narrows, which are about three miles west of the mouth of the Canoe River. A long point, running up from the south side, here contracts the lake to about half-a-mile. The extremity of this point is rendered conspicuous by a clump of white pines, and the name O-bi-ji-ko-ka, or Lake of the White Pine Narrows, which the Indians gave to Lonely Lake, has reference to this locality. This large lake is also called by different persons, or on different maps, by the various names of Lac Seul, Sal and Sel, Lake Saul and Salt Lake; but I prefer to adhere to the name Lonely Lake, by which it was also known in my report of 1869.

White Pine Narrows.

Various other names for Lonely Lake.

Course of Lake.

West of the Hudson's Bay Company's post, the general direction of

Lonely Lake is a little north of west. Its width varies from a few chains to eight or ten miles, but we passed some bays which were so deep that we could not see to their extremities. From the mouth of Canoe River to the outlet of this lake, the distance, according to my plan, is about forty-eight miles, and the Indians say that the eastern section of the lake, which runs a little north of east, is nearly as long, so that the whole length of Lonely Lake will not be far short of one hundred miles.

Deep bays.

Length of Lonely Lake.

The rocks observed around the shores of the western section of this lake consist entirely of Laurentian gneiss, all having a west-south-westerly strike. We noted many varieties among these rocks, but none of them are remarkable or require special description.

Gneiss around Lonely Lake.

From the outlet of Lonely Lake to Separation Lake a distance of about fifty-five miles in a straight line, according to my plan, the English River consists of a chain of twelve lakes connected by chutes, narrows or short stretches of river. At ten miles from Lonely Lake, it receives the Mattawa River on its north side, and at about forty miles, the river which discharges Wabigoon and Eagle lakes, lying to the south.

English River.

Branches.

The rock in this district consists of Laurentian gneiss, having the same west south-westward run as around Lonely Lake. About the outlet the gneiss is very micaceous, and is cut by numerous granite veins, mostly running with the strike, which is here nearly due west. The granite, as in many other places, may here indicate the proximity of a band of Huronian schists. The Indians at the mouth of the Mattawa River showed us specimens of a soft, grey, uncrystalline slate, which they carve into pipes, and informed us that they obtained it from the solid rock at O-nimini Sagaigan or Red Paint Lake, which, from their description, would appear to lie about five miles north of the junction of the two rivers. These facts appear to show the existence of another band of Huronian rocks, which, judging from the strike, would be identical with the one observed below the junction of the English with the Winnipeg River.

Laurentian gneiss.

Micaceous gneiss and granite veins.

Pipe-stone.

Probable Huronian band.

From the extremity of the southern arm of Separation Lake to Sandy Bay on the Winnipeg River the distance in a southerly course, is only five miles. A canoe-route over five small lakes and five portages, leads from one to the other. The general upward course of the Winnipeg River from the portage into Sandy Bay to Rat Portage is about due south, and the distance, according to my map, about twenty-four miles. Rat Portage is at the head of the Winnipeg River or outlet of Lake of the Woods, and is thirteen chains in length. The only other portage which we passed in ascending this river is the one at the Dalles, eight miles below Rat Portage, and which is also thirteen chains in length.

Canoe-route from Separation Lake to Sandy Bay.

Winnipeg River.

Rat Portage.

The Dalles.

The Laurentian gneiss, which is the only rock along the section of the Winnipeg River which I examined, strikes generally about south-west.

Gneiss.

Conformable junction with Huronian rocks.

The junction of the Laurentian rocks on the north with the Huronian schists of the Lake of the Woods on the south, takes place on Rat Portage. The two rocks are seen almost in contact with each other, and have the same strike and dip.

Lake of the Woods.

Gneiss begins.

Dr. Bigsby's map.

Course of boundary between Laurentian and Huronian rocks.

In going south-westward from Rat Portage to the entrance to the North West Angle of the Lake of the Woods, a distance of about forty miles, the rocks observed on all the islands consist of Huronian schists, with associated granites. Laurentian gneiss begins just where we entered the creek leading to the government station on the route to Red River. Dr. Bigsby, in his map of Lake of the Woods, published in the journal of the Geological Society, Vol. VIII, p. 400, shows gneiss all along the main north-western shore of the lake. At Rat Portage the strike of the Huronian schist, as well as of the Laurentian gneiss to the north of it, is S. 75° W., but it curves gradually round to S. 45° W. before reaching the North-West Angle. An island, lying about twenty miles from the North-West Angle, on the travelled route to the mouth of Rainy River, was found by Mr. Maynard, one of my assistants during the past season, and also by Mr. W. W. Russell, who assisted me in 1869, to be composed half of Laurentian gneiss and half of Huronian schists. Dr. Bigsby's map, above referred to, and other sources of information show the Huronian schists to run easterly along the northern shore of the southern part of Lake of the Woods. At this part of the lake, according to Dr. Bigsby, they turn round to the southward, leaving Laurentian gneiss between them and the eastern shore of the lake all the way to the mouth of the Rainy River. Laurentian gneiss is known to exist elsewhere around the southern part of Lake of the Woods, and I found it exposed at intervals along the road to Red River, for about thirty miles westward of the government station at the North-West Angle. Mr. Maynard found a fine-grained dark green mica schist running across the Rainy River at the Long Rapids, and Laurentian gneiss at Fort Frances. All these facts appear to show that the boundary between the Huronian and Laurentian rocks, skirts the north-western shore of Lake of the Woods from Rat Portage to the north-west angle, and then, curving round, strikes eastward to the eastern bay of the lake, and thence southward to Rainy River.

Gneiss on Red River Road.

Rainy River.

Fort Frances.

Geological details on Lake of the Woods.

Slate conglomerate.

On the islands between Rat Portage and the North-West Angle we met with a great variety of chloritic, micaceous, talcoid, hornblendic, dioritic, silicious and dolomitic schists of various shades of green and grey. At the western extremity of a large island, called Manitou-Minis, about fifteen miles south-west of Rat Portage, a reddish-grey talcoid schist, running S. 80° W. dip to S. $<80°$, is followed to the south by green dioritic schist, full of white-weathering pebbles and boulders, the largest of which are about two feet in diameter. The green schists are associated with masses, apparently intrusive, of fine-grained reddish-grey granite, which again are cut by quartz veins. On an island about twenty-five miles south-west of Rat Portage the bedding was observed to be horizontal, while the slaty cleavage cut it at a high angle and ran about south-west. At another place about thirty miles south-west of Rat Portage, where grey calcareous mica schist and dark calcareous hornblende schist occur, the dip is S. 45° E. $<$ 60°, and both varieties are of a conglomerate character, the pebbles or lenticular patches ranging from an inch to a foot in diameter. On the above route we found some bands of a fine compact even-grained light olive-coloured nacreous mica schist, suitable for hones, and we were given a specimen of the same kind of rock from an island which lies a few miles, in a southerly direction from Rat Portage. The green chloritic schist at Rat Portage is cut by small lenticular veins of quartz. A specimen from one of these on being assayed by Mr. Hoffmann was found to contain no gold or silver.

Bedding and cleavage of schists.

Conglomerates.

Compact nacreous mica schist.

Quartz veins.

Assay.

General Descripton of the Geology of the Region North-west of Lake Superior.

Upper Copper-bearing Series. This series attains its greatest development in British territory in the geological basin of Nipigon, which includes the valley of the Black Sturgeon River and the shores of Black and Nipigon Bays on Lake Superior. The outline of the area occupied by these rocks appears to have the form of an arrow-head lying due north and south, the point lying north of the north-western bay of Lake Nipigon, and the opposite extremity at the entrance of Black Bay. Lake Nipigon itself lies in the eastern half of this area. The length will be about 170 miles, and the breadth, in the latitude of the southern part of Lake Nipigon, about 80 miles. The floor of this basin is overspread by the slates, marls and sandstones of the series, lying nearly horizontally on the edges of the Laurentian and Huronian rocks, but they are covered up and concealed in a large part of the area by the great trap overflows, which are thickest towards its central and southern parts and appear to become gradually exhausted towards the north. The source of these great trappean flows is probably marked by the widely spread cracks and fissures which are now filled with dense trappean rock, appearing in the form of dykes that may be regarded as the roots, so to speak, of the overlying sheets of igneous matter: there may also have been vents in the form of craters, and the same fissures and craters may have served as the outlets through which the successive trappean outbursts made their way to the surface. Some of the main vents from which the trap has flowed, are probably to the southward within the space now covered by the waters of Lake Superior, indeed it is probable that the several trappean flows met with in this series had their origin within the area referred to.

Geological basin of Nipigon.

Outline and dimensions.

Horizontal strata.

Source of trap.

The evidence of this lies partly in the fact that these rocks are found on all sides of the lake, but not at any great distance from it, and their arrangement appears to indicate that they have been pressed, as it were, against the older rocks forming the margin of the basin from a point lying towards the centre. On the east side of Lake Superior, Sir W. E. Logan has observed wrinkles on the surface of a bed of trap indicating an easterly flow; and, on the east side of St. Ignace Island, similar wrinkles occur indicating a north-eastward flow, or towards and at right angles to the main shore opposite. (Geology of Canada, pp. 71 and 72.) The structure of a bed of trap which I observed on the Wabinosh route in 1871 appeared to shew that the material composing it had rolled forward in a north-westerly direction, while still in a viscid condition. The greater length of the area occupied by these rocks in the Nipigon basin is nearly at right angles to the strike of the Laurentian and Huronian rocks lying beneath them. If it were found desirable to give a shorter name to the rocks of the upper copper-bearing series of Lake Superior, I would suggest that of Nipigon. These rocks, as shewn on Sir W. E. Logan's Geological map of Canada, form a broad band along the north-west side of Lake Superior, running all the way from Thunder Bay to Duluth, at the western extremity of the lake. Within our own territory their north-western limit runs inland in a general south-western course from the north shore of Thunder Bay to Gun-flint Lake.

Prevalence of greenish schists.

Huronian Series. In the region under consideration, the rocks which are classified as Huronian consist principally of a great variety of crystalline schists, in which a greenish color prevails. In addition to these there are greyish quartzites and schists, sometimes with iron ore, massive green diorites which are sometimes porphyritic, and imperfect gneisses, which are usually finer-grained and less crystalline and hard than those of the Laurentian series. The areas of granite and syenite of this region, which vary in extent from small isolated patches to ranges, many miles in length, and differ considerably in composition, appear to be always more or less intimately connected with the Huronian bands.

Other rocks in Huronian series.

Granite areas.

Conformity of Laurentian and Huronian rocks.

As mentioned in the present and in my previous reports on this region, the Huronian rocks appear to succeed the Laurentian conformably, the distinction between the two being chiefly of a lithological character. As nearly as the distribution of the two series can be mapped by means of our present data, it would appear that the various bands of each set of rocks in contact with each other, correspond in their general run, and partake of the same curves and flexures. The general strike of both series of rocks throughout the whole region is W.S.W.

General strike.

Six bands of Huronian rocks.

In going north-westward from Thunder Bay to Lake Winnipeg, six apparently distinct belts of Huronian rocks are crossed. They appear to occupy long V-shaped basins in the folds of the Laurentian strata, and their aggregate breadth is about half that of the Laurentian bands between them. The first, or Thunder Bay band, has a breadth of about fifteen miles behind Thunder Bay, but appears to spread out to a greater width west of the Kaministiquia River. I have observed Huronian rocks in the northern part of the Battle, or Copper group of Islands, east of St. Ignace Island. These may belong to the Thunder Bay band, while the Huronian schists which cross the Black Sturgeon River about sixteen miles from its mouth, and which are again seen at Lake Maria, on the Nipigon, may constitute a spur from the same band. The Huronian schists of the second, or Upper Lake Shebandowan band, on which the new gold field is situated, and which are so largely developed along the national boundary line between Seiganagah and Whitewood Lakes, are separated from those of the Thunder Bay band by the granite and syenite of the Giant's Range.

Thunder Bay band.

Upper Lake Shebandowan band.

The third, or Mille Lacs band, has a breadth of ten to twelve miles. The narrow belt of schists which has been mentioned as crossing the outlet of Pembina Lake is in the strike of this band and apparently represents it. Huronian schists with gold-bearing veins are said to occur at Cross Lake on the Red River Route. These would belong to a band between that of Mille Lacs and the fourth band which we crossed. A band of schists said to occur on the Seine below the point at which we left it appears to be identical with the latter. The Huronian schists, which are described as occurring around Vermilion Lake, in Minnesota, may belong to the Cross Lake band, or that of Mille Lacs, or partly to both.

Mille Lacs band.

Cross Lake.

Schists reported on the Seine.

Vermilion Lake.

Our fourth, or Brush Creek band began about a mile north of the point at which we left the Seine River, and has a breadth of about eight miles. As already stated, the schists met with on Carr's River to the northward may belong to a fold in this band. The Huronian schists described by Dr. Bigsby as crossing the middle of Rainy Lake (Journal of the Geo. Soc., vol. X., p. 215,) would appear to be connected with this band. The fifth, or Minnietakie band, beginning on the south side of Great Sturgeon Lake and ending at the Pelican Falls, is the broadest one we traversed, having a width of about thirty miles across the strike. At the Lake of the Woods it has a breadth, from north to south, of about forty miles, but this increase in width is due to its folding round upon itself in the manner already described. The sixth or Winnipeg band appears to pass not far to the north of the outlet of Lonely Lake, and was found by you as already stated to cross the Winnipeg a little below its junction with the English River.

Brush Creek band.

Rainy Lake.

Minnietakie band.

The Laurentian series in the country under description presents few points of much interest. It is made up for the most part of common varieties of greyish and reddish crystalline gneiss. They are generally massive and frequently approach a granitic character, but there are also broad micaceous belts and some bands of dark coarse mica schist. They

Varieties of gneiss.

Not rich in useful minerals. No limestones known. General strike. have, as yet, afforded no useful minerals, nor any bands of limestone such as are met with in the Laurentian series in central Canada. Like the Huronian rocks, their general strike throughout the whole region is about W.S.W.

Progress of Mining on Lake Superior.

Since the date of my previous report on this region, there has been much activity in exploring for mines and making trials in places supposed to be valuable, as well as in working some of the mines which were then known to exist. In pursuing our regular geological investigations, it was impossible for us to visit the whole of the localities at which work was being done, but I shall briefly notice some of the more important of them.

Lead Hills Mine. I visited the Lead Hills Mine, situated on mining-lot C., in the township of McTavish, about three miles in a straight line west of the shore of Black Bay, and found the vein, as described by Professor Chapman, (see Geological Survey Reports for 1869, page 359) to hold, in one part of its course, a solid lode of intermixed galena and copper pyrites, at least four feet in width. The vein runs about N. 60° E. and S. 60° W., and cuts the red indurated marl, which is here associated with grey sandstone; but, at about 300 yards north of the part which is being worked, the red granite of the region rises in the form of a low bluff. The granite is here moderately coarse-grained, and consists of white quartz, light red feldspar and scales of black mica, with a little hornblende in small specks. Where it comes in contact with the red marl in this neighborhood, the latter appears to be somewhat altered.

Red marl and granite.

Silver Islet. The workings under Silver Islet had attained a depth of about 150 feet below the level of Lake Superior, the vein continuing productive and giving the miners comparatively little trouble from water. Silver, to the value of about one million dollars, had been extracted since the opening of the mine.

McKellar's Island. A shaft had been sunk to the depth of about 20 feet on the large calc-spar and barytes vein which occurs on McKellar's Island, a short distance from Pie Island (see Geological Survey Reports for 1869, p. 359) and promising specimens of native silver and silver glance had been obtained.

Jarvis' Island. A large vein of barytes, calc-spar and quartz crosses the southern part of Jarvis' Island. It runs in a north-westward course and underlies to the north-eastward at a considerable angle. At the time of my visit, a shaft was being sunk upon it, which had reached a depth of about forty feet. Small streaks of silver glance were then being found in a gangue of light grey barytes.

McKellar's Point. The large calc-spar vein which crosses McKellar's Point has also a north-westward course. A shaft had been sunk upon it to a depth of about twenty feet, but in the material which had been thrown out I did not observe any ore. A vein holding silver ore and running in the same course was reported to have been discovered upon an island at Pine River Bay. Other discoveries of veins are said to have been made in the new townships in the neighborhood of Cloud River, at Sturgeon Bay, and at a lake lying a short distance south of Loch Lomond formerly called Lake Ka-za-zee-kee-gee-wa-ga-mog. Reported discoveries.

On the north shore of Thunder Bay, beginning to the eastward, a vein which was being opened on lot 11, Con. VIII, in the township of McTavish, was visited by one of my assistants, who found it to contain some galena. The "Beck," or Silver Harbor Mine, a short distance from the shore, opposite the east end of Mary's Island, is situated on a brecciated quartz vein, about five feet thick, running north-eastward, and cutting the smoke-colored cherts and black argillaceous shales, which were there seen to run nearly horizontally under what appears to be a thick bed of dark grey trap. From the information given you by Captain Talon that at the "Algoma" Mine, half-a-mile to the east of this spot, the horizontal slates abut against a wall of trap, it would seem that what appears to be a bed at the Silver Harbor Mine may possibly be a dyke with an angle projecting over the slates seen at the base of the cliff. A shaft had been sunk to a depth of about thirty feet, and an adit run to a short distance along the vein on either side of it. In addition to the quartz, which is of a white, granular character, the vein holds barytes, calc-spar, fluor-spar, amethyst, blende, galena and silver glance. Silver Harbor Mine.

The workings on the vein which had been discovered on mining lot 3 A, about half a mile northward of the Silver Harbor mine, were flooded with water at the time of my visit to that locality, but I was informed by Mr. Borron, Inspector of Mines, and Mr. Peter McKellar, that the vein cuts Huronian slates, and that although small upon the surface it appeared to be widening rapidly in going down. Judging from the specimens which I have seen, this vein must be rich in silver, which occurs native in the form of nuggets, and is associated with sulphide of nickel in a gangue of calc-spar and quartz. 3 A Mine.

The Shuniah Mine, situated on lot 8 in the township of McIntyre, about four miles north of Prince Arthur's Landing, was being actively worked at the time of my visit in July. The vein is here about thirty feet in width, and cuts the granular, silicious, cherty and dark argillaceous slates of the upper copper-bearing series. It has a south-westward course, and is supposed to be identical with the large vein on mining-lot M in McIntyre, the Algoma vein on the north-west corner lot of Neebing, and the large vein at the Paresseux Rapids on the Kaministiquia River. (Geological Survey Reports for 1869, p. 358.) On the Shuniah location a north-facing cliff of trap runs parallel with the vein at a short distance to the south of it, Shuniah Mine.

and the same rock spreads over a considerable area to the southward. The gangue at the Shuniah mine is coarse crystalline white calc-spar, with some lilac patches. The silver occurs both in the native form and as silver glance, but, so far, not very abundantly. Three shafts had been sunk on the vein to the depth of about 15, 50, and 65 feet respectively, and an adit driven between the two deepest.

Singleton Mine. An opening, known as the Singleton Mine, was made during the summer to the depth of a few feet on a quartz vein in the north-west corner of the town-plot of Prince Arthur's Landing, and some fine specimens of disseminated native silver obtained.

Thunder Bay Silver Mine. The Thunder Bay Silver Mine, described in my report for 1869, has not been worked since the winter of 1869-70.

Shebandowan gold region. I had not an opportunity of visiting the Shebandowan gold region. Mr. Peter McKellar, who was engaged with me on the Geological Survey in 1869 and 1870, has described it so well in a letter which he wrote me on the 14th of November, 1871, that I cannot do better than copy his description in this place. He says: "Last spring I was exploring in the new gold-field. It is situated between fifteen and twenty miles south-west of the western extremity of Lake Shebandowan, on Huronian strata of the same kind as those which cross the old Dog Lake trail in the vicinity of the twelve-mile post," (see Geological Survey Reports for 1869, p. 329.) "They are composed of highly inclined beds of diorite, dioritic, chloritic, argillaceous, silicious and talcoid slates, massive greenish porphyries and porphyritic slate, and thick beds of greenish slate-conglomerate, with granite. The latter is intrusive and may have something to do with the metalliferous character of the lode in question. There are bands of magnetite and of quartzite interstratified with these rocks. The strata dip north-westward, the angles being from 60° to 80°. The gold is found in grains and thin leaves, associated with the ores of copper, silver, lead, iron, &c., in a quartz vein from two to six feet wide, which is well defined and carries a highly metalliferous character for more than half a mile to my knowledge. There is also a layer of soft talcoid slate along with the quartz, which I believe will also be rich in the precious metals. The vein, in general at least, conforms with the strata. I have had the pleasure of being the discoverer of the free gold and also of the silver in this new region." Mr. McKellar also observed that the slates in the vicinity of this vein contain a good deal of dolomite.

Heron Cove Mine. Gold and silver have also been found in a quartz vein, which was being worked, about a mile east of Heron Cove, near the Pic, in a horizon in which Mr. McKellar had predicted, from the geological relations, it would be found. I had an opportunity of paying a hurried visit to Heron Cove on our way home from Thunder Bay in the autumn. The rock at the landing, in the bight of the cove, consists of rusty-weathering greenish-grey, dolomitic schist and other Huronian schists of a similar color, all striking westward. Some specimens of the ore which I took from a heap at the landing, on being assayed by Mr. Hoffmann, have yielded gold 0.058 oz., value $1.19, and silver 7.03 ozs., value $9.06 per ton of 2000 lbs.

SURFACE GEOLOGY.

The superficial geology of the Nipigon and Thunder Bay regions was described in my report for 1869. In proceeding westward by the Red River Road, the stiff red clay of the Kaministiquia valley was found to extend westward up the valley of the Mattawa to the outlet of Shebandowan Lake, becoming apparently less abundant all the way, and finally diasppearing on reaching Shebandowan Lake. Around the shores of this lake, and indeed of nearly all the lakes we passed through on our journey to Lake of the Woods, by way of Lonely Lake and the English and Winipeg Rivers, wherever the vegetation is burnt off, the rocky mammillated hills are seen to be strewn with rounded and angular boulders, from the size of a man's head, to to a diameter of thirty or forty feet. Many of these are perched in positions, from which they look as if they might be easily rolled into the water below.

Red clay of the Kaministiquia.

Mammillated hills.

Perched boulders.

The glacial striæ might be observed on the surface of the rocks almost everywhere in the region examined between the height of land and Lake of the Woods. I noted their course in a great number of places and found it to vary from south to south-west, averaging perhaps S. S.W.

Glacial Striæ.

ROBERT BELL.

Office of the Geological Survey,
Montreal, February 24th, 1873.

All the bearings in this Report have reference to the Magnetic Meridian.

REPORT

OF AN EXAMINATION OF THE

COUNTRY BETWEEN LAKES TEMISCAMANG AND ABBITIBBE.

BY

MR. WALTER McOUAT;

ADDRESSED TO

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

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, May, 1873.

SIR,—In accordance with your directions, I was engaged during the past season in making a geological examination of a portion of the country on the Ottawa to the northward and eastward of Lake Temiscamang. The country bordering the Ottawa River, as far as the head of this lake, was explored many years ago by Sir W. E. Logan; and in 1870 and 1871, exploratory traverses were made, in the former year by Mr. Richardson, and in the latter year by myself, across the country in a north-westerly direction from Lake St. John, on the Saguenay, as far as Lake Mistassini. Between the latter lake and the head of Lake Temiscamang, and extending northward to Hudson's Bay, there is a large area, of the geological character of which almost nothing was known. I was directed to turn my attention to this region, with a view of determining, as far as possible, the boundaries of the principal rock formations; a special interest having recently been given to it by the discovery in 1870, by Mr. Richardson of the Geological Survey, of a series of crystalline schists, with serpentine and conglomerates, occurring to the south of Lake Mistassini, and having a north-east and south-west strike. These rocks possess the double interest of containing important deposits of copper ore, and of having furnished a fossil coral. It was therefore part of my instructions to endeavour to ascertain how far they extend to the westward, and if possible, what may be their relation to the Huronian rocks so extensively exposed along the north shores of Lakes Huron and Superior.

Previous exploration.

Instructions.

As it would not be possible to make even the most cursory examination of so extensive an area in one season, it was understood that, in conducting the work of the first season, I should take advantage of whatever opportunities I should have when on the ground, to obtain such information as would enable me to make arrangements for conducting, to the greatest advantage, the operations of succeeding seasons. The present Report, therefore, on the work of the first season, is to be regarded as a Report of Progress, and will not be expected to give anything like the amount of information in regard to the region in question, which may be looked for after the completion of a more comprehensive plan of exploration, even though that should extend only over one additional season.

I have here to make the usual acknowledgment of indebtedness to the officers of the Hudson's Bay Company, with many of whom I was necessarily brought into contact. To Charles Stuart, Esq., of Temiscamang, and Mr. George Burgess, of Abbitibbe, my special thanks are due for aid rendered in many ways, and for the readiness with which they furnished needful information. **Acknowledgement of aid.**

I was assisted during the whole of the season by Mr. John McOuat, and until the end of August, by Mr. Herbert L. Reddy, of this city, both of which gentlemen are at present students in McGill University. **Assistants.**

In making arrangements for the work of the season upon which I have now to report, my original intention was to begin at Grand Lake on the Ottawa, proceeding thither by way of the Ottawa and its tributary the Du Moine, and with this intention I set out from Montreal. It was subsequently decided, however, that it would be a better plan to follow the Ottawa river all the way to Lake Temiscamang, and to make that our base of operations. By doing so I would have the advantage of setting out from a district which had been previously examined and reported upon by Sir W. E. Logan. There was also reason to believe that the latter lake would be much more easily reached than Grand Lake. **Plan of operations.**

This point settled, my plan was to get the supplies for the whole season up the Ottawa as rapidly as possible, and having, with the permission of the officer in charge, deposited them in the store of the Hudson's Bay Co., at Fort Temiscamang, to make excursions of a month or six weeks duration into the country to be examined, returning at the end of each trip for the supplies required for the next one. I regret to be obliged to report, however, that in carrying out this plan, serious delay was occasioned, and additional expense incurred, by unexpected obstacles, arising chiefly from the fact that it was found to be almost impossible to engage suitable men as *voyageurs*. The only practicable mode of travelling in the unexplored regions of Canada, as is well known, is by following the water, and using light birch-bark canoes, manned by skilful *voyageurs*, and it is of course of the utmost importance that the latter be thoroughly experienced and trustworthy. This is especially true when, as in our case, very light canoes are used, so that only two men are required to manage them. In this case, if a single man in a party be in any way **Unexpected obstacles causing serious delay and additional expense.**

Employment of Indians.

deficient, the whole force is more or less crippled. It is usual to employ Indians for this work, but these people, though unsurpassed in point of skill and endurance when employed only for a short time, dislike long continued employment; and are, moreover, liable at any time to become possessed by some unaccountable whim or fancy, and, forgetful alike of their own interests and those of their employers, to act upon it, even to the extent of deserting the party in the uninhabited wilderness. The disadvantages arising from these causes are of course diminished in proportion to the tact and general good management of the person in charge of the party, but at best there is considerable risk. In our case this would have been especially serious, owing to the distance from civilization of the scene of our labours, and the length of time we expected to be at work. With a view of avoiding this risk, it was thought advisable that at least half our *voyageurs* should be white men, and that the Indians should be depended on only for guides. I therefore hired four white men in Ottawa, and set out with these, hoping to have no difficulty in hiring, at Temiscamang, a couple of Indian hunters acquainted with the country, thus making up the number of six which would be required for the season. In addition to this, I proposed to pick up some additional hands before leaving the Ottawa steamers, to be taken as far as Temiscamang, so that our supplies might be got up at a single trip. This would have been a good plan, if white men could have been had who were as good, or nearly as good canoe-men, as most Indians are. Such men, unfortunately, I failed to find, and of the four who were hired, two showed symptoms of serious illness before reaching Temiscamang, and had to be left behind. More unfortunately still, we found the Indians of the Ottawa and Temiscamang exceedingly difficult to deal with. Most of them demanded from two to three dollars a day for their services, and the few who were found willing to go with us on more reasonable terms, would do so only for a short time, leaving us perhaps when it would be still more difficult to supply their places. Similar difficulties attended us during the whole season, seriously interfering with the success of the work. A natural consequence of this state of things was, that our operations were limited to a smaller area than would otherwise have been the case. We had the advantage, however, of being able to do our work somewhat more minutely than we should have done if we had had the means of travelling more rapidly. We were also enabled to make a large collection of specimens of the rocks met with. These specimens are now in the Museum of the Survey, and as there is reason to believe that they represent pretty correctly the crystalline rocks of the whole region, a careful study of the collection will be of the greatest value in preparing for future explorations.

Difficulty in dealing with the Indians.

Excursions from Fort Temiscamang.

Starting from Fort Temiscamang, three different excursions were made.

The first and principal one extended northward to Lake Abbitibe, and included a survey of that lake; the second was up the Blanche to Round Lake; and the third up the Ottawa through Lac des Quinze to Lake Mijicowaja. I shall describe each of these in the order in which they were made.

TEMISCAMANG TO ABBITIBBE.

Leaving Fort Temiscamang on the 11th of July, we set out for Lake Abbitibbe by the route usually followed by the canoes of the Hudson's Bay Company. From the head of the lake, we ascended the Ottawa to Lac des Quinze, a distance of about fifteen miles, though in a straight line the distance is only eleven. This portion of the Ottawa is locally known as "The Quinze," from the fact that, in ascending it in canoes, about fifteen portages have to be made, though the number varies according to circumstances. Its general upward course is E. by N., or nearly at right angles to the general direction of the valley of Lake Temiscamang, and that of the River Blanche, its extension northward. It is, for the greater part of the distance, a succession of formidable rapids and cascades, the difference in level between the two lakes being probably not less than 250 feet. The rocks are well exposed throughout, especially at the portages. I shall therefore describe the rocks with reference to the various portages. The first of these is about two miles above Lake Temiscamang, and is succeeded by two others in a distance of a little over a mile. The first two are quite short, and overcome two falls from ten to twelve feet high; the third is half a mile long, and the fall is about fifty-six feet. At one point in this latter, there is a descent of about twenty feet in a single fall, which appears to be the highest at any one point on the Quinze. The rock exposed at all these portages appears to be very uniform in character, being a very hard, dark grey silicious mica slate, or schist, usually having a rather imperfect cleavage parallel with indistinct whitish lines and streaks. These lines, though usually obscure, were always detected on close inspection; and as they are remarkably uniform in direction and inclination, and appeared to correspond with occasional slight variations in texture and colour, I think they may be regarded as indicating the bedding of the rock. This supposition is confirmed by the fact that the dip which they give corresponds with that observed farther up at various points where there cannot possibly be any doubt of its character. The dip obtained in this way, on the first three portages, varies in direction from 50° to 80° W. of N., and in amount from 61° to 85°, the prevailing strike and dip being about N. 70° W. $<$ 70°. The direction of the dip appears to become more nearly west, and the inclination less in going up the river.

Lac des Quinze or "The Quinze."

Rapids and Cascades.

Three portages.

Uniform character of the rocks.

Above the third portage, there is an interval of nearly three miles.

before the fourth is reached. The rocks are the same, as far as they are seen, but there are few exposures. The fourth portage is the first of another group of three, occurring in about the same distance as the first three, and situated on the south side of an island which here divides the river into two channels. It is only a few chains long, and overcomes a beautiful cascade just above where the two channels unite. The whole fall at this portage is about twenty feet. The rock is the same as on the lower portages, except that it is finer and more compact in texture, and less silicious. The dip, observed only at one point, is S. 68° W. < 62°.

Second group of three portages.

Fifth portage.

The fifth portage begins about a quarter of a mile above the last, is nearly half a mile long, and the fall in the river is about fifty feet. The rocks are well seen, and consist chiefly of fine-grained, rather soft mica slate, cleaving readily into thin regular sheets. The colour is lighter than on the lower portages, and considerable masses are very soft, and greenish-drab in colour, approaching in character to nacreous slates. In the lower part of the portage, the slates are interstratified with massive-grey quartzites, very slightly micaceous. At the head of the portage, crystalline diorite forms a ridge of about a hundred paces wide, having a direction which accords with the strike of the slate rocks. The dip of the rocks on this portage is well seen, and is pretty uniform throughout, being about S. 34° E. < 76°. Similar soft rocks occur along the river for about three miles farther, for which distance the river runs nearly in their strike, or about N. E. and S. W. The dip, for the greater part of this distance, as on the portage just described, is to the south-eastward, but at so high an angle that a very slight change would give an inclination in the opposite direction, which is the prevailing one throughout the Quinze section. No lower inclination than the above (76°) was observed, and in the upper part of the distance the strata are generally nearly vertical.

Crystalline diorite.

Sixth portage.

The sixth portage is about a quarter of a mile above the fifth, and reaches to within a few yards of the head of the island. The fall here is about eight feet. On the upper part of the island there is a conspicuous exposure of a light grey granitic gneiss, consisting of glassy quartz and white feldspar, with a smaller amount of dark brown mica in small scales. The whole mass, as far as observed, is quite uniform in colour and texture, and occasionally there is a decided parallelism in the arrangement of the constituent minerals. The strike and dip of the planes thus indicated, at the only point where they were well observed, is the same as that of the stratified rocks in the vicinity. The whole rock, however, is affected by another remarkably regular set of divisional planes, forming layers from two to five or six feet thick, and of which the underlie is about N. 8° E. < 26°. The mass is lenticular in form, and is about six hundred yards long by one hundred wide, the longer axis being approximately parallel with

Granite.

Divisional planes.

the strike of the slate rocks in the vicinity. On the south-west side it presents a nearly vertical escarpment facing to the south, and rising to a height of about a hundred feet above the river. At the base of this cliff, near the head of the portage, there is an exposure of soft, greenish-grey, massive, steatitic rock; and a little farther up, soft chloritic slates are seen in contact with the granitic gneiss, sometimes corrugated and apparently unconformable with it, but at other points quite conformable. For about two miles above this island, as already mentioned, the soft slates are the predominating rock, and the river runs in their strike; but besides these, diorites and dioritic slates are met with occasionally, and appear to come in from the south-east side. At the end of this distance there is an abrupt turn to the south, going up the river.

Steatitic rock.

Diorites, and dioritic slates.

Just before reaching the turn, there is a short portage (the seventh from Temiscamang) on the north, or right bank of the river. This leads from the river to a small lake, after following which, for a few chains the canoe route passes into the Ottawa again by the outlet of the lake. Immediately below the portage, a bed of greyish felsitic rock was observed, containing a considerable quantity of iron and copper pyrites disseminated through it. At the outlet of the little lake, mica slate and micaceous quartzite, similar to that on the lower part of the fifth portage, were observed; but after a short distance these give place, on the S. E. side, to diorites and dioritic slates.

Seventh portage.

Iron and copper pyrites.

The upward direction of the river, for about three miles, is a few degrees E. of S. A portage leads from the river immediately below the turn, on the opposite side from the above small lake, to another small lake situated in a ravine running parallel with the river above the turn, and about half a mile long. This portage is about three hundred paces long; and beyond the lake, another portage of similar length continues in the same direction, to the river at the foot of a lake-like expansion. From this point to the turn, a distance of nearly a mile, the river flows swiftly, with occasional falls, between high rocky banks, and the total fall is a little over forty feet. The canoe-route just described crosses the strata nearly at right angles, and the rocks are well exposed. These are chiefly massive crystalline diorites. At the foot of the lower portage, however, the diorite is not distinctly crystalline, and is occasionally slaty. In some parts it contains much epidote in veins and disseminated grains. Much of this fine-grained diorite seems made up of flattened shuttle-shaped masses from three to twelve inches, or more, in width, and perhaps six or eight times as long. At one point, a width of about twelve feet was made up of regular hexagonal columns, having a diameter of about ten inches, and inclining at an angle of 57°, in a direction S. 42° W. Towards the head of the second portage, the slaty character is in some places pretty highly developed.

Two portages.

Diorite with epidote.

The stratification of the massive crystalline diorites, which occur largely in this locality, is well shown by the frequent occurrence of quartzite in thin, regular layers, and often interstratified with similar layers of magnetic iron ore. The most conspicuous example of this which was observed is near the head of the lower portage, where a thickness of about thirty feet is made up of such layers. The quartzite is fine and close-grained, sometimes approaching jasper in character, and in layers from the thickness of paper to about an inch. The colours are light and dark grey, and blood-red. Interstratified with these are similar layers of black magnetic iron, forming about a fourth of the whole. These various layers being perfectly regular and even, and the different colours alternating with each other, the rock has a very striking appearance. The dip of these strata is N. 70° W. < 70°.

Quartzite and magnetic iron ore.

After passing these two portages, which, with the preceding short one, may be regarded as a third group of three, there is an interval of about a mile to the next. The direction, as already stated, is S. by E., and the strata are crossed obliquely, the dip being still W. by N.

Tenth portage.

From the foot of the next, or tenth portage, the direction is east to the Lac des Quinze. On this portage, which is the longest on the Quinze, its length being a little over half a mile, the rocks are well seen, and are slaty throughout, displaying a fine but distinct lamination, and are chiefly hornblende slate. It is usually greyish-green in colour, but frequently there are streaks and patches tinged with red. There are also in many places numerous obscure lenticular masses of a feldspathic character, lighter in colour than the above, and showing crystals of feldspar, and usually flakes and streaks of dark green hornblende. The latter, as well as the whole mass, which may be from an inch to several feet long, and from a line to several inches in thickness, are parallel with the general bedding of the rock. The dip at the foot of the portage is W. < 62°; about two hundred paces to the eastward, S. 82° W. < 45°; and at the upper end, S. 78° W. < 50°. The fall in the river here, as nearly as I was able to ascertain it, is about twenty feet.

Hornblendic slates.

Continuing up the river, the rock is hornblendic slate, differing from the last chiefly in being apparently quite homogeneous in texture, and in its dark greenish-grey colour. The same obscure interlamination of darker and lighter layers was observed, and the rock cleaves with tolerable facility parallel with these. This rock, as well as the last, though usually hornblendic, occasionally contains considerable mica. It occurs for about half a mile across the strike, extending across the next, or eleventh, portage, to about half way between it and the twelfth, which is the last before reaching Lac des Quinze. Here it is succeeded and underlaid by syenitic gneiss. For some distance before it gives place to the latter, it is more coarsely schistose, and the colour is lighter and more

Syenitic gneiss.

nearly grey. There are also lighter and darker bands, and immediately at the base there are occasionally thin reddish layers resembling the underlying rock. At this point the river expands to a width of about a quarter of a mile. The dividing line between the rocks just described and the succeeding gneiss crosses this wide part obliquely, the rocks being exposed on both sides. On the south side the shore is low, and the rock is often concealed; but the two varieties, though not seen immediately in contact, were seen within four or five feet of each other at a point where the rock rises only a few inches above the water. On the north side there is an interval of 200 paces between the last exposure of slate and the first of gneiss. The dip here, as on the portage below, is S.W. $< 50°$, while on the south side it is, immediately at the point of contact, S. 32° W. $< 52°$. In both cases the dip of the two rocks, where they approach nearest to each other, is the same. The gneiss is made up of reddish feldspar, with a considerable quantity of dark green hornblende, and a smaller amount of glassy quartz; sometimes it contains a little mica. It is moderately large-grained, and breaks up readily under the hammer. The hornblende and mica are so arranged as to give the whole a stratified appearance, which, though usually obscure, is often sufficiently distinct to allow of the dip being ascertained. This rock occurs, with little change, to Lac des Quinze, a distance of about three-fourths of a mile in a direction nearly east. At the head of the uppermost portage, however, a quarter of a mile to the eastward, though made up of the same constituents, it is coarser, and has a porphyritic appearance owing to the occurrence of numerous crystals of reddish orthoclase, many of them as much as half an inch across. The stratification is very obscure in this locality, but some distance further east it is quite plain and unmistakeable. The fall in the river at the last (12th) portage is about ten feet, and at the next one below, eighteen feet.

Width of the river.

Large crystals of orthoclase.

In regard to the levels given in this Report, it is necessary to state that they are only approximate, being the result of observations with a small aneroid barometer. It is believed, however, that they are on the whole pretty accurate. We had occasion to pass between Lakes Temiscamang and des Quinze four times in the course of the summer; each time barometric observations were taken at both extremities of every portage, and the average of the four results adopted. In addition to this, the difference in level was calculated from the mean of a large number of readings taken during steady weather both on Lake Temiscamang and on Lac des Quinze. The two results agree so closely that I can state, with a considerable degree of confidence, that Lac des Quinze is about 260 feet above Lake Temiscamang.

Levels.

Barometric observations.

Height of Lac des Quinze.

Lac des Quinze is an expansion of the Ottawa, and is in most parts about a mile wide. Its direction, going up stream, is south-east for eight

Dimensions of Lac des Quinze.

miles, then north-east for fifteen miles. At its lower extremity a bay extends northward, with a tolerably uniform width of about a mile, for a distance of eight miles, when it divides into two arms continuing in the same direction for about three miles further. About two miles above the first bay another bay, rather less than half a mile wide, extends in the same direction for three miles; and near the point where the direction of the main body of the lake changes from S.E. to N.E., a third bay extends southward for five miles. These three bays are as nearly as possible parallel, their direction being a few degrees E. of N. and W. of S. This is also the direction of the strike of the rocks on the first two; the third I did not examine. The rock is chiefly grey syenitic gneiss, generally highly quartzose. It is often schistose, and sometimes passes into well-marked hornblende schist, consisting chiefly of glistening black plates of hornblende with some mica. This rock was observed especially along the east side of the lower half of the principal bay, and it seems probable that all these bays lie on the strike of similar schistose bands. On the north side of the lake, between the first and second bays, the rock becomes finer in texture, with a granular appearance, sometimes resembling a sandstone, and frequently contains a considerable amount of epidote. On the lower part of the lake massive crystalline diorite was observed at several points, and evidently belongs to two dykes which cut the above rocks. They appear to have a course about N. by E. and S. by W., and to be from fifty to one hundred feet wide.

Three Bays.

Diorite dykes.

The mean of a number of dips observed at various points along the east side of the first or principal bay, from one to four miles from the foot of it, was W. $< 29°$; that of a similar number taken along both sides of the second bay was N. 85° W. $< 45°$.

Boundary between the gneisses of Lac des Quinze and the overlying slaty rock.

On the accompanying map, I have indicated the dividing line between the gneissoid strata of Lac des Quinze, and the overlying series of slaty rocks. Assigning to it a direction a little E. of N. and W. of S., which appears to be that of the general strike of the rocks of both divisions, it would, when continued southward, coincide very nearly with the line traced for six or eight miles by Sir W. E. Logan, as the boundary between the Laurentian and Huronian on Lake Temiscamang, near the mouth of the Montreal River. Continued in the opposite direction, it would run a little to the westward of the first described or most westerly bay of Lac des Quinze, and parallel with it.

Canoe route from Lac des Quinze to Lake Abbitibbe.

The distance in a straight line, bearing N. 6° W., from the outlet of Lac des Quinze to the Hudson's Bay Company's post on Lake Abbitibbe is about seventy-six miles. The canoe route followed by us passes from the head of the western arm of the first bay of Lac des Quinze up Lonely River, and thence through two long narrow lakes, named respectively Obikoba and Opasatika, which are connected by a small stream. With the exception of a short portage, at a rapid with a fall of four or five feet on Lonely River, a little below Lake Obikoba, there is uninterrupted navigation for canoes from the foot of Lac des Quinze to within half a mile of the height of land between the waters of the Ottawa and those flowing to Hudson's Bay, there being scarcely even a perceptible current to overcome all the way. Rapid on Lonely River.

The distance from the mouth of Lonely River to the height of land is about thirty-one miles. The rocks over the greater part of this distance are of the same gneissoid character as on Lac des Quinze. The regular north and south strike, and westerly dip, were, however, not observed farther than about half way up Lac des Quinze Bay, on the upper part of which very few rocks of any kind were seen. On Lonely River, and on the lower part of Lake Obikoba, the stratification was not apparent. The rock is usually granitic, fine-grained in texture, and of very light grey, brown, or reddish colours, often approaching white. Associated with this, there is often another somewhat similar rock, but containing a large amount of black hornblende, giving the whole a dark colour. This appears to cut the former, but the two varieties are often so entangled with each other, that it would be difficult, without examining a large area, to determine which is the intrusive rock. This is characteristic of the whole district, along the line examined, from the head of the Lac des Quinze bay to the foot of Lake Opasatika, a distance in a north and south direction of about fifteen miles. There are also many veins of coarse granite, consisting usually of vitreous quartz, red feldspar, and brown or greenish mica. The feldspar is occasionally milk white, giving a white or light grey rock. It is plain, however, that the staple rock of this district is gneiss, which was observed, especially in the northern part of the above mentioned fifteen miles, to pass into a distinctly stratified schistose rock chiefly composed of quartz and mica. The best instance of it occurs on the upper part of Lake Opasatika, just above where, going northward, the lake suddenly contracts in width from upwards of half a mile to six or eight chains. Here a well defined micaceous gneiss was observed, very regularly and finely stratified, the dip being S. $<$ 77°. Wherever the stratification appeared in this locality, the strike usually approached east and west, with a dip to the south, the inclination apparently becoming less going northward. Lonely River and Lake Obikoba. Granite veins. Lake Opasatika.

Continuing northward, the rock on the lower part of Lake Opasatika, where it is well seen, is the same fine-grained granitic gneiss, but it is not so much cut up and disturbed by veins and dykes as the above, and it is generally quite distinctly stratified, the bedding being often shown by the occurrence of lighter and darker bands, owing to the varying amount of dark mica in the rock. The same rock occurs all along the lake for about nine miles, and then gives place to a series of slates and schists similar to those of the Quinze. It seems to occur here in the form of a low anticlinal, the dip being southerly in the lower portion of these nine miles, and in the opposite direction in the upper portion. Epidote occurs occasionally in this rock, especially in or near small veins, in much the manner as it does in similar rock near the foot of Lac des Quinze.

Towards the north end of Lake Opasatika, as already stated, these gneissoid strata give place to others of an entirely different character. The upper part of the lake is much wider than the lower half, the width being upwards of two miles. From the east side a bold tongue of land nearly a mile wide extends more than half way across, the extremity facing to the west, and divided into two small promontories by a narrow deep bay. Along the edge of the water round the lower promontory there are exposures of a dull grey micaceous schist, much resembling the lowest members of the slaty series of the Quinze, but more micaceous and somewhat more coarsely schistose. This is overlaid by a rather complicated and greatly varying series of strata which the time at my command did not enable me to examine very minutely. First, there is a thickness of twelve or fifteen feet made up almost entirely of foliated brown mica, very much corrugated, and often folding round what appeared to be nodular masses of grey quartzite often nearly a foot in diameter. Succeeding this there are thirty or forty feet of quartzites and hornblendic schists, including layers containing large quantities of magnetic iron, always finely stratified, and having exactly the appearance of having been originally in the condition of fine sand. Along with these there is also a layer eight or ten inches thick made up chiefly of magnetic pyrites. A specimen of this having been submitted to Dr. Harrington was found to contain traces of copper and cobalt. Above these quartzites there is a considerable thickness of massive steatitic rock and steatitic schists, with probably chloritic schist. These steatitic rocks contain numerous minute grains and octahedral crystals of magnetic iron. The dip is to the eastward, at an angle of about 40°, but the rocks are much disturbed. The northern part of the tongue of land above described is made up of massive crystalline diorite, evidently a dyke, running apparently, in a direction a little north of east.

Rocks of the upper part of Lake Opasatika.

Magnetic pyrites with copper and cobalt.

Steatitic schists with magnetic iron.

Diorite dyke.

Immediately opposite, on the west side of the lake, similar rocks are seen, but they are still more irregular. Crystalline diorite occurs in the line of the above dyke, and is no doubt a continuation of it. Immediately to the south of the diorite there is a large exposure of massive greenish-grey steatitic rock, while to the north of it mica schist occurs along the shore in such a way as to give the idea that an anticlinal axis occurs beneath the waters of the lake. There are also on the west shore some exposures of a soft greenish talcose slate containing great numbers of cubical crystals of iron pyrites, some of them more than half an inch in diameter. The

Talcose slate with iron pyrites.

dip of all these rocks is so irregular that it was found impossible to form any correct notion of their general attitude. Similar rocks, however, are well seen a little farther north, towards the height of land, and the strata are more regular, the dip being usually N. by W. Proceeding up the lake, no rock was seen for about two miles, beyond which on both shores there are large exposures of coarse mica schist; but as higher strata are reached, the rock becomes finer grained and more compact, and is associated with close-grained hornblendic slate, precisely similar to that on the Quinze. The dip, as already stated, is northerly, generally somewhat to the west of north. The inclination is at first from 20° to 40°, but increases on going northward.

At the head of the lake, the rocks last described are succeeded, in ascending order, by conglomerate. The matrix is usually a dull greenish fine-grained sandstone or quartzite, and the imbedded pebbles consist of syenite, greenstone, chert, and white quartz. They appear to be all rounded, and are usually small, but are occasionally nearly a foot in diameter. Sometimes the rock is chiefly made up of these pebbles, but sometimes they are sparsely scattered through the matrix. From this to the Height of Land, the distance is about half a mile, and there a similar rock was observed; but at an intermediate point it is a hard greenish-grey slate, the slaty structure not very well developed, and the rock apparently dioritic. All these rocks appear to dip with tolerable regularity a little W. of N., and the angle of dip at the head of Lake Opasatika is from 70° to 80°.

Conglomerates.

Continuing northward, across the last mentioned conglomerate, and over the Height of Land portage, the rock exposed on a small lake beyond the latter is dark greenish diorite, with little or no appearance of stratification. From this lake, which is about a mile long, the head of Lake Matawagogig is reached by a small tortuous stream without any rapids. The distance from the Height of Land portage to Lake Matawagogig is about two miles, and the direction a little west of north. Here the rocks are similar to those between the head of Lake Opasatika and the Height of Land, but the conglomerate, of which, however, not much was seen, is finer, having a very hard, close-grained matrix, and closely resembles the slate conglomerate of Lake Temiscamang. The distance across the measures to this point, from the part of Lake Opasatika where this series of strata with a regular northerly dip was first observed, going northward, is about five miles; while from the point where the micaceous schist first appears, succeeding the gneiss, the distance is about ten miles.

Height of Land portage to Lake Matawagogig.

It will be seen by these observations that on Lake Opasatika we crossed the boundary line between the two great classes of rocks described in this report, the gneissoid division being on the south, and the slaty and dioritic division on the north. It seems probable that, from where this line was crossed near the head of the Quinze, it runs northward for a few miles, and is then thrown to the westward, how far I had not the means of determining. It may curve round uninterruptedly to Lake Opasatika, or it may be intercepted by the gneissoid rocks just described, extending westward to join similar rocks met with later in the season, about twenty-five miles to the west, on the River Blanche. The former supposition seems the more probable, and I have so indicated it, provisionally, on the accompanying map.

Remarkable hills.

About a mile and a half south-westward of the head of Lake Matawagogig, and just on the north side of the Height of Land, two remarkable hills rise to a considerable height above the surrounding country. All the way from the foot of Lac des Quinze, the country is comparatively low, no hills being seen which appeared to rise more than 150 feet above that lake, but these two hills are more than 700 feet above it. The two face each other in a south-west and north-east direction less than half a mile apart; and at a distance of twelve or fifteen miles in a direction W. by S. an exactly similar hill is very conspicuous, and is said by the Indians to be the highest hill in this part of the country. We ascended the higher of the two nearest ones, reaching it from the small lake already mentioned, on the north side of the Height of Land, the direction being about west, and the distance about a mile and a-half. First, we passed over some low hills consisting of dark greenish diorite, similar to that seen on the lake from which we started; then for a short distance over flat ground where no rocks were seen, beyond which, on the slope approaching the high hill, exposures were met with, of a fine hard bluish-grey slate. The summit of the hill itself was found to consist of very hard close-grained grey quartzite. It was observed to contain what seem to be very small pellucid grains of quartz, and occasional small crystals of feldspar, the whole weathering brown. This rock seems to compose the whole summit of the hill, which is about ten chains across. So far as seen, it is perfectly uniform throughout, without the slightest indication of lines of deposition, and on all sides, except the north, forms vertical cliffs, apparently two or three hundred feet high. The height of the summit of the hill above Lake Matawagogig was found to be 690 feet. The other hill, which is not quite so high, is separated from this one by a very deep, narrow ravine. It presents exactly similar appearances, as does also the more distant one already mentioned, so much so that it seems very probable that all are composed of similar rock.

Diorite, slate and quarzite.

Fine view of surrounding country.

From the summit of the above hill, a good view is obtained of the surrounding country, and it was observed that on the north a series of hills extends east and west for many miles. These hills are not so high as the one from which they were seen, though many of them are probably not less than 300 feet above the general level; and instead of rising, like it, square and precipitous, they are all rudely cone-shaped, and appear to be mostly isolated. They form a conspicuous feature over a large extent of country, and will be again referred to.

From Lac des Quinze to the small lake which occurs at the foot of the Height of Land portage, a distance of about thirty miles, the rise is only about ten feet: thence crossing the portage, three-quarters of a mile in length, there is a rise of about sixty-five feet in the first eight or ten chains and then a gradual descent of forty feet to another small lake, the water of which discharges by the Abbitibbe River, the fall in which, to Lake Abbitibbe, is about fifty feet; and therefore the latter lake is about fifteen feet lower than Lac des Quinze. As this lake has been estimated to be about 260 feet above Lake Temiscamang, and as the latter is 612 feet above the sea (Geology of Canada, 1863, page 6) the height of Lake Abbitibbe above the sea is about 847 feet. Height of Lake Abbitibbe.

Continuing northward to Lake Abbitibbe, we passed through Lakes Matawagogig and Agotawekaim, respectively eight and six miles long. These are connected by a small stream, with four short portages, the distance being about eleven miles. On this part of our course, we passed through the hilly country referred to above. With the exception of an island in the upper part of Lake Matawagogig, composed of reddish granite probably intrusive, the only rock seen all the way is a hard, fine-grained, greenish-grey diorite, in which no appearance of stratification was observed. In most places, the rock is more or less vesicular, the vesicles being usually filled either with calc-spar or white quartz. It also contains, usually, more or less pyrites in disseminated grains. Vesicular diorites.

A few chains below Lake Agotawekami, the outlet of that lake joins the Abbitibbe River, flowing from the south-west, and this we followed down to Lake Abbitibbe, a distance of about nine miles. The massive diorites were not traced farther than to within a mile or two of the foot of Lake Agotawekami, where they give place to obscurely stratified, dark greenish-grey, dioritic schists. These seemed to have a strike approaching east and west, as did also a somewhat similar rock at a short portage a little over a mile below the lake. At an intermediate point, however, a rock was observed which appears to be an impure limestone. It is very close-grained and homogeneous—slightly saccharoidal—in texture, of a light grey colour, but somewhat harder than ordinary limestone. As the locality was not examined very minutely, the extent of it was not ascertained. About a mile below the portage, a somewhat similar calcareous rock occurs, but differing in being mottled with greenish and pale pink spots. This rock appears to be partly composed of serpentine, and a specimen of it is at present under examination. Dioritic slates. Limestone. Serpentine.

A track survey of the route followed by us from the Ottawa to Lake Abbitibbe, was made several years ago by Mr. Lindsay Russell, P.L.S., Survey by Mr. Lindsay Russell.

and his plan has been used in constructing a general map of the region to illustrate our observations on the geology. Lake Abbitibbe was also sketched by Mr. Russell with a remarkable degree of general accuracy. There is, however, necessarily an absence of details in the conformation assigned by him to the shore lines, which rendered it difficult for me to indicate on his plan the precise position of the rocks observed on the ground. It was therefore considered advisable to make a micrometer survey of this lake, from which, accordingly, it has been laid down on the accompanying map.

Micrometer survey of Lake Abbitibbe.

Lake Abbitibbe consists of an upper and a lower lake. The upper lake, the eastern extremity of which we have now reached, lies due east and west. Its length is thirty-three miles, and its width from two to eight, except a little to the eastward of the middle, where a bay extends eight or ten miles to the north, and another bay directly opposite increases the width of the lake two or three miles southward, giving the upper lake a total width here of about seventeen miles. At the north-west corner, it is connected with the lower lake, at its south-east side, by the *Narrows* running in a direction about N. by W. for two miles. The latter is rudely circular in form, with a width varying in different parts from fifteen to twenty miles. The greatest length of the whole, in a direction about W. by N., is about forty-seven miles. The shore line in both lakes is exceedingly irregular, and the number of islands in all parts is very great. The main body of the lower lake is to the north of that of the other, so that an east and west line can be drawn on the north side of the latter, but cutting off the above-mentioned bay, which when continued westward will pass to the south of the lower lake. The principal stream falling into Lake Abbitibbe is the Abbitibbe River, by which we reached it, but there are several other tributaries nearly as large. The outlet retaining the same name flows from the south-west part of the lower lake, and was surveyed for about seven miles, to the first fall. Its direction for the first two miles is south-west, beyond which it is west to the falls.

The *Narrows*.

Abbitibbe River.

The position of the two portions of this lake with reference to each other is closely connected with the geological structure, the longer axis being parallel with the curved line which represents the strike of the rocks. The rocks belong to the same two classes met with farther south. Gneissoid and granitic rocks occur all along the north side of the upper, and on the south-east side of the lower lake, while the other portions of both are occupied by micaceous, hornblendic, and chloritic schists, fine-grained hard quartzites, diorites, and dioritic schists, with serpentines. The dividing line between the two classes of rocks, as shown on the map, coming evidently from the east, passes to the south of the east end of the upper lake; and, turning north for three or four miles, divides longitudinally, the club-shaped peninsula on the west side of which the Hudson's

Rocks of Lake Abbitibbe.

Serpentine.

Bay Co.'s post is situated, and strikes across to the north shore, where it again turns westward. After following the north shore for a few miles, it continues westward through the lake, (having some of the islands on one side, some on the other,) cutting a thin slice from the north side of a mallet-shaped peninsula extending more than half way across from the south side, and situated towards the west end of the lower lake. Still continuing westward, it passes to the south of the Narrows, curves round to the northward in the south-east part of the lower lake, returning on itself in a north-easterly direction, so as to include a space of which the width is twelve or fourteen miles. It would appear, therefore, that this is the western extremity of a band of these rocks coming from the eastward, or probably, considering the prevailing strike of the contiguous stratified rocks, from a direction north of east. I have no means of forming even a conjecture as to how far they may extend in this direction.

Gneissoid rocks.

The gneissoid rocks on this lake, as far as they were examined, are uniformly massive and coarse-grained in texture, and usually of a light grey or brown colour. They are chiefly composed of vitreous quartz, white or light flesh-red feldspar, and brown, sometimes greenish mica, in large scales and flakes, the latter being in most cases parallel with each other. Sometimes the mica is partially or wholly replaced by hornblende. At the western extremity of the area occupied by these rocks, in the vicinity of the *Narrows*, the gneissoid structure is generally obscure, and sometimes could not be seen at all. Near the lower end of the *Narrows* on the east side, a coarse grained syenitic rock was observed, which contained a considerable amount of magnetite.

Syenitic rocks with magnetite.

Schistose rocks.

The schistose, or slaty rocks, which, as already stated, occur over the greater portion of the lake, have a strike for the most part parallel with the line indicated as the boundary of the gneiss. It cannot be said, however, that they were actually seen to curve round the western extremity of the band of gneiss included within this line, as no exposures of rocks showing stratification were observed in this locality; but in the case of the subordinate curve indicated on the map as occurring near the east end of the upper lake, they were plainly seen to conform with the outline of the gneiss. The general strike on the south side of the gneissoid area, as seen along the south side of the upper lake, varies but little from east and west; and usually where they were seen within a mile or so of the gneiss the strata are either nearly vertical, or they dip away from the gneiss, the angle of inclination being sometimes as low as 45°. About the middle of the upper lake, however, the strata, in many places, dip towards the gneiss, at angles varying from 45° to 70° or 80°: but this is usually at a considerable distance from the latter, and the locality shows indications of disturbance. The strike of the similar rocks occurring on the north half of the lower lake, where it is generally well seen, is about E. by N., a direction which would carry them along the north side of the gneissoid area. The dip is seldom less than 80°, and it seems to be about as often southward as northward.

Off a prominent point, about the middle of the west side of the lower lake, there is a small island, not more than six or eight chains long, which is composed of a dark green, rather soft rock, with splintery fracture and resinous lustre, and weathering a dull white. It is so strongly magnetic that our compasses were found to be quite useless on this island. This rock proves to be serpentine, and specimens of it being, at your suggestion, handed to Dr. Harrington for examination, it was found to contain grains of chromic iron.

Serpentine with chromic iron.

At several points along the south side of the upper lake there are exposures of a rock somewhat similar to that described on page 125, as having been observed on the Abbitibbe River about a mile below the portage, and which is supposed to be partly composed of serpentine. This was observed chiefly towards the east end of the upper lake, but it was also noticed on the south-east part of the lower lake. It was not here seen *in situ*, but large angular masses of it were seen on the shore of the lake, in a locality where no other rocks were met with, their appearance being such that there can be little doubt they were not far removed from the parent bed. All the localities where this rock was observed are on a line which is approximately parallel with the general strike of the rocks.

At many points, especially along the south side of the lake, there are large exposures of dark green crystalline diorites,passing into dioritic schists and having a close resemblance to those of the Quinze. These usually appear to be destitute of any appearance of stratification, but as in the case of the Quinze diorites, the bedding is occasionally shown by the occurrence of thin, angular layers of quartzite, here approaching the character of chert, with thin layers of magnetic oxyd of iron, the quantity of the latter seen, however, being insignificant. Much of the diorite also contains epidote, which is another point of resemblance to the diorites seen on the Quinze.

Resemblance to the rocks of the "Quinze."

Besides these crystalline diorites, there are hills along the south side of the lake, which, as far as examined, are composed of the same light greenish-grey compact diorites already noticed in speaking of the hills observed along Lakes Matawagogig and Agatawekami, and the connecting stream. They are precisely similar in appearance, and from one of them which was ascended, and which rises to a height of about 400 feet above the lake, the country was seen to be studded with them as far as the eye can reach, looking southward as well as east and west. Diorite similar to that which composes these hills, was also seen at the falls on the Abbitibbe River, about seven miles below the lake.

Diorite hills.

In regard to the stratigraphical relation of the two classes of rocks on this lake, the only fact which I have to offer is, that at the only two localities where they were observed to approach within about a quarter of a mile of each other, and where both showed stratification, both have the same dip. One of the localities is on the point on which the Hudson's Bay Company's post is situated, where quartzites and slates are exposed on the west, and gneiss on the east side, both dipping to the westward at an angle of about 50°. The other locality is twenty miles further west, where, at the "mallet-shaped peninsula" already noticed, both were seen, within a very short distance of each other, with an east and west strike, and nearly vertical attitude. In both these cases, the only indication of stratification in the gneiss is the parallelism in the arrangement of the different minerals composing it; but this is quite distinct and regular.

Quartzite, slate and gneiss.

SURVEY OF THE RIVER BLANCHE.

Having returned to Temiscamang on the 27th of August, we started on the 4th of September to commence the survey of the River Blanche. This survey was carried from the mouth of the river, at the northern extremity of Lake Temiscamang, to a small lake about three miles in diameter, known by the Indians as Round Lake.

River Blanche.

Round Lake.

The upward direction to the north-west side of Round Lake is N. 36° W., and the distance, in a straight line, about forty-four miles. Following the stream the distance is nearly sixty miles.

Ascending the river, no rock exposures occur for about twenty-five miles, the stream flowing for that distance, with a rather strong current, but no rapids, between banks of clay and sand. Above this there are occasionally exposures of crystalline diorite for several miles, succeeded, a little further up, by chloritic and dioritic slates. Of the former there was very little seen, and the slates were observed only along the edge of the water, at the foot of high cliffs of clay and sand.

Diorite and chloritic and dioritic slates.

For a distance of ten miles in a straight line, above the chloritic slates, the only rock met with is granitoid gneiss, very similar to that of Lake Abbitibbe. Like the latter, it is uniformly coarse-grained and light grey or brown, occasionally red, in colour. On the south-east side the stratification of this rock is well shown, both by the usual parallel arrangement of the constituent minerals, which is here very distinct, and by the occasional alternation of coarser and finer layers. The dip and strike, the latter about N. by E. and S. by W., are exactly the same as those of the slates to the south-east, which, though not seen in contact with the gneiss, were observed at a distance from it not exceeding eight or ten chains. The dip being always nearly vertical, it was found impossible to determine which are the uppermost beds.

Granitoid gneiss.

On the north-west side of the gneissoid area, which extends to Round Lake, slates are again met with. The principal exposures examined are almost immediately in contact with the gneiss, and are chiefly hard grey micaceous and hornblendic schists; but a little more distant from the gneiss it has a greater resemblance to the slates described above. The strike being E. by N. makes an angle of about 45° with that of the latter. The dip, though sometimes to the northward, appears to be usually to the south, and at a very high angle. In one place the dip is S. E. $< 55°$, but the rocks in this locality are much disturbed, and are cut up by numerous dykes of diorite and porphyry, from six inches to as many feet wide. The slates are exposed on this lake for about a mile across the strike, when they are cut off by a rock which appears to be intrusive. It much resembles ordinary red syenite, but was not observed to contain quartz, being made up of large grains of a rather dark red feldspar with a smaller amount of greenish hornblende, and sometimes a little epidote. This occurs all along the north side of the lake, but I have no means of knowing how far it extends beyond the lake.

Micaceous and hornblendic schists.

Dykes.

Intrusive rock.

Lac des Quinze and Lake Mijicowaja.

Having again returned to Temiscamang, on the 17th of September, from the survey of the Blanche, I paid off the two Indians who had been engaged for the short term of about two weeks which it was expected would be required for this trip; and notwithstanding that they expressed themselves well pleased with the treatment they had received, as well as with their pay, it was found impossible either to induce them to re-engage or to procure others to take their places; the chief reason being, no doubt, that the hunting season had commenced, and all the Indians were eager to get away to their hunting grounds. We were therefore unable to make further surveys with the micrometer telescope, as to do so we should have required two canoes, and as we had now only the two white men who had been with us the whole season, we could man only one. Under these circumstances it was thought advisable to devote the remainder of the time still available for our work, to making a further examination of the rocks on the Quinze, and exploring the upper portion of Lac des Quinze and Lake Mijicowaja, (another lake-like expansion of the Ottawa, and occurring immediately above Lac des Quinze,) which lakes extend for about thirty miles to the eastward from the point where, at the foot of the first named, we turned northward going to Abbitibbe. These lakes, as well as the Ottawa River both above and below them, having been already surveyed and mapped, and no further measurements being necessary in order to fix the positions of the rocks observed, a single canoe was sufficient for this trip. We accordingly set out once more from Temiscamang on the 25th of September.

Departure of Indians.

Second start from Temiscamang.

The facts obtained during this excursion in regard to the rocks of the Quinze and of the western portion of Lac des Quinze have been embodied in the account already given of them. The only rock met with farther east is gneiss, occasionally passing into hornblendic and micaceous schist of a coarse texture. The latter is seen occasionally along the shores of the upper part of Lac des Quinze, where, as already stated, the direction of that lake is north-east for fifteen miles, apparently conforming with the strike of the strata, which dip north-westerly at a high angle. The gneiss is generally reddish and rather coarse-grained, with obscure bedding; but it is often grey in colour, and is also occasionally, regularly and distinctly stratified. Along the upper part of Lac des Quinze the gneiss forms hills which rise sometimes from 200 to nearly 300 feet above the level of the lake, being the highest hills seen between Lake Temiscamang and the Height of Land on the route to Abbitibbe.

Gneiss passing into hornblendic and micaceous schists.

Hills along Lac des Quinze.

Having ascended the Ottawa for several miles above where it falls into lake Mijicowaja, and the season being now too far advanced to allow the ascent of this river to be continued sufficiently far to make it probable that any important results would be attained, we returned to Temiscamang reaching the fort on the 12th of October. After a delay of a couple of days, owing to a severe storm of wind and rain, we set out for home, reaching Ottawa on the 24th of October.

Return to Temiscamang.

ECONOMIC MINERALS.

Copper.—In several localities copper pyrites in small disseminated grains, and small quantities of the green carbonate of copper, were observed. The latter was noticed particularly in small veins in the diorites and dioritic schists below the eighth portage on the Quinze. At the foot of the seventh portage, which leads from the Ottawa to a small lake on the north side, copper pyrites associated with iron pyrites was observed disseminated throughout a bed, about three feet thick, of a greyish feldspathic rock. The quantity, however, both here and at the other localities where copper ore was seen, is not sufficient to render it of economic importance.

Copper ores.

Iron.—Magnetic iron was met with in several localities. The most important of these is that already mentioned, on the eighth portage of the Quinze, which leads from the Ottawa River, immediately below the point where, after flowing northward for three or four miles, it turns abruptly round to the south-west. The portage is on the south, or left hand side of the river, running in a direction about south-east to a small lake in a narrow ravine, and is not more than a quarter of a mile long. The iron ore crosses the portage near the upper or south end. It occurs in the form of layers from the thickness of paper to about an inch, and is interlaminated with similar layers of whitish, grey and dull red, fine-grained quartzite. The iron ore constitutes probably from a fourth to a third of the whole, and as the thickness of the whole band is about thirty feet, the total

Iron ore.

thickness of the layers of iron ore would probably not be less than eight feet. The band was traced along the strike for about a hundred yards. Magnetic oxyd of iron was observed under similar conditions at several points on this portage, and on the next above, but in much smaller quantity. This ore occurs also on lake Opasatika, about six miles south of the Height of Land. On lake Abbitibbe, it was observed on the south side of the upper lake, and also on the west side of the lower lake. At none of these localities, however, was it found in important quantities.

Magnetic pyrites.

Magnetic Iron Pyrites.—A bed, eight or ten inches thick, composed chiefly of magnetic pyrites, was observed on the west side of lake Opasatika, at the locality already described as the first where, in going north, the gneissoid and granitic rocks of the southern part of that lake are found to have given place to the crystalline schists and conglomerates of the northern part. It is associated with siliceous layers containing a large proportion of magnetite.

Steatite.

Steatite.—This rock occurs largely in the same locality as the last; considerable exposures, as has been stated (page 122), occurring on the west side of lake Opasatika. Steatite was also observed on the Quinze, near the upper end of the island, on the south side of which are situated the fourth, fifth and sixth portages.

Roofing slates.

Roofing Slates.—On the fifth portage of the Quinze, some of the dark-grey, and light greenish-grey argillaceous slates which are there exposed, have a very perfect cleavage, and would probably be well adapted for roofing purposes.

TIMBER.

White and red pine.

White and red pine are found over the whole region examined, and are by no means rare even as far north as Lake Abbitibbe; but on this Lake, with the exception of a few healthy-looking individuals, about six feet in circumference, observed near the outlet, they are all very small and scraggy, and are confined to the numerous islands and points. They are quite abundant and of excellent quality on the slopes of the hills along both sides of the Height of Land. When ascending the hill described as rising to a height of 700 feet above lake Matawagogig, on the north side of the Height of Land, several fine trees were measured and found to be from eight to nine feet in circumference, at a height of four or five feet from the ground; and from the summit of the hill, groves of white pine were observed in all directions. White spruce, yellow birch and cedar, are also tolerably abundant, and of good size. Fine specimens of the latter tree—tall and straight—were observed, chiefly in hollows among the hills, on the south side of lake Abbitibbe.

Spruce, birch and cedar.

Pine on Lakes Opasatika and Obikoba.

Groves of white pine are conspicuous along the shores of Lakes Opasatika and Obikoba, generally a little distance from the water. Both red and white pine are met with, but not abundantly, on the lower portion of Lac des Quinze; but with one exception, probably the best timber seen by us during the summer is that which grows on the hills on both sides of the upper part of Lac des Quinzes and the lower part of Lake Mijicowaja. The exception mentioned is on the Quinze, in the vicinity of the fourth and fifth portages, where there is a great quantity of very fine pine, both red and white. There is very little pine on the Blanche, the only specimens observed being a few very small ones near Round Lake. Other pine regions.

Sugar maple is tolerably plentiful round the head of Lake Temiscamang, but was not seen further north. The same remark applies to swamp maple and white oak. Large numbers of these grow on low level land near the mouth of the Blanche, and also, in smaller quantities at the mouths of other rivers falling into the same lake. Hemlock is abundant on the lower half of Lake Temiscamang, but no specimens were observed as far north as the Hudson's Bay Company's post. Sugar maple.

The most abundant tree in this region, north of the limit of sugar maple, is aspen, after which come canoe-birch, spruce, Banksian pine, and Canada balsam. Elm and ash occur occasionally on low flats as far north as Lake Abbitibbe. Aspen, birch, &c.

SOIL AND CLIMATE.

The whole region examined, extending northward from the mouth of the Montreal River, which is about thirty miles south of the head of Lake Temiscamang, may be pretty correctly described as a level clay plain, with a great number of rocky hills and ridges protruding through it. There is a marked distinction between this region and the country to the south. The unyielding Laurentian rocks of the latter maintain a uniformly high surface, considerably higher than the level at which the clay is found; while the softer slates and schists which occupy so large a portion of the country further north have been largely removed by denudation, leaving only the harder rocks—diorites, quartzites, and conglomerates,—to form more or less isolated hills, surrounded by arable clay land. Level clay plain. Isolated hills.

The height of the clay appears to be pretty uniform throughout the whole region. Around Lake Abbitibbe it is about thirty feet above the level of the lake, which was estimated to be 245 feet higher than Lake Temiscamang, giving 275 feet as the height of the clay at Abbitibbe above Lake Temiscamang. On the upper part of Lac des Quinze it is occasionally seen along the edge of the lake, and rising about twenty feet above it; and therefore as the latter lake is supposed to be about 260 feet above Lake Temiscamang, its height above that lake would be about 280 feet. On the Blanche, the highest clay plains, about thirty-five miles up the river, are nearly on the same level with Round Lake, which was esti- Height of the clay plain.

mated to be 275 feet above Lake Temiscamang. Clay is seen, I believe on all the portages between Lac des Quinze and Lake Abbitibbe. This would give a greater height than the foregoing, since on the highest of them—the Height of Land portage—it is about sixty feet above Lake Abbitibbe or 305 feet above Temiscamang. Taking the mean of all these heights and adding it to 612 feet, the height of Lake Temiscamang above the sea, we find that the height of the clay plain above the sea level is about 900 feet.

Areas of arable land.

The largest areas of arable land are on the Blanche, and around Lake Abbitibbe. On the Blanche, the banks are at first only eight or ten feet above the ordinary summer level of the river, but ascending the stream they gain in height, step by step, until thirty miles up they rise to a height of from 100 to 150 feet above the water. Until within a few miles of Round Lake, no rocks are seen, except in the channel of the stream or in the face of the cliffs. Towards Round Lake the gneiss only occasionally appears above the level surface. Bluish clay was exposed in the bed of the river all the way to Round Lake, but about half way up is overlaid by a rather coarse brown sand, which in its turn, farther up, is again overlaid by clay. Six or eight miles below Round Lake, where the cliffs are upwards of a hundred feet high, the middle portion consists of sand, while at the base and summit nothing is seen but clay. The level land in the valley of this river will therefore be partly clay and partly sand, perhaps in nearly equal proportions. The width of arable land is probably, on an average, not less than six miles, and may be much more. On the lower levels, a good deal of the surface is probably swampy. The higher levels have been almost entirely denuded of vegetation by repeated fires.

Clay around Lake Abbitibbe.

Lake Abbitibbe is surrounded on all sides by level clay land. At a good many points, however, the rock rises above the level of the clay. This is especially the case along the south side of the upper lake, where the dioritic hills, already described, approach the lake ; but even here there is generally a strip of clay land along the shore. To the north, and especially the north-westward, the clay level seems almost unbroken, and it is well known that it extends in this direction to the shores of Hudson's Bay.

Crops.

Several acres of this clay soil are cultivated at the Hudson's Bay Company's post at Abbitibbe, and with satisfactory results. The only crop grown at present is potatoes ; but I was informed by the man who has charge of the farming operations, (a French Canadian, who has been more than thirty years at Abbitibbe, but was brought up as a farmer near Sorel, in the Province of Quebec,) that several other crops, including wheat, had been tried in former years, and with such results that he is inclined to insist that all the ordinary cereals can be cultivated as successfully at Abbitibbe as on the St. Lawrence. Such an opinion from a man who has been for so many years practically engaged in the cultivation of the soil, is worth recording, and ought to be reliable.

Indian corn is grown at more than one locality near the head of Lake Temiscamang, and is said to ripen well. I am able, personally, to testify to this, as I was shown some good ripe ears, which had been grown during the summer of 1872, on the farm of Mr. Angus McBride, at the head of the lake. It should be said, however, that the locality is perhaps unusually advantageous, as, besides being close to the lake, it is particularly well sheltered on all sides, except the south.

I have the honour to be,

Sir,

Your most obedient servant,

WALTER McOUAT.

REPORT

OF EXPLORATIONS AND SURVEYS IN THE

COUNTIES OF ADDINGTON, FRONTENAC, LEEDS AND LANARK,

BY

MR. HENRY G. VENNOR,

ADDRESSED TO

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

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—The report which I have now the honor to lay before you contains a summary of investigations made during the summer of 1872 in the section of country already partly described in my report for 1871; namely, the townships of North Burgess, South Sherbrooke and Bathurst in Lanark county; North and South Crosby in Leeds county; and Olden, Oso, Bedford, Loughboro' and Storrington in the county of Frontenac. These investigations, however, being still in progress, it will chiefly contain further details respecting explorations which have been in progress since the publication of my Report on Hastings County (Report of Progress, 1866–69, page 143, etc.,) and which have been steadily carried on from this last county in an easterly direction through Addington and Frontenac to my present field of labor. Respecting these explorations I have already handed you several brief reports or summaries of the progress made. These have been published in the respective Reports of Progress for the years 1866–69, 1870–71 and 1871–72. In the present report further details are given respecting the geological structure of the region, and they are now accompanied by a suitable map on the scale of four miles to one inch. This map, which may be considered a second edition and extension of that of Hastings county accompanying my report for 1866-69, is referred to in your Summary Report for 1870, where it is stated that in it would be found some important topographical information not given in any previously published map.

Regions examined.

Map.

Before proceeding to describe the geology of the section of country which has more immediately engaged my attention during the past two summers, I will first give a description of the characters and distribution of a series of rocks met with in the counties of Addington and Frontenac, lying between Hastings county and the counties of Leeds and Lanark. These rocks separate the troughs or basins of rocks of Hastings county from similar troughs, now being traced out through Burgess, Crosby, Bedford and Loughboro' townships. I shall therefore go back to a point where the map and report on the county of Hastings terminated, and proceed in my description thence in an easterly direction in the order in which the various explorations were made. The geological features of the whole of the country examined naturally divide it into three parts, namely a western, a middle, and an eastern section, occupied respectively by the two sets of troughs and the series of rocks which, as above stated, separates them. The western section, of which this report chiefly treats, embraces the great granitic areas of Elzevir, Kaladar, Anglesea, Effingham, Abinger and portions of Miller and Canonto townships; the granite and gneiss areas of the northern portions of Kennebec, Olden, Oso and southern portions of Barrie, Clarendon and Palmerston townships; and the intermediate series of crystalline schists, slates and crystalline limestones, already noted (Report of Progress 1870-71, pages 310-11,) as stretching from the north-eastern quarter of Kaladar township, north-eastward into Levant and Darling townships.

Rocks of Addington and Frontenac counties.

Country divided into three sections.

Western section.

The middle section comprises the southern two-thirds of the townships of Kaladar, Kennebec, Olden and Oso, and the whole of South Sherbrooke and Bathurst, through which are spread out a great volume of granitoid gneisses, schists and crystalline limestones, with magnetic iron ores, and some deposits of apatite or phosphate of lime. And lastly, the eastern section embraces the townships of Burgess, Crosby, Bedford, Loughboro' and Storrington, including the great phosphate-bearing area, and in which granitoid gneisses, pyroxenic schists, crystalline limestones and dolomites with serpentine occur in lengthened irregular trough-like forms, often repeated, and to the south-eastward, passing under the unconformable sandstones and limestones of the Lower Silurian series. The rocks of this section appear to lie conformably on the red gneisses and limestones, which represent the middle section, and in their general characters bear a strong resemblance to the formations described by Sir W. E. Logan as existing in the neighborhood of Grenville on the Ottawa river,—a fact which will be again referred to. It may be further stated that the western section had never been previously geologically examined, but that in the middle and eastern sections some investigations had already been made by Mr. A. Murray, details of which are given in his report for the years 1852-53, now unfortunately out of print; and by Sir W. E. Logan, whose observations are embodied in the "Geology of Canada, 1863." The micrometer measurements, corrections and sketches made at that time by Mr. Murray have been embodied in the

Middle section.

Eastern section.

Resemblance to Grenville rocks.

Investigations of Mr. Murray and Sir W. E. Logan.

map which accompanies the present report, and I would particularly mention the townships of Bedford and Loughboro' as having been thus corrected. At the request of a number of persons, more or less interested in the various lines of railroad at present projected through this region, I have also repeated in this report the levels of all the principal lakes above Lake Ontario, as determined by Mr. Murray, and given in his report above referred to.

Western section.

Western Section.—In the Report of Progress, 1870–71, pages 310 and following, I briefly alluded to the general geological structure of this section, as follows:—" In my explorations of 1869 and 1870, the rocks of divisions B and C, the character of which had been previously studied in the great areas occupied by them in the townships of Madoc, Marmora, Tudor and Lake, were followed for a considerable distance in another area or basin, apparently connected at its south-west extremity in Elzevir with the one just noticed. This latter basin has been traced to the north-eastward through the village of Flinton, in Kaladar, and thence through Barrie, Clarendon, and Palmerston, into Darling, a distance of about sixty miles. It is not more than two miles in breadth in Elzevir and Kaladar, but widens very much to the north-eastward, and is limited on either side by a more elevated region of coarse gneissic and granitoid rocks." I also alluded to the occurrence among these gneisses of " great areas of fine-grained granitic rocks, consisting of little else than red orthoclase and white quartz, without any apparent marks of stratification," which might either be eruptive or indigenous. I wish now to lay before you some further details respecting these elevated regions of coarse gneissic and granitoid rocks bounding on either side the depression above described; and, also, to give a more minute description of the characters and distribution of the rocks in the depression itself. The area occupied by the gneissic and granitoid rocks on the north-western side of the depression, comprises the townships of Elzevir, Grimsthorpe, Kaladar, Anglesea, Effingham, Abinger and Miller; a barren and broken up hilly region, only partially settled, and with but few roads. That on the south-eastern side stretches from Kaladar through portions of Kennebec, Barrie, Olden, Clarendon, Oso and Palmerston, and into North Sherbrooke. In the north-western area the prevailing rocks are unstratified granites, which present one or other of the following characters:—

Characters of rocks.

1. Granite made up chiefly of flesh-colored, or occasionally brick-red, orthoclase feldspar and translucent quartz; with sometimes a very little greenish mica, and occasional crystals of specular iron and iron pyrites. This rock composes a very large part of the area examined, and appears to be the oldest.

2. Dark red, or brownish, coarse-grained, mottled syenite, composed of dark hornblende and red orthoclase feldspar, in nearly equal proportions,

with a very sparing admixture of quartz, and occasional crystals of iron pyrites.

3. Cleveable masses of flesh-red orthoclase feldspar, often largely mixed with black or brownish mica.

The above three varieties of rock graduate the one into the other. Their age is yet uncertain; but they appear to form the base upon which all the rocks yet to be described rest.

4. A great mass of white, micaceous, granitic gneiss, both coarse and fine-grained, and in some places without apparent stratification. It consists of a mixture of white feldspar and greyish quartz, in nearly equal quantities, besides a considerable amount of black or brownish-black mica irregularly distributed throughout the mass, and not, as a general rule, showing any parallelism. Occasionally, however, where the mass is much broken up by atmospheric or other agencies, large angular blocks are met with, in which one or more of the faces are covered with a fine layer or coating of mica.

5. Heavy dark-colored syenite, consisting for the most part of greyish and greenish hornblende, greyish-white feldspar, and a sparing addition of quartz and iron pyrites. This rock may possibly graduate into the coarser varieties of diorite described further on with the rocks of a higher series.

Country occupied by the above rocks.

In my report for 1869, (Report of Progress, 1866-69, p. 148,) allusion was made to these rocks as being very largely developed " from the neighborhood of Queensborough on the one hand, to Mazinaw Lake in Barrie on the other; and transversely from the vicinity of Flinton in Kaladar, to the north-west corner of Grimsthorpe." It was further thought probable, that they would be found coming to the surface in four north-east and south-west anticlinals, forming parallel ridges, and thus spread over " the western half of Anglesea, and the rough and unsurveyed township of Effingham." These statements, which were then partly conjectural, have through subsequent explorations been proved correct. It has been found that these granites and gneisses occupy a line representing the axis of an elevation, starting from near the twelfth lot in the third range of Elzevir, and running N.N.E. through this township into Anglesea, and thence through the south-east quarter of Effingham into Abinger. They are also extensively spread out to the north-westward and south-eastward in a number of subordinate transverse undulations. The course of the first of these transverse undulations may be represented by a line drawn from the south-east to the north-west corner of Elzevir, and passing into the adjoining portion of Grimsthorpe, a distance in all of about fourteen miles, along which the white mica granites and gneisses of (4) and occasionally the darker syenites of (5) are the predominant rocks. The white granites are particularly well seen along the road known as the " new

Four anticlinals.

White granite on Flinton Road.

Flinton road," between Bridgewater and Flinton Village in Kaladar. They occur from lots seven in the sixth and seventh ranges continuously to lots fourteen and fifteen in the tenth range of Elzevir, where they form the south-eastern portion of this granitic area. Much of the rock is a coarse-grained, white granite, with brownish-black mica irregularly distributed through it, and presents no appearance of stratification. Occasionally, however, it graduates into distinctly stratified gneiss, in which the mica is arranged in regular layers. Along the same road approaching the boundary line between Elzevir and Kaladar, the darker syenites of (5) are the most frequent rock masses; and both these and the white gneisses and granites are here much cut up by pale-white and sometimes flesh-colored veins, composed almost entirely of a very fine-grained mixture of feldspar and quartz, with here and there a little black tourmaline. North of the same road in Elzevir, similar white granites cover the remaining portion of the township and, passing into Grimsthorpe, rise into abrupt hills or mountains of considerable altitude. Two of these, known in the neighborhood respectively as the East and the West Mountain, are situated close to the line dividing the townships of Elzevir and Grimsthorpe, between lots twenty and twenty-eight, in the first and second ranges of the latter township, where they form the most elevated points of the country. The West mountain rises abruptly to the height of 250 feet, and from its summit a great stretch of country can be overlooked southward towards the river St. Lawrence. These hills, or mountains as they are called, may be said to form here the north-western extremity or limit of the granite mass in the first transverse undulation. Much of the rock is of a coarse syenitic character, and contains a large proportion of a dark-green hornblende, with very sparing admixture of quartz. Iron pyrites is also abundantly disseminated through the rock in small-sized grains or crystals. This rock would appear to pass into a coarse diorite, by the entire disappearance of the quartz, when the rock is composed of a greyish-white feldspar and a dark-green or greyish hornblende. The red granites also occur in many localities throughout the area just described, but in a very irregular manner, so as to render it difficult to determine their age in relation to the other rocks. Their greatest development is, however, to be found further north-eastward along the main axis of elevation, where they entirely replace the white gneisses. In the vicinity of the East and West Mountains in Grimsthorpe, they are unstratified, and often appear to be of more recent date than the white mica granites and even than the diorites of division B. (Report of Progress, 1866–69). This point, however, requires further investigation. The country underlaid by rocks of the foregoing characters, presents a very rough and mountainous surface. The soil is light and sandy, but little suited for cultivation, and supports a growth of small pines and hemlock. Hence,

Gneiss.

Syenites.

Veins of feldspar, quartz and tourmaline.

East and West Mountains.

Coarse diorite.

Soil.

the comparatively unsettled state of nearly three-quarters of the township of Elzevir, and much of Grimsthorpe. There are, however, to be found isolated patches of land suitable for agricultural purposes, as examples of which may be given the farm of Mr. Arnott on the twelfth and thirteenth lots of the ninth concession of Elzevir, also those of some other settlers further northward, on the fifteenth and sixteenth lots of the eighth, and the twenty-second lot of the tenth ranges in the same township. Mr. Arnott's farm is surrounded by bare rounded ridges of white granite, but he informed me that the soil was all that could be desired for farming purposes. Proceeding north-eastward from Elzevir we find these granitic rocks narrowing in the south-east and north-west corners of Grimsthorpe and Kaladar to a breadth of between five and six miles, owing to a transverse north-west and south-east depression which brings in the diorites and green slates of a higher series yet to be described; they then again spread out on a second transverse north-westerly undulation to over fifteen miles in Anglesea and in the north-western parts of Grimsthorpe and Kaladar. This second extension of these rocks in Anglesea is of a very irregular shape, and consequently it was found difficult to draw a line which would represent its true axis; but one drawn from the vicinity of the Kaladar Post Office, in the neighborhood of the twenty-seventh or twenty-eighth lot of the seventh range of Kaladar, north-westward through Anglesea, and into the north-east corner of Grimsthorpe, would probably prove to be the most correct. On this line the red granites prevail, and cover nearly the whole of Anglesea, extending from Loon Lake and the Scutomatto River, westward into the eastern portion of Grimsthorpe, in all a breadth of about nine miles. The north-western part of this area, owing partly to the almost impassable nature of the country, has yet been only partially examined; but specimens sent to me by Mr. Murdoch, P. L. S., who was then surveying this township, from prominent bluffs on lots ten, eleven and twelve of the twentieth range, and lots fifteen and sixteen in the sixteenth range, are similar to the granites and dark syenites already described as composing the East and West Mountains in the southern portion of Grimsthorpe. Wolf Lake, a small body of water situated on the corners of Grimsthorpe, Anglesea and Effingham, is also entirely surrounded by masses of red granite: as is also Deer Lake, eleven miles to the south-eastward, on the boundary line between Anglesea and Kaladar. In this last locality the white micaceous granites of Elzevir again come in, dipping at a low angle, and appear to overlie the red granites. At the time of my visit there were no settlers upon this Anglesea granitic area, which forms the second transverse undulation; it, however, had been extensively explored by "lumber-men" who had exported a great quantity of first class timber. Excepting a "lumber depot," or an occasional "trapper's shanty," little accommoda-

Mr. Arnott's farm.

Grimsthorpe and Kaladar.

Red granites.

Wolf and Deer Lakes.

tion is to be met with, while the absence of anything like even tolerable roads, and the frequent occurence of *brulés* and wind-falls make the working out of geological details an exceedingly difficult matter. From Anglesea similar rock masses—chiefly the red granites—continue north-eastward into Effingham and Abinger, where they again cover a very large area, probably along another and third north-west and south-east transverse undulation. They are, however, first considerably narrowed between Anglesea and Effingham by a transverse depression, the axis of which may be described as coursing midway between Muddy and Stony Lakes in the north-east quarter of Anglesea, north-westerly through Effingham into the south-eastern part of Cashel. This depression brings in a large volume of the overlying gneissoid and green slaty rocks, which have yet to be described. In Effingham and Abinger the outline of the red granites is very irregular and indefinite, and so difficult is the access to many parts of these townships that for the present I can only describe these rocks as occupying a large part of Effingham north-westward towards Weslemkoon Lake, an extensive sheet of water situated on the line between the latter township and Ashby, and probably also a portion of the eastern side of Cashel, while eastward they pass into the township of Abinger, where they cover a very considerable area extending along the Addington Road. Between the head of Mazinaw Lake and the Mississippi Road in Denbigh township the granite rises into an abrupt cliff, known through the surrounding country as "Denbigh" or "Eagle Hill," respecting the mineral wealth of which many fabulous tales are in circulation. It rises abruptly to a height of several hundred feet, and forms an almost complete barrier to the passage of wheeled vehicles in this direction. It was with the greatest difficulty that we succeeded in pressing our horses to its summit with only a light waggon-load of camp equipments and provisions. I have since, however, been informed that the road was in its worst possible condition at the time of our visit, owing partly to the extreme wetness of the season, and that now, through the outlay of considerable sums of money, it has been much improved. At the head of Mazinaw Lake in Abinger and Barrie, red granite forms the whole eastern and western shores, and is particularly well displayed around Big Bay in Abinger on the western shore, from lots twenty to twenty-five of the first and second concessions, where it is seen to be immediately overlaid by stratified gneisses, dipping at comparatively slight angles, and to which we will again refer. Eastward from Mazinaw Lake the spread of these granites becomes greatly diminished. They were found to cover a considerable portion of the south-eastern three-quarters of Abinger township, and thence passing into Miller township become so intermingled with and concealed by the overlying gneisses that their further course in this direction could not be determined. They, however, continue to be represented by

Bad roads: *brulés* and wind-falls.

Red granites in Effingham and Abinger.

"Denbigh" or "Eagle Hill."

isolated knolls of red granite, and these appear to occur along the crown of an anticlinal through Miller township, on either side of which are great volumes of gneissic strata.

The rocks immediately succeeding and resting upon this area of granite, are also crystalline, but clearly stratiform. They present a variety of characters from very quartzose and highly crystalline masses to schistose. Their dip, where immediately resting upon the granite, is almost invariably slight, and may be given as varying from ten to thirty degrees; but rapidly increases in ascending, until the beds are vertical. As might naturally be expected, the lowest rocks are the most crystalline. They appear to be made up from the debris of the granites upon which they rest, and are largely composed of red and greyish orthoclase feldspar, greenish or greyish-green hornblende and an abundance of grey and translucent quartz. Mica is also generally present in minute scales disseminated through the mass. Magnetic oxyd of iron and iron pyrites also occur in the form of crystals and irregular grains. It is worthy of note here, that among the lowest gneisses, the feldspar, which perhaps composes at least two-thirds of the rock, is generally of a pale flesh-color, although occasionally of a brick-red; while, ascending in the series, gneisses of a more uniform greyish color, and containing a smaller proportion of feldspar, are met with. In the latter, first hornblende, and then mica, form an important ingredient; then through an almost entire disappearance of the feldspar, the grey gneisses graduate into quartzose hornblendic and micaceous schists of varied shades of color. It is amongst these last that crystalline limestones first make their appearance, and in proximity to them the schists and gneisses are generally characterized by the presence of epidote, and occasionally by garnets.

The following are some of the chief varieties of rock met with in this gneiss series, continuing, for the sake of convenience, the enumeration used in describing the granites:— Varieties of rock in the gneiss series.

6. Whitish grey micaceous gneiss, generally coarsely granular, and composed mainly of white feldspar and translucent quartz with the addition of black mica. This differs from (4) only in shewing stratification.

7. Red feldspathic gneiss, generally fine-grained, composed mainly of feldspar, which varies from pale flesh-color to brick-red, vitreous quartz, black and white mica, and, occasionally, disseminated crystals of magnetic oxyd of iron and iron pyrites.

8. Gneiss, varying in color from a whitish-grey to dark greenish-gray, and having the same constituents as (7) with the addition of greenish-black hornblende. In this variety the hornblende and mica largely prevail, and the mass often passes into a black mica-schist.

9. Fine grey hornblendic gneiss, characterized by the frequent occurrence of light yellowish-green epidote in irregular layers and patches.

10. Grey gneiss, holding lenticular streaks of white feldspar, and very much resembling an altered conglomerate. It also bears a striking resemblance to the so-called "Eye gneiss" of Norway. With 8, 9, and 10, are also associated some important bands of white crystalline limestone, holding a great deal of white and occasionally greenish mica. These bands of limestone will be again referred to. Respecting the white micaceous granites and gneisses of (4) and (6), it should be stated that their stratigraphical position is yet uncertain. They are, for the most part, locally distributed, but where most largely developed in Elzevir and Kaladar, immediately underlie the green diorites and slates of division B (Report of Progress, 1866-69), and probably will be found to form a part of this division.

Immediately to the south of the Effingham and Abinger granite areas, gneisses of the characters of 7, 8, 9 and 10, are first well seen south of Big Bay on Mazinaw Lake in Barrie township, where they form part of the northern border of the depression or basin already mentioned (Report of Progress, 1870–71, p. 311) as having been traced from the village of Flinton in Kaladar, north-eastward through Barrie, Clarendon, Palmerston and Levant into Darling township. They here have a transverse measurement of nearly four miles, with east and west strike, and steep incline to the southward. On the east shore of Mazinaw Lake, in lots twenty-eight of the fifteenth and sixteenth ranges of Barrie, a cliff, almost perpendicular, rises to the height of from two hundred and fifty to three hundred feet. It is known throughout the country as the "Great Mazinaw Cliff," and is entirely composed of a rather thinly bedded reddish gneiss, which dips at a steep angle to the southward. The thickness of the gneiss at this point is estimated at not less than 5,000 feet. Westward of Mazinaw Lake similar gneisses cross the Addington road, immediately north of lots twenty-five and twenty-six, striking to the E. and W., with a steep dip to the southward, and pass into Anglesea, where they cover a considerable portion of the north-eastern quarter of that township. Eastward of Mazinaw Lake similar rocks are largely developed in the vicinity of the two lakes, known by the Indian names of Kishkebus and Shahbomeka, whence their strike trends more north-easterly through the remaining northern portion of Barrie and into the south-west quarter of Miller township. In this last named township gneisses were found to be largely developed around Indian or Buck-shot Lake, Brulé Lake, Fortune's Lake, Little or Round Schooner Lake, Big Schooner Lake and Mackie's Lake Of this group of lakes, Indian or Buck-shot Lake is the most south-easterly. The rocks forming its shores consist for the most part of red granitic gneiss —probably a continuation of that at "Mazinaw Cliff,"—striking with the general lie of the lake, namely, N. E. and S. W., and dipping generally to the S. E., on the northern shore irregular, but always steep, on the

"Great Mazinaw Cliff."

western shore at from ten to twenty degrees, and at the eastern end of the lake at sixty degrees. Along the southern shore the dip could not be distinctly made out, except near the eastern end, where it is to the N. W. $< 60°$. On the southern side of the principal point, on the eastern shore of the lake, very coarse-grained hornblendic gneiss was observed, dipping to the N. E. $< 10°$, while on the northern side of the same point, the beds were vertical or dipping at a very steep angle. The next lake to the N. E. is Brulé Lake. It has a length of about four and one-quarter miles, along the line between the fifth and sixth concessions, and its course cuts in an oblique direction the general strike of the rocks, which, from one end of the lake to the other, is to the north-eastward. The rock is chiefly a red granitic gneiss, similar to that noted on Indian and Mazinaw Lakes. Along the southern half of the western shore scarcely any rock can be seen, but the northern half, up to the large bay at the head of the lake, is rocky. The dip at this part is to the north-west, at angles varying from 10°–20°; so also along the north shore. The eastern side is for the greater part rocky and in many respects resembles that of Mazinaw Lake in Barrie. The cliffs, however, are not nearly so high, and the dip is comparatively slight. Along the northern half of the eastern shore the rocks dip uniformly to the north-west at angles of from 15°–30°. On going down the creek from Brulé into Fortune's Lake, in lots twenty-eight and twenty-nine of the sixth and seventh concessions of Miller township, no exposures of rock are seen for the first half of the distance, but on reaching the timber slide, about half way down, an abrupt hill is seen on the left. At its base the rocks are concealed, but the upper half of the hill is seen to consist of grey gneiss, overlaid by crystalline limestone. The gneiss is hornblendic, and contains a small amount of a pistachio-green epidote. The limestone is white and contains quartz, tremolite and a little glassy actinolite.

Brulé Lake.

Granitic gneiss.

Fortune's Lake.

Gneiss and limestone.

The strike here is very irregular, but the dip is uniformly at a small angle. The shores of the creek for the remainder of the distance are low and marshy. Fortune's Lake runs a little east of north from lot twenty-eight in the seventh, to lots thirty-six in the ninth and tenth ranges, a distance of about two and a-half miles, and coincides with the general strike of the rocks. At its south-western extremity the rocks are not well exposed, but, where seen, are dark grey hornblendic gneisses, with strike to the north-eastward and in an almost vertical position, the incline being slightly to the N. W. The southern half of the western shore consists of red and grey gneisses, having the same strike and dip: while the northern half is occupied by white crystalline limestone, which conformably overlies the gneiss. The two small islands (see map) are composed of red and grey gneisses which extend across to the southern half of the eastern shore, the whole being clearly a continuation of those observed along the north-eastern side of Brulé Lake. On Fortune's Lake, the gneiss

Islands of gneiss.

often rises in hills to the height of several hundred feet. The limestone band last noted as occupying the northern half of the western shore of this lake, extends across to the northern half of the eastern shore, where, however, it occupies comparatively low land and is but little exposed. Skead's Creek flows out of the northern end of Fortune's Lake, and runs in a north-easterly direction into Mackie's Creek, a distance of one and three-quarter miles, the whole of which is navigable for canoes. Just north of the outlet of Fortune's Lake on Skead's Creek, the rock is again white crystalline limestone, with strike to the north-east and dip to the north-west, and thence it was followed along the creek through lots thirty-six, thirty-seven and thirty-eight, of the tenth and eleventh concessions to Mackie's Creek near the foot of Little or Round Schooner Lake, beyond which it has yet to be traced. The northern limit of this band of limestone, which for the present we may call the Fortune's Lake band, has not been satisfactorily determined, but a transverse measurement made at the northern end of Fortune's Lake shewed a breadth of over one mile of surface exposures; the dip, however, of these, although for the most part to the north-west, is sometimes uncertain, so that it is difficult to give an estimate of its thickness, and I am inclined to the opinion, that the band repeats itself through frequent foldings. Little Schooner Lake, from which Mackie's Creek flows, is situated towards the north-east corner of the township of Miller, and is the most northerly of the group of lakes under description. Its greatest length is transverse to the general bearing of the rocks, or north-west and south-east. Immediately upon entering this lake from the Mackie's Creek outlet, the Fortune's Lake band of limestone is lost sight of, and we come on a great volume of red and greyish gneiss similar in its characters to that observed towards the southern portion of the lake last named, and of which there can be no doubt it is a continuation. Both shores from the one end to the other, or from the outlet, to the Narrows between this and Big Schooner Lake, are occupied by these gneisses, which in places rise to the height of from two to three hundred feet above the water. Much of the rock shows no stratification, and, when weathered, resembles in general appearance the granites of Anglesea and Effingham; but in many places it shews a uniform dip to the north-westward at angles of from 45°–60°. The distance to the inlet or Narrows from the mouth of Mackie's Creek is a little over one mile. Proceeding up these Narrows, gneiss was observed for the first quarter of a mile, still dipping to the north-westward at a steep angle, when it suddenly gives place to white crystalline limestone. This transverse measurement of the gneiss, from the Fortune's Lake limestone band to that just mentioned, which, for convenience, we may call the Big Schooner Lake band, shews a distance of about ninety chains, and as the dip averages 45°, the total thickness may be estimated at something near 4,000 feet; this esti-

Skead's and Mackie's Creeks

Little or Round Schooner Lake.

Fortune's Lake limestone band.

Red and greyish gneiss.

Thickness of gneiss.

mate being 1000 feet less than that given for a similar body of gneiss at "Mazinaw Cliff" in Barrie township. The rock exposed on the remaining quarter of a mile of the Narrows, before coming to Big Schooner Lake, is entirely white crystalline limestone, dipping to the north-west at $< 45°$, and with this incline it continues south-westward along the north-western shore of Big Schooner Lake, running parallel to the Fortune's Lake band, and only separated from it by the 4000 feet of gneiss just alluded to. Big Schooner Lake has a length of nearly two miles in a general north-east and south-west direction, with a breadth averaging half a mile. As just mentioned, crystalline limestone occupies the whole north-western shore, where the band is a little over a quarter of a mile in breadth. The three large islands seen towards the centre of the lake, and the whole of the south-eastern shore, are composed of red and grey granitic and hornblendic gneiss, with uniform dip to the north-westward. Proceeding up the Narrows at the western end of Big Schooner Lake for about a quarter of a mile, we reach the entrance into Mackie's Lake, the general bearing or greatest length of which is at right angles to that of Big Schooner Lake, or north-west and south-east. Like Little Schooner Lake, it is transverse to the strike of the strata. Its north-western half is occupied by grey and reddish gneisses; these being a continuation of the bands observed along the south-eastern side of Big Schooner Lake, and the dip though almost vertical inclines slightly to the north-westward. Midway along the lake, the dip lessens to angles of from 35°–45°, and both shores are occupied by high bluffs of the red gneiss, which continue all the way to the head of the lake, where the dip was observed to be at a comparatively slight angle to the north-westward. A short distance from the head of Mackie's Lake, and south-eastward from it, a red unstratified granite again comes in, similar to that which has been already described as extensively spread out through Anglesea and Barrie; and it would here appear to occupy the crown of an anticlinal, and to separate the gneisses and crystalline limestones of Brulé, Fortune's, Little and Big Schooner and Mackie's Lakes, from a similar series of gneisses and limestones occurring further to the south-eastward, and which have yet to be investigated.

Limestone parallel with Fortune's Lake band.

Size of Big Schooner Lake

Mackie's Lake.

Granite like that of Anglesea and Barrie.

So far I have attempted to describe the characters and distribution of the rocks over the north-western granitic and gneiss area of the western section. I have shown them to consist of great bodies or masses of unstratified granite, occupying the highest portions of the country; of grey and reddish granitic gneisses, clearly stratified; and of white crystalline limestones.

The south-eastern area, occupied by rocks of similar characters, stretches from Kaladar through portions of the townships of Kennebec and Barrie, Olden and Clarendon, Oso and Palmerston, into North

South-eastern area.

Unstratified granites in patches.

Sherbrooke. In it, the red unstratified granites, although frequently met with, occur only in the form of isolated patches of irregular outline; while the stratified gneisses are continuous. A line, which might be called their *medial line* of distribution, would run from the vicinity of the Kaladar Post Office on the Addington road, through the north-west quarter of Kennebec, and midway between Gull Lake in Barrie and Clarendon and Cross Lake in Kenebec; thence between Hungry and Mink Lakes in Olden township, and through the northern part of the same township into North Sherbrooke. Beyond this, the gneiss region loses its elevation, and may be said to come to a point towards the junction of the Upper and Lower Mississippi Rivers near Playfairville in Dalhousie township. In Kaladar, white micaceous granites and gneisses prevail, and these continue from the neighborhood of the Kaladar Post Office, on the Addington road, through Kennebec, to the outlet of Gull Lake, in the township of Clarendon, where they give place to red and grey granitic and hornblendic gneisses. In Clarendon, the whole of the north-western shore of Gull Lake is occupied by obscurely stratified reddish gneiss, which continues up to its outlet on the Frontenac or Godfrey road, and from this position extends northward to Pine and Malcolm's Lakes, and southward along the same road to a position in Olden township, a little north of a point where this road connects with that running eastward through Olden and Oso.

Medial line of distribution.

White granites and gneisses.

Gull Lake.

Barren country between Gull and Cross Lakes.

The country lying between the south shore of Gull Lake and Cross Lake, in the township of Kennebec, is of a most rugged and barren description. It is occupied by alternate rocky ridges and swampy valleys; composed of an obscurely stratified reddish gneiss, which dips to the south-eastward at a comparatively slight angle, and is traversed by dyke-like protrusions of a coarse aggregate of quartz and flesh colored feldspar. To these dykes we will again refer. Proceeding north-eastward from the Gull Lake outlet through Clarendon into Palmerston, we reach the Lower Crotch or Crutch Lake. Here, red gneiss rocks are very largely developed, and extend all the way to the Upper Crotch or Crutch Lake, where they again form a most barren tract of country, unsettled and unfit for cultivation. The whole country between these lakes and Bolton's Creek in Oso township, is likewise occupied by gneiss of a similar character, and presents the same barren appearance. The dips could not always be precisely determined, but that to the south-eastward was the most common, and appeared to be at a slight angle. On the north-western side of this area, namely, towards the Crotch Lakes, the numerous streams and small creeks flow north-westward into the Upper Mississippi River; while on the south-eastern side they flow south-eastward into Bolton's Creek; the intervening country thus forming a water-shed. It is here, that the great impediment occurs to a direct line of railroad from Kingston to Pembroke, a fact which I pointed

Crotch or Crutch Lake.

Barren country.

Water-shed.

out to parties interested before the projected line was surveyed. Indeed there can be no doubt that to complete the railway, a considerable deviation will have to be made to the eastward, which would pass from about the centre of the township of Oso through the northern portion of South, and southern part of North Sherbrooke into Dalhousie township, and thence through a most favorable valley into Levant and Bagot townships, beyond which there is no great difficulty to be encountered. If, on the other hand, this deviation were not made, and the line passed through North and South Canonto and Blythfield, almost insuperable difficulties would be encountered.

Kingston and Pembroke Railway.

As already mentioned, this gneiss region rapidly loses its mountainous character, and narrows on its extension through the townships of North Sherbrooke and Dalhousie. It also becomes covered to the eastward by a deep soil well adapted for cultivation, and consequently is thickly settled. Throughout the whole area the characters of the rocks are so continually changing that it was impossible to find characteristic bands of gneiss which could be traced for any great distance. In many localities the beds are nearly horizontal, and consequently a band of gneiss which may have only a very small thickness is kept at the surface over a wide extent of country; while in other parts the beds are vertical, or nearly so, bringing in a great thickness in a very short distance. The dyke-like protrusions amongst these gneisses, to which I have already referred, were also noticed by Mr. A. Murray in this section of country, and in his Report of Progress for the years 1852–53 (now out of print) he describes one of them as occurring on a stream flowing from a small lake in Olden into Cross Lake in Kennebec. Mr. Murray says: "On the north side of this stream, about 1,200 yards eastward of the lake, this dyke was composed chiefly of reddish feldspar in large individuals, with which colorless translucent quartz was mingled in smaller quantity, with a very sparing amount of mica. In the widest part the dyke measured upwards of a hundred yards; its course was S. 7° W., and it obliquely cut the strata, which, consisting of hornblendic and micaceous slate, dipped E. S. E. Lateral branches from the dyke, on either side, cut the strata, generally in the direction of the strike; small strings and patches of magnetic iron ore were found in various parts both of the main dyke and the branches." Magnetic iron ore has been reported to exist in many places through the gneiss area, but in my explorations it was only met with in grains or crystals, which were finely disseminated through some band of gneiss, or in connection with one or more of the numerous dykes, and nowhere in sufficient quantity to be of economic importance. The entire absence of crystalline limestones in the section just described is a fact worthy of note; and although it may be rather premature to state positively, that all the available deposits of magnetic and other ores of iron occur, and are to be sought for, in

Good soil.

Beds nearly horizontal.

Dyke-like protrusions.

Extract from Mr. Murray's Report for 1852-53.

Magnetic iron ore.

Absence of crystaline limestones.

proximity to such limestones, still the accumulation of evidence over a great extent of country examined would appear to point in this direction.

Depression between the granite and gneiss areas.

I would next direct your attention to the deposits occupying the depression between the two granite and gneiss areas, which have been mentioned as stretching from the north-east quarter of Kaladar, through the centre of Barrie, Clarendon, and Palmerston, into Levant township. Throughout this area, the various rocks are so irregularly distributed as to render it difficult to arrive at anything like a clear and satisfactory sequence; and they are so often interrupted and intermingled with gneisses and crystalline limestones, resembling the inferior division A, (Report of Progress, 1866-69) that it has been found impossible to represent their distribution on a map. In Barrie and Clarendon townships, for example, the dip is as often to the N. W. as to the S. E., and in many places the beds are nearly horizontal. The general characters of the rock masses have already been given in the Report of Progress for 1870-71, page 311.

Character of rocks.

They are as follows:—

a.—Green diorites, massive and without the slightest appearance of stratification; cut by numerous veins of a glassy white quartz, containing a small quantity of copper pyrites.

b.—Green diorite slates, stained with oxide of iron, and in which the planes of cleavage are in the same direction as the bedding.

c.—Green micaceous and somewhat chloritic schists occasionally colored by peroxide of iron.

d.—Pyroxenic rocks, both massive and schistose, varying from some shade of grey to green, and graduating into, or overlaid by, very black mica schists, holding garnets in abundance.

e.—Conglomerates; composed of quartz pebbles enclosed in an arenaceous and micaceous matrix, similar to those described as occurring in Madoc and Elzevir townships. (Report of Progress, 1866-69.)

f.—Finely laminated, greyish mica slates, of a glossy lustre on fresh fracture.

g.—Dolomites, of drab, yellowish, flesh and pure white colors.

h.—Sandy, crystalline limestones, grey calc-schists, and impure earthy limestones; the latter interstratified with siliceous and micaceous slaty layers, and imperfect gneisses, and diorites.

Resemblance of rocks to those of Marmora, Madoc, Tudor and Elzevir.

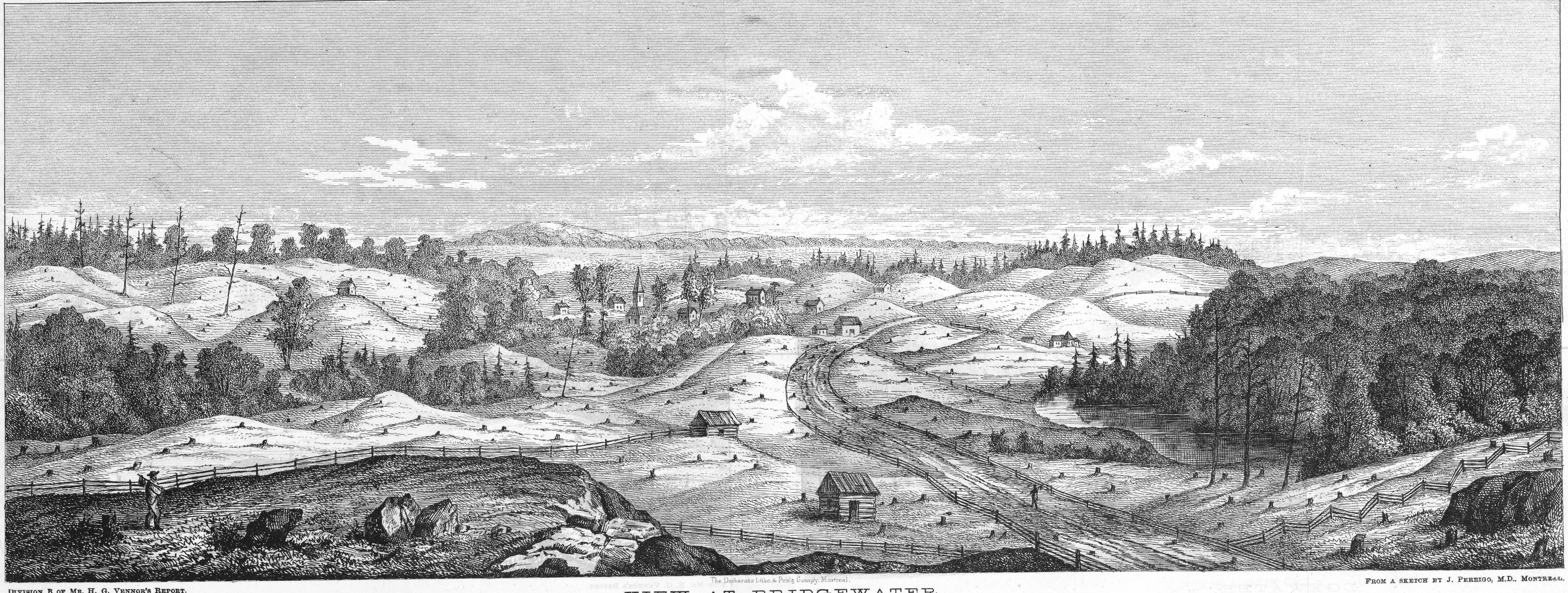
A comparison of the foregoing, with the section given in the Report on Hastings County, Report of Progress, 1866-69, page 145, will at once shew that we have here a series of rocks resembling those of Marmora, Madoc, Tudor and Elzevir townships; occuring under similar conditions, and like them filling up depressions in the older crystalline rocks. The diorites, green slates, schists and conglomerates, are particularly well developed around the village of Flinton, situated on the twenty-first and twenty-second lots of the third and fourth concessions of Kaladar. Here, much of the rock is a light green slate, graduating into a finely speckled hornblendic schist impregnated with reddish brown garnets. A short distance beyond this village, on the road leading to the Addington road, the first conglomerate is met with. In it, the pebbles, which are of quartzite, are enclosed in a matrix of sand and mica, or micaceous quartzite, and are clearly seen to be flattened out, and elongated along the plane of bedding. They are mostly small, or would appear to be so from an inspection of the mere worn surface of the rock; but, on fracture, the pebbles, which on the surface shew only perhaps a cross measurement of say from a-half to one inch, are found to have a length of from five to ten inches, the length being generally proportional to the thickness. They are easily removed from the matrix, and a number were found lying loose in the soil, near the outcrop of the band. In some localities, the character of this conglomerate changes in a most marked manner. Instead of interstratified layers of pebbles, we have alternate layers of vitreous quartz or quartzite and glistening mica schist, with here and there something like an enclosed pebble; and again—on the course of the same outcrop—we find these layers of quartz or quartzite pinched out into lenticular or eye-shaped forms, and entirely surrounded by mica schist. Still higher in the series, and about sixty chains farther along the Flinton road, a second conglomerate is met with of a coarser description. In it, the pebbles, which are much larger, and of different shades of color, are enclosed in a greyish and greenish hornblende schist. This is separated from the first by green slates and greyish hornblende schists with garnets, and similar rocks again overlie it. The general strike here, and throughout the north-eastern portion of Kaladar township, is to the N. N. E., with dip to the south-eastward $> 85°$. North-eastward from Flinton village, similar green schists, with an interstratified conglomerate, cross the Addington road a short distance above the Kaladar Post Office, namely, on lots thirty and thirty-one in the seventh, and thirty-one and thirty-two in the eighth concessions. They here follow the general course of the road, and form a high ridge along its western side up to the boundary line of Anglesea and Barrie. A little over a mile to the westward of the lots just named the country is composed of the rusty greenish diorites (*a*). These rocks shew no marks of stratification, but rise in rounded domes, or conical hills, and form a country similar to that seen to the north of the village of Bridgewater in Elzevir, represented in the sketch accompanying the present report. Light green and yellowish epidote runs through these massive diorites in strings and patches, and gives to the weathered surface of the rock a reticulated appearance. Continuing on the north-eastward course of these rocks, we again have a large development of the conglomerate on lot three of the Addington road range in Barrie township. Here it presents much the same general

Conglomerate.

General strike.

Diorites.

Conglomerate on the Addington road.



DIVISION B OF MR. H. G. VENNOR'S REPORT.

FROM A SKETCH BY J. PERRIGO, M.D., MONTREAL.

VIEW AT BRIDGEWATER,

TOWNSHIP OF ELZEVIR, ONTARIO.

Shewing the aspect of the Country underlaid by the Diorite Rocks, with hills of Red Syenite in the distance.

appearance as that already described, but the enclosed pebbles are much more numerous and more regularly distributed along the planes of bedding. On this lot I was surprised, at the time of my first visit, to find a five-stamp quartz crushing mill erected on one of the exposures of conglomerate. It had been used for crushing material taken from an opening in which there was no appearance of a vein, and, as might have been expected, no gold or silver was found.* Associated with this conglomerate, there are green slates and hornblende schists, similar to those described as occurring in Kaladar township, and these extend into the fourth lot of the same road-range, where they trend more eastwardly. On following the rocks, however, in this direction, the conglomerate is for a considerable space lost sight of, but is again well displayed in the northern parts of the thirty-third and thirty-fourth lots in the first concession of Barrie, and again in the southern parts of the twenty-ninth and thirtieth lots of the same concession, beyond which it passes into the township of Kennebec, and is lost sight of. In the intervals, between the exposures of the conglomerate, the exposed rocks are the green slates or garnetiferous hornblende schists, belonging to the same group. Westward of the Addington road in Anglesea, and between it and the Scoutomatto River, the country is occupied by dome-shaped hills of the massive, rust-colored and greenish diorites. (See Sketch accompanying Report.) These rocks extend northward from the first to the tenth concessions of this township, and also occupy a position on the Addington road, from the sixth to the twenty-fourth. White quartz veins, carrying the yellow sulphuret of copper, are of frequent occurrence in these diorites, and numerous openings have been made in search of copper ore by the settlers, but so far without profitable results. On lots fourteen, on both sides of the road, I observed a number of shallow pits or openings, from which copper pyrites had been taken some years ago by some parties from Kingston. The hand specimens shewn me, which were said to have been obtained from the surface quartz, were rich in copper pyrites, but these were doubtless picked specimens. The chief rock thrown out in the various blastings, was a milky white quartz, and large piles of this still remained beside some of the pits. On examining these piles of quartz I could detect but little copper ore, and the rock had a most barren appearance. At the bottom of one of the chief openings the quartz had almost entirely disappeared, although at the surface it was said to have measured from three to four feet. Nothing like well defined veins were observed, and apparently the quartz occurs merely in the form of

Quartz crushing mill.

Diorites.

Quartz veins holding copper pyrites.

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* This mill was subsequently sold, and removed to the "Williams" gold-mining location in the township of Marmora, as mentioned in my last report (Report of Progress, 1870-71, page 133).—H. G. V.

lenticular shaped patches. As already mentioned, epidote is a marked feature in these massive diorites; it occurs in waving lines or strings, intersecting each other, and thus producing the reticulated appearance seen on the weathered surface of the rock. This massive form of diorite is the lowest rock in this series, and in Kaladar and Anglesea it is seen to adjoin the red granites, and also to penetrate them beyond the line of contact, in the form of fine-grained diorite dykes. From the east end of Loon Lake in Anglesea to the Addington road the surface is occupied by similar diorites, and they extend a few chains eastward into Barrie. No strike could be discerned in them, but in places there are indications of a dip to the north-westward. Similar massive diorites were also noted near the mouth of a small stream which empties into the eastern end of Loon Lake from the north-westward, where they appeared to be vertical and to strike W.N.W., which would carry them into the south-western corner of Effingham, and south-eastern portion of Cashel; but in this direction they have not been traced. Small exposures of dioritic rocks and speckled greenish schists were met with through Barrie township, eastward of the Addington road, namely, at the foot of Mazinaw Lake; near the "Marble Rapids;" at the western end of Mis-sis-sa-ga-gon Lake; and in several other localities north-eastward into the township of Clarendon. These rocks possibly occupy in this direction the place of the massive epidotic diorites already described; but it is more probable that future explorations will prove that the latter continue on a W.N.W. course from Anglesea through Effingham into Cashel, and at some point in this direction, join similar rounded forms of dioritic rocks, extending from those of Madoc, Tudor and Grimsthorpe townships, along the western flanks of the great granite area of Elzevir and Anglesea. (See map of Hastings County, Report of Progress, 1866–69.) Should this prove to be the case, this granite area would be completely encircled by the diorites and associated green slates of division B. (Report just cited.) Northward on the Addington road, from the twenty-fifth lot, to where this road enters the township of Abinger, all traces of the diorites are lost, and a great volume of gneisses, belonging to the inferior formation, succeed, as already mentioned on page 148.

Epidote.

Position of diorite in the series.

Probable course of dioritic rocks.

The expansion of this area or basin through Barrie and Clarendon is referred to in a former Report, (Report of Progress, 1870-71, page 311) and also the fact that dolomites, slates and calcareous schists, with gneisses, prevail, to the almost entire exclusion of the diorites of division B. Dolomite intimately associated with silicious and fine shining mica slates, was first observed crossing the Addington road in Barrie through the fourth and fifth lots. It is rather compact, of a pinkish color on fracture, but weathers to a yellowish drab, and resembles in a marked manner many of the dolomites of Madoc township; particularly so, those occur-

Dolomites, slates, &c.

ring along the Hastings road, close to the Richardson mine, (Report of Progress, 1866-69, pp. 154, 155) where they are likewise accompanied by silicious slates. The strike of this dolomite on the Addington road, although obscure, appears to be to the north-eastward, and the beds to be in a vertical position. On the road the measurement across the strike is about 400 feet, but to the south-westward in Anglesea this volume rapidly lessens, and, shortly after crossing the boundary of Kaladar township, the dolomite either thins out, or is covered over and concealed. North-eastward from its position on the Addington road it becomes overlaid by the sandy limestones, calcareous schists, and imperfect gneisses (*h*), but is further traceable along a north-easterly out-crop from the third to the ninth concessions of Barrie, and thence to the "Marble Rapids" and Marble Lake on the Mississippi River, in which locality it is very largely developed. It was also traced along its south-eastern out-crop, on the line between the second and third concessions of the same township, to the northern end of a small lake or pond situated on the twenty-ninth and thirtieth lots of the third concession. Beyond this point the strike changes to the southward of east, and the measures are concealed by thickly wooded and rather low country. Around the small lake situated on the twenty-seventh and twenty-eighth lots of the third concession a great dead of drab magnesian limestone was noted, with masses of rock resembling the grey calc-schists of Madoc. Near Marble Lake, on the northern out-crop of this band several quarries have been opened; but very little stone has yet been raised from any of them. Dr. B. J. Harrington, who here accompanied and kindly assisted me in my explorations, spent some time in examining the limestone or dolomite in the vicinity of some of the quarries, and the following is an extract from his note book :—

Thickness of dolomite.

Marble quarries near Marble Lake.

"This marble in many of its characters resembles that found near the village of Bridgewater, but is for the most part much finer-grained. From its weathering to a light brown color, and crumbling rather easily, it would appear to be dolomitic.* The northern portion of the band is very finely granular, and is in some parts pure white and in others of a delicate flesh color. Here there is quite a large excavation made by Mr. Alex. Cowan of Brockville, and some very fine blocks of marble have been quarried. These, however, among other defects contain scattered crystals of tremolite. At a short distance from this opening, there is another in which the crystals of tremolite are absent and the marble very pure.

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* Analysis of a specimen from the same band on Mazinaw Lake. Geol. of Canada, p. 593.

Carbonate of Lime	53.90
" " Magnesia	45.90
	99.80

The centre part of the band is also white and flesh-colored, but is of much coarser grain. This portion occasionally contains scales of mica, as well as crystals of tremolite. The latter are in some places very abundant, and so much so, in one locality, that the rock is almost entirely composed of tremolite. The northern portion of the band is for the most part of a banded structure, shewing white and grey, or light bluish colors in alternate layers, each layer being about half an inch in thickness. A very good exposure occurs on the property of Mr. Cole, at a short distance to the north of his house. Here, the white layers, which weather brown, appear to be softer than the grey, and have weathered out, leaving these last in ridges; thus giving to the rock a striated appearance. If this portion was cut transverse to the stratification, and polished, it would doubtless have a fine effect. Other parts appear to be clouded rather than banded. Mr. Cowan has also opened a quarry on the southern portion of this band, but it was not examined. In the Bridgewater band of limestone, black tourmaline is found in crystallized masses, and a small amount of graphite towards its middle portion. At Marble Lake, on the property of Mr. Cole, there is a vein cutting the clouded marble, composed of quartz, black tourmaline and graphite." This clouded and banded limestone thus described by Dr. Harrington, and which was also noted by myself in a number of localities, bears a marked resemblance to a band which heretofore has been considered of Lower Laurentian age, and which occurs frequently through the townships of Olden and Oso, associated with the gneisses, etc., yet to be described as forming a part of the Middle Section of the country to which the present report relates. A description given by Mr. A. Murray in his Report 1852–53, now out of print, of a limestone met with on the Salmon River in Kennebec, a little south of Cross Lake, is so applicable to the one occurring in Barrie, that it may not be out of place to quote it here. After mentioning some very sharp bends in the Salmon River, previous to its entrance into Bull Lake, Mr. Murray says:—"In this crooked part of the stream, crystalline limestone is largely exposed in the rapids which it occasions. In the upper bend it is of a slaty character, and it is interstratified with a band or two of mica slates; at the lower, supposed to be on the fourteenth lot of the tenth concession of Kennebec, it is arranged in very regular alternate layers of white and bluish-grey: the bluish-grey layers are thinner and harder than the white; they appear to owe their color to the presence of a multitude of very fine scales of plumbago, each so small as scarcely to be discernible by the naked eye, and their hardness to an aggregation of fine rounded grains of quartz, not distinguishable, on weathered surfaces, from quartz sand; with these are present, a few, very small, modified cubes of iron pyrites. In the action of the water upon the rock, the hard thin bluish bands offer a greater amount of resistance than the white, which, being purer limestone,

Vein of quartz, tourmaline and graphite.

Limestone in Olden and Oso.

Extract from Mr. Murray's Report for 1852-53.

are more readily dissolved. The result is, that the latter stand out in relief, presenting sharp edges, while the intermediate more calcareous part is worn into rounded grooves, and the contrast of colors and forms presents a very distinct and striking picture of the stratified character of the rock. The grain of the calcareous part of the rock is generally rather coarse, but patches of it are tolerably fine and very white; these, however, rarely afford more than hand specimens, which are of a quality resembling statuary marble. The exposures in this part of the river, which so distinctly afford the evidence of stratification, appear to be in a nearly horizontal attitude, and hence, in the square mile which they occupy, very little thickness is seen. A few local and very limited contortions were observed, however, and in the neighborhood of these, tremolite was usually found in abundance."

Course of the Marble Lake band.

From Marble Lake this banded and clouded limestone was further traced through the ninth, tenth, eleventh and twelfth concessions of Barrie to Shawenego Lake, and thence through McClintock's Lake in Clarendon, to the Frontenac road, which it crosses on lots forty-one and forty-two. Beyond this point its course could not be clearly made out. It was again observed on the Mississippi road in Miller township, a short distance east from Playfair's Corners, where the strike was to the north-eastward, but in attempting to follow it in this direction, all trace of it was lost in a small lake called Grindstone Lake, situated a few chains to the north-east of this road, in the tenth and eleventh concessions. Another and similar band was also noted on Mosquito Lake in the extreme south-eastern corner of Miller township; and a third was followed along the entire length of Trout Lake in Palmerston and South Canonto townships. It is, however, probable that these are all portions of the one band; its out-crop being carried from Grindstone Lake by minor zig-zags, due to subordinate undulations, to its position on Trout Lake. From this lake it again resumes its north-easterly course, and continues through South Canonto into Levant, whither it has yet to be followed. So far, the limestones described occur along the north-western edge of the Barrie and Clarendon basin. Their south-eastern out-crop is not well defined, but exposures were met with towards the western end of Gull Lake in Barrie, as well as in several places between this position and Malcolm's Lake on the Frontenac road in Clarendon. In this last locality, and immediately to the northward of the Ardoch Post Office (lot 20 of the S.W. road-range) we observed the junction of the dolomitic limestones with the inferior gneisses, and the intervening groups a, b, c, d, e, f, appeared to be wanting; unless a rock which was noted as partaking somewhat of the character of (d), may possibly represent it. The rock referred to is a striated or banded hornblendic gneiss, shewing parallel layers of greyish and whitish colors. Thin beds composed almost entirely of dark green hornblende with

Junction of dolomitic limestones and gneisses.

garnets were also interstratified, and these weathered out in relief and gave to it a furrowed appearance in the direction of the strike, which is E.N.E. with a constant dip to the north-westward at a steep angle. This gneiss is immediately followed by the sandy, clouded limestones of (h), which for some distance from their line of junction, likewise hold interstratified hornblendic beds with garnets. The Frontenac road here affording an excellent opportunity for the transverse measurement and further examination of the rocks of this basin, a chained survey was made along it, northward to Playfair's Corners in the township of Miller. Shortly after leaving Macolm's Lake the limestones are much confused, and are thrown into hills, and present abrupt escarpments, with varied strike and dip; Large disconnected masses are scattered over the surrounding fields, and from their horizontal position more resemble the debris resulting from the decomposition and breaking up in situ of a patch of the Lower Silurian limestones, than an out-crop or exposure of crystalline limestone. Similar rocks were observed all the way northward to Swamp Creek, a distance of about four and a-half miles, for the whole of which distance the limestones form irregular hilly country, and present the appearance of a superficial deposit. The greater part of these limestones is of an arenaceous character, and of a brownish color on the weathered surfaces, but on fracture shews streaks of bluish and whitish colors. They are in places thickly interstratified with corrugated layers of siliceous slate or hornstone, and differ in a very marked manner from the crystalline limestones of the Laurentian formation—at least, so far as examined by me in this section of country. Imperfect bands of gneiss and hornblendic strata frequently occur with the limestones, but they occupy only a comparatively small portion of the country. Small exposures of grey calc-schists, similar to those of Madoc and Tudor townships, were seen a short distance above the point where the Mississippi River crosses the road. A little to the northward of Swamp Creek grey, speckled gneiss rocks are again brought to the surface, probably through a subordinate undulation, and occupy a few chains along the Frontenac road, beyond which the limestones and gneisses we have just been describing again come in, and continue northward along the road, to where they occur as already stated on lots forty-one and forty-two of this road-range, and where they may be said to form the limit of the basin in this direction. The width of the basin in Clarendon, as shown by the chained survey above mentioned, is close upon seven and a-half miles. In its extension into, and through Palmerston township, the extent and shape of it have not been clearly ascertained, and some further exploration is necessary both in this township and in Levant before the geological structure can be determined. In the Report of Progress, 1870-71, pages 311 and 312, I have alluded to a series of friable and silvery white mica schists, as occupying portions of Palmerston and Levant, and which,

Measurement of the Frontenac road.

Limestones.

Calc-schists like those of Madoc and Tudor.

Resemblance of mica schists to those of the White Mountain series.

according to Dr. Hunt, bear a close lithological resemblance to the schists of the White Mountain series in New England, and to those found both to the north and to the south of Lake Superior. The position or horizon of these rocks is at present being worked out in Levant and Blythfield townships, and I trust in a future Report to be able to state something definite respecting them.

Middle Section.

Middle Section.—This section embraces the country lying immediately to the southward of the granitic area of Kaladar, Kennebec, Olden and Oso; namely, the southern portions of these townships and the whole of South Sherbrooke and Bathurst. In it, the characters of the rocks are undoubtedly Lower Laurentian, being in a marked manner similar to those given by Sir W. E. Logan in the Geology of Canada, and by Mr. Thomas McFarlane in a series of papers on the "Primitive gneiss formation of Norway," published in the Canadian Naturalist and Geologist, vol. VII. The rocks met with are as follows:—great thicknesses of red, grey and whitish-grey gniess; for the most part clearly stratified, and with well defined strike and dip. Masses of hornblende rock and diorite, graduating into slate or schist often largely epidotic, with which are interstratified zones of rotten, rust-colored strata, or *fahlbands.* Large and important bands of crystalline limestone, and groups of calcareous strata, with which are also associated mica slates, some *fahlbands*, and workable beds and masses of magnetic iron ore. These rocks, as in the gniess region of Norway, are clearly interstratified, and maintain a general parallelism over a large extent of country. Their strike varies from E. and W. to N.N.E., and sometimes even to N.W., and their dip from S. to E. and N.E. at angles varying from ten or twenty degrees to vertical, in which respect they differ from most of the Laurentian rocks heretofore described in Canada and elsewhere. On this point Mr. McFarlane remarks: "It seems also respecting the Laurentian rocks of Norway, that a generalization is possible, as well with regard to the dip, as to the strike of the rocks constituting this group. The strata are almost always vertical or nearly so. This is the distinguishing character of the formation; and, *en passant*, let me remark the great difficulty hitherto experienced in all theorizings as to its origin. Horizontal and less inclined strata have indeed been remarked in several places, but they must be regarded as exceptional. The dip is almost always over 45°, generally 60° to 80°, while perfectly vertical strata are often observable." In portions of the townships of Kaladar and Kennebec, gneiss in an almost horizontal position covers a large area, and is followed by a series of schists, slates and crystalline limestones which are seldom inclined at a greater angle than 45°. With regard to the succession of these rocks, I think some general order may be observed. For example, the red and grey gneisses, almost invariably, immediately succeed and overlie the great areas of un-

Lower Laurentian.

Character of rocks.

Remarks by Mr. McFarlane.

Order of Succession.

stratified red granite; these are followed by gneisses in which hornblende becomes an important ingredient, and which almost imperceptibly graduate into the micaceous gneisses, schists and hornblende slates of the series. These again are overlaid by the calcareous groups and the more important bands of limestone. A similar succession of rocks would appear to be repeated between each of the bands of limestone—the volume of the intervening gneiss, hornblende rock and schist being to some extent proportionate to the thickness of the succeeding band of limestone. Whether this repetition of precisely similar rocks is due to frequent foldings of the strata, or whether they represent deposits made under like conditions during successive periods, or, still further, whether they may be looked upon as caused by repeated upthrows connected with faults, are questions yet undetermined, and which will require much detailed investigation. The possibility of upthrows connected with faults first suggested itself to me, while examining a series of granitic gneisses which crossed the Addington road in Kaladar, at a short distance below the road to Flinton Village. Here I found a great volume of stratified red gneiss, the planes of bedding well displayed, dipping at a slight angle to the south-eastward. On making a measurement transverse to the general strike, I observed that the out-crops of the different beds all presented a steep and abrupt face to the north-westward, and had the appearance of a gigantic flight of steps, or as if one plane of bedding after another, in succession, had slipped in the direction of the dip of the mass to the south-eastward. As I had previously examined this mass of gneiss in its extension a little farther to the south-westward, where the strata are inclined at a comparatively steep angle, and had estimated its thickness to be between one and two hundred feet, I was at a loss to account for its very sudden expansion in Kaladar. For on measuring as closely as possible the faces of the successive steps or out-crops—which I thought must represent the total thickness of the mass—I found it to be more than five times the above thickness. If, however, we suppose the 100 or 200 feet of gneiss to become inclined at a slight angle, and then to be traversed by parallel and almost equidistant breaks, connected with upthrows of the strata, the conditions observed in the gneiss hills of Kaladar would be produced, and the great apparent increase in the thickness would be accounted for. Respecting the sequence and distribution of the rocks occupying this middle section of country, my report must for the present be brief, as the work of examination is still in progress, and, in this thickly timbered country, is beset with so many difficulties, that any conclusions as to its geological structure would be premature. As mentioned in my last report, Report of Progress, 1871-72, page 120, the bands of crystalline limestone were made a special object of investigation; first, because they presented characters which

Repetition of strata.

Difficult country to work in.

Special investigation of limestone bands.

enabled them to be much more easily followed than any of the intervening gneiss bands; and secondly, because, that with them or in close proximity to them, there occur important economic deposits of iron ore and phosphate of lime or apatite. Therefore selecting the townships where these limestones were best represented, a section was made through Olden and Oso, which also extended a short distance into Bedford township. This line of section starts from near Conboye's Lake, situated on lots twenty in the tenth and eleventh concessions of Olden, and runs in a south-easterly direction through Sharbot Lake in Oso to the head of Crow Lake in the same township, and thence to the shores of Bob's Lake in Bedford, a total distance of about eleven miles. On this line no less than five apparently distinct bands of crystalline limestone are met with, separated by volumes of reddish granitic and dark hornblendic gneisses; they are as follows in ascending order, but at present no estimate of their respective thicknesses can be given:

Five distinct bands of limestone.

1. White Lake and Bolton's Creek band; crossing the boundary of Olden midway between Conboye's Lake and Sharbot Lake.
2. Upper Sharbot Lake, Playfairville, and Lanark village band; crossing Sharbot Lake at the Narrows in the first concession of Oso, where it is underlaid by much mica-slate, and is followed by dark hornblendic slate.
3. Lower Sharbot Lake, Maberly Lake and Bennet Lake band; crossing at the outlet of Sharbot Lake into the Fall River, and again at the extreme eastern end of the lake. This consists in reality of two bands, separated by a volume of gneiss, which is seen to form the promontory on lots six, seven, eight and nine, in the second concession of Oso.
4. Crow Lake, Rock Lake, and Silver Lake band; crossing the line of section at the extreme northern end of Crow Lake, at the boundary line between Bedford and Oso.
5. Bob's Lake, Tay River, and Myers' Lake band; occurring at the extremity of the line of section in Bedford, at the northern end of Bob's Lake.

The dip throughout this line of section is constant to the south-eastward, and varies from an angle of 28° to 60°. On another line of section made eight miles to the eastward of this, at about the centre of the township of South Sherbrooke, the four uppermost of these bands of limestome were again crossed, and a sixth met with, namely:—

Farren's or Sherbrooke Lake band.

6. Farren's or Sherbrooke Lake band, averaging two chains in width, and running E.N.E. along the southern shore of this lake in the first concession of the township. On a third line of section, made ten miles further to the eastward, from the village of Playfairville through Bathurst township, the second, third and fourth bands were again crossed.

Band (2) crosses the Mississippi River diagonally at the bridge in Playfairville; (3) is crossed at the bridge over the Fall River on the twenty-second lot in the tenth concession; and (4) on the line between the seventh and eight concessions of the same township. Continuing the line of section southward, gneiss was the only rock seen; but as the country here was covered by a considerable depth of soil, it is probable that the two remaining bands of limestone (5) and (6) are concealed. It will be seen from the foregoing, that the White Lake and Bolton's Creek band (1) was only noted on the first section line through Olden and Oso; it is probable that its further course north-eastward would carry it to the north of the townships of South Sherbrooke and Bathurst, namely, through the southern portions of the townships of North Sherbrooke and Dalhousie, which have yet to be examined. The total distance, represented by these lines of section, on which at least three of the bands of limestone were constant, is between eighteen and twenty miles. Country covered by soil concealing the rocks.

As already mentioned, ores of iron are of frequent occurrence in the neighborhood of these limestones, and some of these have been mentioned in my last report, (Report of Progress, 1871-72, pages 121, 122). Heretofore, no attempt has been made to assign them to any fixed geological horizon; it now, however, appears that these iron ores occur along lines which bear a certain relation to the course of some of the bands of limestone and form distinct horizons which can be followed, and in which other deposits of iron may be sought for. Immediately above the sixth and highest band of limestone, magnetic iron ore occurs in South Sherbrooke in two places, namely, at the Bygrove mine on the third lot of the first concession and at the Fournier mine on the fourteenth lot of the same range; also in other places on the same horizon to the eastward through Bathurst and to the south-westward through Bedford. At the base of the fifth band, magnetic iron occurs along the northern shore of Meyer's or Christie's Lake in South Sherbrooke, in the eighteenth, nineteenth and twentieth lots of the third concession, at the mines known as the "Watson" or "Meyer's, Lake mines." Immediately below the fourth or Crow and Silver Lake band of limestone, magnetic iron ore occurs at the Foley mine, in the tenth lot of the eighth concession of Bathurst, whence it is traceable through the eleventh, twelfth and fourteenth lots of the same concession; and here for the first time we find apatite or phosphate of lime in considerable deposits, closely associated with, and even in some instances intermixed with the iron-ore, a fact already alluded to (Report of Progress, 1870-71, page 313.) In the remaining third, second and first bands of limestone, no magnetic iron ore, so far as I am aware, has yet been met with, although at the base of each of these rust-colored strata occur. It is worthy of note, however, that the great bed of hematite in Dalhousie township, upon which is situated the "Dalhousie mine," (see plan accompanying this Report) Iron ores. Bygrove and Fournier mines. "Watson" or "Meyer's Lake" mine. Foley mine. Dalhousie mine occurs in a position between the first and second of these bands of limestone, and is not far removed from the base of (2). From the foregoing it will be seen, that in the section of country so far examined by me, magnetic iron ore has been found only in connection with the three highest bands of limestone; while in the other bands, it is represented by only rust-colored beds of gneiss and quartzite.

Eastern Section

Eastern Section.—This section comprises the townships of North Burgess, North Crosby, Bedford, Loughboro' and Storrington, which immediately border upon the waters of the Rideau. These townships have been already incidentally alluded to by Sir W. E. Logan, Mr. Alexander Murray, Dr. Hunt and myself in previous reports of the Geological Survey, but so far the facts mentioned have had more reference to the minerals of the limestones, and to economic deposits, than to the characters and distribution of the rock masses. These rocks, while they resemble in many respects those we have just been describing, yet present some important differences, and it is probable they represent beds somewhat higher in the series. The rocks most frequently seen are of the following characters, describing them in what appears to be their ascending order :—

Previous observations.

Character of the rocks.

1. Gneiss, largely composed of reddish feldspar and colorless quartz, in which the stratification is obscure.
2. Pyroxenic gneiss, coarsely granitoid in its lower portion, but towards its summit graduating into a pyroxenic schist, which holds small garnets in great abundance. It is traversed by a net-work of fine-grained granitic veins, of white and flesh-red colors, and is frequently cut by dykes of a fine-grained, black, glittering dolerite. Apatite or phosphate of lime occurs in this rock, and often forms deposits of economic importance.
3. Gneiss, largely composed of red orthoclase and quartz, of various shades of red and grey, in which the stratification is very obscure. Apatite or phosphate of lime also occurs in it in irregular grains and lenticular veins or pockets.
4. Limestone, coarsely granular, and highly crystalline, containing scales and crystals of a yellowish-brown mica, plumbago, and disseminated grains of apatite. It is associated with white and rust-colored strata, composed of quartz and orthoclase.
5. Reddish feldspathic and very quartzose gneiss, stratified and thinly bedded, holding light claret-colored garnets in great abundance, distributed along the planes of stratification.
6. Gneiss, fine-grained and micaceous, composed of alternate thin beds of grey and flesh-red colors. It is cut by a net-work of thread-like veins of reddish feldspar and quartz, which appear to emanate from lenticular patches of a similar character, occurring on the planes of bedding.

7. White and highly crystalline granular limestone, with which are interstratified bands of reddish gneiss, and white strata composed of quartz and orthoclase.
8. White and greenish, granular pyroxene, and granitoid pyroxenic rocks, holding apatite or phosphate of lime in disseminated grains and irregular veins. The veins show aggregations of crystals of apatite and black mica in a pyroxenic gangue.

This last group occurs at the summit of the series, and occupies the centre of the North Burgess synclinal.

Distribution and surface features. The geographical distribution of these rocks—as in the county of Hastings—shows a series of north-east and south-west undulations, corresponding with anticlinal and synclinal forms, the latter occupied by the upper rocks 2, 3, 4, 5, 6, 7 and 8, in long irregular and comparatively narrow troughs. These undulations are crossed at intervals by south-east and north-west ridges which intersect and limit the synclinal valleys. The axes of these north-east and south-west undulations in the townships above named form four irregular and curving lines, roughly parallel to one another, marking, as far as ascertained, two anticlinals and two synclinals. **Parallel undulations.** In the remarks which follow, I shall confine myself to the first or more north-westerly of these anticlinal axes, and to the synclinal which immediately adjoins it to the south-eastward; the second or more south-easterly anticlinal not having yet been fully investigated. This first or north-western anticlinal may be represented by a line drawn from the north-eastern corner of North Burgess south-westward between Black and Pike Lakes, through the centre of North Crosby, and thence through the southern arm of Wolf Lake in Bedford, and through the entire length of Canoe Lake into Loughboro' township. Along the whole of this line, the red and obscurely stratified gneiss (1) forms the crown of the anticlinal. In North Burgess to the north-eastward, and in Bedford, to the south-westward, this rock occupies but a comparatively small portion of the country, but in its intermediate position in North Crosby, a north-west and south-east line of elevation causes it to spread over the greater part of this township, where it is thrown into a series of high hills, known by the name of the Westport Mountains, which border upon the waters of the Rideau, **The Westport Mountains.** from the Narrows between North Burgess and North Crosby, north-westward to the head of Wolf Lake in Bedford. This transverse elevation of the gneiss in North Crosby separates the troughs in North Burgess from those in Bedford. On descending the Westport Mountains to the Rideau,—here represented by Sand, Mud and Wolf Lakes—there is a very sudden change in both the physical and geological aspect of the country, which thence, to the south-western quarter of North Crosby is flat and cultivated. This change is apparently caused by a fault, running **Fault.** in an east and west direction, which brings the horizontal limestones of the

Contact of Silurian and Laurentian rocks.

Lower Silurian formation into abrupt vertical contact with the Laurentian gneiss. The gneiss (1), however, greatly diminished in volume, is still seen along the crown of the anticlinal from Wolf Lake to the southern extremity of Canoe Lake in Bedford. This break or fault is the first of a series of parallel faults which occur to the south-westward, through the townships of Bedford, Storrington and Loughboro', and which will be described in a future report.

Position of phosphate deposits.

In the Report of Progress for 1871–72, page 123, in connection with notes on the phosphate locations of North Burgess and Bedford, I briefly alluded to the south-eastern of these two synclinals or troughs, stating that in it the detailed sequence of the rocks had yet to be investigated but that the workable deposits of phosphate of lime appeared to me to "occur in a certain belt or zone of pyroxenic and gneissic strata, and in the form of lenticular bedded masses, and irregular veins." I further stated that "this belt or zone, which was found to have a thickness of from 2,600 to 3,900 feet, lies in a long irregular trough, the axis of which may be described as running from the north-east to the north-west corner of North Burgess, thence south-westward through South Crosby into the south-east corner of Bedford township—between Devil and Opinicon Lakes—and still further in this direction through the townships of Storrington and Loughboro'." These statements now require to be somewhat modified, and in further describing the south-eastern trough, it seems advisable to subdivide it into two parts, namely :—

1. *The North Burgess Phosphate Basin.*
2. *The Bedford, Storrington and Loughboro' Phosphate Basin.*

Whether these basins form portions of one or two distinct synclinal forms, remains to be determined.

North Burgess phosphate basin.

The North Burgess Phosphate Basin.—The general characters and sequence of the rocks occupying both of these basins has been already given in the list, page 162 numbers (2) to (8) inclusive but the following section made in North Burgess furnishes some further details of importance, and will better illustrate what I have further to state respecting the distribution of the respective rock masses. This section was made at the extreme south-western end of Black Lake and on the northern side of the basin; the strike of the rocks being to the east and west, with dips varying from 45° to vertical.

Section at Black Lake.

a. Pyroxenic gneiss, varying in color from grey to a greyish blue, sometimes speckled; it is both massive and schistose, and towards its summit becomes garnetiferous, the garnets being mostly small and of a pale claret color. It is cut in many places by a net-work of fine-grained whitish granitic veins, and an occasional doleritic dyke. Apatite or phosphate of lime occurs as described in (2) of the more general and immediately preceding section.

b. Reddish contorted quartzose gneiss, also holding a little apatite, and black mica, in irregular veins or pockets.

c. Coarse white crystalline limestone, with which are interstratified masses of a white and rust-colored aggregate of quartz and orthoclase, and an occasional band of gneiss. The limestone is characterized by an abundance of disseminated plumbago, and grains of a greenish-blue apatite, as well as of a dull greenish pyroxene and small crystals of yellowish-brown mica.

d. Thin-bedded gneiss of a brick-red color.

e. Banded reddish and very quartzose garnetiferous gneiss, composed of alternate thin layers of reddish feldspar and cellular colourless quartz. The garnets are small, and are thickly distributed along the planes of stratification.

f. Whitish granular pyroxene, and rock composed chiefly of quartz and orthoclase, but in which both apatite and mica occur, either in the form of aggregations of crystals, or as grains and crystals disseminated through the mass.

g Thin-bedded grey and reddish, cleavable gneiss, cut by a network of fine-grained feldspathic veins, and with interstratified layers of a like character.

h. Massive, and granular, white, crystalline limestone, with disseminated plumbago, and yellowish-brown mica, with which are interstratified numerous small bands of reddish orthoclase gneiss.

i. Pyroxenic rocks, similar in character to those of division (*f*), but much more extensively developed. These appear to occupy a position at the summit of the series, but it is not improbable that they may prove to be merely a repetition of (*f*) brought to the surface by a subordinate undulation.

The pyroxenic rocks of (*a*) are very largely developed in North Burgess, immediately to the north of Black or Salmon Lake Creek in the western portion of the seventh, and between this creek and the southern shore of Pike Lake, in the eighth concessions. Their strike coincides with the general outline of the north-western shore of the lake, namely, first to the N. E. and then to the N. N. E., and the dips which are constant to the south-eastward are at angles varying from 40° to 60°. Towards the northern extremity of Black or Salmon Lake, these rocks are overlaid and concealed by a great patch of horizontal Potsdam sandstone; but similar pyroxenic gneisses were again noted, on the northern side of the trough, through the twelfth, eleventh, tenth, ninth, and eighth lots in the seventh concession, where the strike is still to the north-eastward, and the dip to the south-eastward, but at a very steep angle. Proceeding north-eastward, into the eighth concession, these rocks were further traced from the seventh to the first lot, where they are

Potsdam Sandstone.

in an almost vertical position, and strike east and west. Thence striking in the same direction they extend to and along the northern shore of Otty Lake, on the front portions of the fourth, third, second, and first lots of the same concession. It is extremely probable that a similar and abrupt change of strike, concealed by the overlying Potsdam sandstones, affects the pyroxenic rocks of Black or Salmon Lake, connecting them with those first followed through the twelfth, eleventh, tenth, &c., lots of the seventh concession. On the course of the pyroxenic gneisses (*i*) through North Burgess, large deposits of apatite or phosphate of lime are of frequent occurrence; many of these, which have already been described in the Report of Progress, 1871–72, pages 124 and following, are still being worked successfully, and will be further noticed in a future Report, which it is proposed to accompany with a suitable map shewing the position of every shaft or other opening, from which phosphate of lime has been extracted.

Map.

The outcrop of these pyroxenic gneisses, on the southern side of the North Burgess trough or synclinal, occurs to a large extent under the waters of the Rideau, but they again occupy a considerable area from the eleventh to the sixteenth lot of the third, and from the fifth to the seventeenth lot of the fourth concession of this township, where the strike is to the E. N. E., with dips to the northward at steep angles. And I would here note, *en passant*, the uniformly steep dip, and often even vertical position of the rocks, on the southern side of these synclinal forms, while that on the northern side is almost invariably at angles, varying from 40° to 60°. Another section, made from one of the foregoing lots, namely, lot eleven in the fourth concession, may here be given, as illustrating the characters and sequence of the rocks on the southern side of this synclinal in North Burgess. It is as follows :—

Section on the southern side of the North Burgess basin.

a. Banded, and thin-bedded gneiss, more or less pyroxenic, with east and west strike, and steep dip to the northward. This rock extends transversely to its strike, from Hogg's saw-mill southward to the Rideau.

b. A marked rust-colored, quartzo-orthoclase rock, sometimes weathering opaque-white, when it much resembles the surface appearance of the white crystalline limestones.

c. Coarse-white and easily disintegrating crystalline limestone, with yellowish-brown mica and scales of plumbago; it often encloses fragments of rusty-colored quartzite, in which plumbago also occurs. Bands of rust-colored gneiss are also interstratified with the limestone.

d. White and rust-colored quartzo-orthoclase rock similar in character to that of division (*b*).

e. White-weathering pyroxenic, and quartzo-orthoclase rock with apatite in grains and bunches of crystals; and a great deal of dark colored mica in crystals of various sizes.

f. Thin-bedded feldspathic gneiss, characterized by an abundance of garnets, and composed of alternate layers or beds of colorless cellular quartz and reddish feldspar. This gneiss is much fissured, and is cut by veins of pink calcite, holding numerous beautiful crystals of a pale-green apatite, greyish pyroxene, and an abundance of very black mica.

g. White-weathering pyroxenic, and quartzo-orthoclase strata, similar to (*e*).

h. Reddish orthoclase gneiss, and whitish orthoclase and pyroxenic rocks, much confused, and traversed by a multitude of white granitic veins.

This, and the section previously given, the one on the northern and the other on the southern side of the North Burgess phosphate basin, will show at a glance the characters and sequence of the rocks which occupy it, and I shall now briefly notice the further distribution of the more important of these rocks. On the northern side of the basin, and almost immediately overlying the pyroxenic gneisses (*a*) we have an important band of crystalline limestone (*c*). This was first observed on the boundary line between North Crosby and North Burgess, a few chains south of Black Creek, and was traced eastward through the sixth concession, to the twenty-third lot in the same concession, where it runs into Black or Salmon Lake. Crossing the bay at the southern end of this lake, it was again seen occupying the opposite shore on lots twenty-one, twenty and nineteen in the sixth concession; where it runs into Black or Salmon Lake. Crossing the bay at the southern end of the lake, it was again seen occupying the opposite shore on lots twenty-one, twenty and nineteen in the sixth concession; whence, changing its course, it runs north-eastward through the last named lot, across the base of a long promontory, and passes beneath the main body of the lake. It, however, continues to occupy points on the shore, towards the rear ends of lots eighteen, seventeen and sixteen in the sixth, and fifteen in the seventh concessions, and also forms part of an island situated near the centre of the lake on the line between these two concessions. The further course of the limestone in this direction is concealed by the patch of Potsdam sandstone already referred to, but a band of similar character was again noted along the northern shore of Long Lake, towards the fronts of the tenth, ninth and eighth lots of the sixth concession, where it is in a similar relative position to the pyroxenic gneisses, as the Black or Salmon Lake limestone just described, and of which there can be little doubt it is a continuation. From Long Lake this limestone was further traced through the fronts of the sixth and seventh lots, and

Black or Salmon Lake.

Long Lake.

Otty Lake.

the centre and rear portions of the fifth, fourth and third lots of the sixth concession, where it forms a part of the shore of Otty Lake. Beyond this point its course is again concealed by the Potsdam sandstone. Its southern out-crop was followed north-eastward through the rear parts of lots twenty-five, twenty-four and twenty-three of the fourth concession, and front portions of the same numbered lots in the fifth concession, beyond which its course changes, and it thence appears to strike in an easterly direction to an indentation of the Rideau, known as Horse Shoe Bay, on the seventeenth lot of the third concession, where it is folded back upon itself so as to double the width of its out-crop. It then strikes in a westerly direction from the sixteenth lot of the third, through the seventeenth and eighteenth lots of the fourth concession to Black Creek, where, making a sharp turn, it resumes its easterly course following the northern bank of the creek, through the fronts of lots seventeen, sixteen, fifteen, fourteen and thirteen, in the fifth, and rear portions of the same numbered lots, and the twelfth lot in the fourth concession. The course of Black Creek from where the band strikes it as above described indicates the junction of the crystalline limestone with the pyroxenic gneisses. Proceeding eastward, the same band of limestone occupies the strip of land between Loon Lake and Burgess Bay on the Rideau, and after coursing through the rear and front portions of the ninth, eighth and seventh lots in the fourth and fifth concessions, again passes beneath the waters of the Rideau at Murphy's Point in Noble's Bay, on lots seven on the line between the same two concessions, beyond which it is lost sight of. It may be mentioned that in a map now in preparation the course of these two out-crops of limestone, on the opposite sides of the Burgess synclinal, will be clearly shown. This map will, I trust, also afford a much clearer understanding both of the outline of this synclinal, and of the distribution of the rocks which occupy it.

Map.

It is unnecessary to go over the same ground in describing the further distribution through North Burgess of the remaining rocks of the sequence. I would, therefore, simply state that the course just sketched out for the crystalline limestone (*o.*) will also indicate sufficiently that of the banded and quartzose garnetiferous gneiss through the township. In this gneiss the garnets, which are mostly small and of a claret color, are always present, but in some localities are much more numerous than in others. An average estimate of the thickness of this garnetiferous gneiss may be given as 600 feet, and it is overlaid by a body of red gneiss, averaging at least 600 feet more, making in all a volume of gneiss estimated at 1,200 feet. The centre of the trough is occupied by reddish and white quartzo-orthoclase and granular pyroxenic strata, which are much confused, and irregularly distributed. These are particularly well displayed in North

Thickness of garnitiferous gneiss.

Burgess, between Long Lake and Noble's Bay, through the centres of lots eight, nine and ten of the fifth concession, and four, five and six of the sixth concession, where the dip of the beds is slight, while sometimes they are nearly horizontal.

A doleritic dyke was traced from the centre of the first lot, in a westerly direction, to the rear portions of the fourth and fifth lots of the fifth concession, and thence to the fronts of the ninth and tenth lots in the sixth concession. It is composed of a fine-grained, black, glittering dolerite, weathering to a greyish-white, and holds disseminated grains of pyrites. The strike of this dyke is from N. 80° E. to E., with steep underlie to the northward, and in width it varies from four, to one hundred feet. In the *Geology of Canada*, 1863, pages 37 and following, mention is made of a number of doleritic dykes, similar in character to the one just mentioned, in North Burgess, and these were traced by Sir W. E. Logan for long distances, on an almost east and west strike, through Grenville and Went worth, north of the Ottawa River; their width varying from a few feet to one hundred yards. In these townships the rocks are in many respects similar to those of North Burgess, both in their general characters and mode of distribution, and they, also, like them, contain phosphate of lime and mica; the latter in sufficiently large crystals to be of economic value. It is more than probable that in both of these localities, namely, North Burgess, in Lanark County, and Grenville and Wentworth, north of the Ottawa, the rocks are of the same geological age, and represent a very recent portion, if not the summit, of the Lower Laurentian series. In the townships of Burgess, Bedford, Storrington aud Loughborough, these rocks are intersected by numerous veins, carrying baryta and lead ore, which likewise cut the overlying and unconformable Calciferous formation, but do not, so far as known, extend into the inferior gneisses and limestones which occupy the area described in this Report as the middle section. Further, it will be remembered, that in the county of Hastings, and townships of Madoc, Marmora, Lake and Tudor, similar veins, carrying baryta and lead ore are found intersecting the calc-schists, dolorites and gneisses of Division C. (Report of Progress, 1866-69, page 163), which in like manner occupy troughs or depressions in the older rocks. These facts suggest some questions of great importance, which when satisfactorily answered will throw much light upon the age of these trough-forms of rocks both in Hastings, Lanark and Ottawa counties, and will further, perhaps, enable us to arrive at some definite conclusion respecting the range of *Eozoon Canadense*, in the Laurentian system.

Dolerite dyke.

Veins of baryta and lead ore.

Range of Eozoon Canadense.

In addition to the dykes of dolerite which traverse the rocks in North Burgess, there are also large and important veins, composed of white orthoclase and opaque-white quartz. One of these occurs a few chains south of the mouth of Black Creek, at the south-western end of Black or Salmon

Veins of orthoclase and quartz.

Lake. This vein was of an opaque-white colour on the weathered surface, and varied in width from three to eighteen feet. It is composed of large cleavable crystals of milk-white orthoclase and white quartz in irregular forms, together with hornblende in similar forms, and in scattered crystals. The crystals of hornblende occupy the sides of the vein, and are arranged transverse to its strike, while the irregular forms occur towards the centre portion, and are distributed along a medial line on the strike of the vein. Silvery-white mica in small scales, and light greenish-yellow pyroxene also occur occasionally. The strike of the vein is N. 30° E., with a steep underlie to the north-westward, and it was traced upwards of an eighth of a mile in this direction. A similar, or probably an extension of the same vein, was again crossed in the "Old Kingston road," in the seventeenth lot of the seventh range of North Burgess, where the strike is still N. 30° E. Such veins belong to the second class of mineral veins (described, Report of Progress, 1863-1866, page 187) which are found to cut the Laurentian, but have not been observed to intersect the Silurian rocks.

Bedford, Storrington and Loughboro' basin.

2. *Bedford, Storrington and Loughboro' Phosphate Basin.*—This synclinal or trough is occupied by rocks precisely similar to those of North Burgess, consequently the sections already given may still be referred to. It is situated about ten miles to the south-westward of the last named township, from which it is separated by the waters of the Rideau and by a great patch of Lower Silurian limestones, both of which conceal the structure of the intervening phosphate bearing rocks. As this second basin has as yet been only partially investigated, I shall at present attempt little more than a sketch of its general outline, with some observations on the probable course along which deposits of phosphate of lime may be expected to occur.

A line, which may be said to represent as nearly as possible the axis of this synclinal, runs from about the centre of Wright's Island,—situated in the Rideau, towards the north-west corner of South Crosby township,—south-westward through the south-eastern corner of Bedford, and midway between Buck Lake and Opinicon and Rock Lakes in Storrington and Loughboro' townships. The outline of this trough is clearly indicated by two out-crops of white crystalline limestone, a north-westerly and a south-easterly one, which converge on their south-westward course until they meet or almost meet at the extreme south-western end of Buck Lake in Loughboro'. This limestone is supposed to represent division (*c*), as given in the section page 165, where, it will be remembered, the limestone was stated to be immediately underlaid by pyroxenic and orthoclase gneisses, through which apatite or phosphate of lime was of frequent occurrence. The north-western out-crop of this limestone is first seen coming from under the Lower Silurian limestones, at about half a mile south-westward of the village of Newboro', where it is not far from the Chaffey iron mine on Mud Lake. From this position it was followed by occasional exposures along the shore of Mud Lake on the Rideau, eastward, to the northern extremity of Wright's Island, and thence close to Mr. Chaffey's Mills, through the twenty-fifth lot of the ninth concession of South Crosby, beyond which it passes into Bedford, and keeping to the south of Massasagua Creek, curves through the sixteenth, fifteenth and fourteenth concessions of this township and passes beneath the north-eastern end of Buck Lake, close to its outlet into the creek just named.* Its course thence is south-eastward through the entire length of the eastern arm of this lake in Loughboro', the breadth of which almost corresponds with the width of the limestone. Several islands in this arm are entirely composed of white crystalline limestone, and some of these rise abruptly out of the water to a perpendicular height of from sixty to seventy feet.

Wrights Island.

By the long continued action of the water, these masses or islands of limestone have been fashioned into grotesque shapes, and hollowed out into deep caverns, and two of the former, towards the northern extremity the lake, are distinguished respectively by the names of the "Devil's Pulpit," and "Devil's Arm Chair." The eastern side of the long promontory which divides this lake into two arms, is also in part occupied by white crystalline limestone, which is closely associated with masses of white quartzo-orthoclase rock. Towards the south-western extremity of this eastern arm of Buck Lake, the out-crop of limestone just described forms a junction with that on the south-eastern side of the trough or synclinal, which may here be said to terminate.

The south-eastern out-crop of this band on the opposite side of the trough was traced along the greater part of the northern shore of Opinicon Lake, in South Crosby and Bedford; thence in a south-easterly direction along the road leading from this lake to the south-eastern end of Rock Lake in Storrington, where a fault occurs which throws the out-crop of the limestone in a westerly direction to Stonehouse Lake, a small lake situated—as nearly as I could determine—on the rear portions of lots six and seven of the thirteenth concession of the township last named. From this position it resumes its original south-westerly course, and was thence followed to its junction with the limestone of the eastern arm of Buck Lake in Loughboro'. The greatest distance observed between these two outcrops of limestone on opposite sides of the trough, is about two miles and a-half. Immediately underlying this limestone along the whole of its course, there occurs a belt of gneissoid strata abounding in garnets, and towards its upper portion becoming thin-bedded and schistoze, in which

* I have been unable to find any correct map of this lake, and it will require to be re-surveyed.

deposits of phosphate of lime frequently occur, but to what extent is not at present known. During the summer of 1872, while engaged in endeavoring to connect these rocks with those of North Burgess, I was followed by a number of persons who were on the look out for new phosphate locations, some of whom afterwards opened numerous trial pits on the strike of a certain band of gneiss in which I informed them it was probable the phosphate of lime would be found; and I have since learned through letters kindly forwarded to me, both by Mr. Edward Schultze and Mr. William Davis, of Perth, Ont., that a number of these trials have already proved, in a measure, successful. On lot six in the thirteenth concession of Bedford, and not far from the shore of Devil Lake, there occurs an exceedingly promising deposit, from which a very good quality of phosphate of lime has been obtained; but as is usually the casewhen inexperienced hands are employed, an immense amount of useless rock has also been removed, and has been piled up upon the very ground on which an opening should have, perhaps, first been made. From this lot the phosphate bearing rocks were traced south-eastward through the fifth and fourth lots of the sixth concession, as well as through the third, second and first lots of the twelfth concession of Bedford, to the northern end of the western arm of Buck Lake. Along this course phosphate of lime was frequently noted, and more particularly so on the last named lot in the eleventh and in the twelfth concessions. The long promontory, which separates the two arms of Buck Lake in Loughboro', like wise consists of reddish, banded gneiss, occasionally interstratified with beds characterized by an abundance of garnets; and in proximity to some of these, on the western side of the promontory, a few déposits of apatite have been observed. While engaged in exploring this promontory, and the country contiguous to Buck Lake, I was besieged by settlers who assured me that they had abundance of "phospphuret"—as they term it—on their lands, but in most instances the specimens shown me were crystals or fragments of greenish pyroxene, a mineral which abounds in many of the veins throughout this section. Other specimens, however, brought to me were undoubtedly true phosphate of lime, and in such cases every encouragement was given to the land-owners to follow up their discoveries. In this connection I may state that a great hindrance to the development of phosphate lands, both here and elsewhere, is the ridiculous prices asked for them by land-owners, who, unfortunately for themselves and others, have heard of some of the enormous prices recently stated to have been paid for such lands in North Burgess. It must, however, be borne in mind that in this latter township, phosphate deposits have been more or less worked for upwards of twenty years, and this in a country which is well cleared and settled, and abounds in roads; yet even here, up to the present time, there are

Promising deposit of apatite.

Hindrance to the development of phosphate lands.

only one or two phosphate mines that can be said to have turned out well. Besides, the sales recently made in North Burgess include the fee-simple of the lands as well as all the mining rights, and, in some instances, also valuable farms, and good mill sites, with easy access to navigable waters; yet with all these advantages, the general opinion amongst experienced men still is, that the prices paid have far exceeded the actual value of the lands. In the phosphate-bearing section around Devil and Buck Lakes in Bedford and Loughboro' townships, there are none of these advantages. The country is rough and almost uncultivatable, heavily timbered, and traversed by but few roads: while access to navigable waters is, at least for the present, an expensive and difficult matter. Besides this, the ground is new and comparatively unexplored, and it will probably be years before the country is in a suitable condition for even systematic prospecting. In view, therefore, of these facts, I would strongly urge upon the settlers throughout this section of country the better policy of throwing their lands open to intelligent prospectors, and giving them sufficient time to make a fair trial of the ground. Mr. Edward Schultze, a gentleman whose name has been already mentioned in this and in a previous report, and who has for some time both bought and mined phosphate of lime in North Burgess and South Crosby for export to Germany, has recently turned his attention to the Bedford and Loughboro' phosphate-field; and in a letter recently received from him, he speaks in most favorable terms ot a number of localities opened by him in both of these townships; all of these openings being on, or in proximity to the course of a belt of gneiss, which maintains a fixed relation to the course of the band of limestone already described through Bedford and Loughboro'.

Better policy suggested.

The phosphate mine described as Cowan's Location No. 19 (Report of Progress, 1871–72, page 129), is situated on the southern side of this second trough or synclinal, and the produce can be shipped from Mr. Cowan's wharf on Opinicon Lake, and sent without change, *via* the Rideau Canal, to Kingston, Montreal and ports in the United States. From the Opinicon Lake mine, phosphate-bearing rocks can be traced south-westward along a part of the northern shore of Rock Lake in Storrington, to the fault or break referred to on page 163, and which also throws the rocks we are now describing in the same direction. Beyond this fault to the south-westward, the course of the gneiss has not been clearly made out, but in many localities between the fault and the Opinicon Lake mine, phosphate of lime is reported to exist. None of these localities, however, have yet been examined, and further notice of them will have to be deferred to a future report, in which I shall also describe the distribution of the succeeding rocks in the centre portion of this trough, and also the geological structure of the remaining portions of Bedford, Storrington and Loughboro' townships.

Cowan's phosphate mine.

Levels of Lakes.

Levels of Lakes.—In compliance with the request mentioned page 138 of this report, the levels of some of the principal lakes above Lake Ontario, as determined by Mr. Alexander Murray, and given in his Report of Progress, 1852–53, now out of print, are here repeated.

Name.	Townships.	Height in ft.	Falls into
Loughboro' Lake	Storrington & Loughboro'	166·12	Rideau River.
Sloat's Lake	Loughboro'	189·05	Lake Ontario.
Knowlton Lake	"	217·53	Mud Lake.
Mud Lake	"	217·53	Desert Lake.
Desert Lake	Bedford	217·53	Birch Lake.
Birch Lake	"	217·53	Devil Lake.
Devil Lake	"		Rideau River.
Canoe Lake	"	229·97	Desert Lake.
Batting's Mill Pond	"	287·00	Wolf L. & Rideau R.
Green Bay & Bob's L.	"	384·80	Tay & Rideau Rs.
Crow Lake	"	398·88	Mud Lake.
Sharbord Lake	Oso and Olden	505·29	Madawaska & Ottawa Rs.
White Lake	Olden	555·29	Sharbord Lake.
Cross Lake	Kennebec	412·84	Long Lake.
Long Lake	Sheffield	365·69	Beaver Lake.
Beaver Lake	Sheffield	307·22	Salmon R. & B. of Quinte.

ECONOMIC MINERALS.

The minerals of economic value known to exist in the three sections of country described in the foregoing Report, are the ores of iron, lead and copper, phosphate of lime, sulphate of barytes, plumbago, mica, garnet rock, and building and paving stones. Of these the most important are the ores of iron and lead, phosphate of lime, plumbago and mica.

Iron ores.

Iron Ores.—In my last Report (Report of Progress, 1871–72, pages 121–123) the principal iron mines, viz: the Chaffey, Yankee, Bygrove, Fournier, Christie's Lake, Foley and Dalhousie mines were briefly described, and partial analyses of all but one of the ores were given. In the foregoing pages of the present Report, I have further attempted to show the true geological position or horizon of the ore beds in these mines, and I shall now describe the Meyer's or Christie's Lake iron ore deposits, of which no particulars were previously given; and then give a summary of the work done at the Dalhousie Iron Mine since the year 1870.

Meyer's or Christie's Lake mine.

Meyer's or Christie's Lake Mine (*Watson Mine.*)—This location is situated on the eighteenth, nineteenth, and twentieth lots of the third concession of South Sherbrooke, and embraces an area of 259 acres; the openings made, are on the first and last numbered lots. On a high bluff on the north shore of the lake, on lot eighteen, three beds of iron ore have been uncovered, and to some extent worked during the past summer. The strata, which here consist of dark greyish and greenish hornblendic gneiss, dip to the southward at angles varying from 15° to 80°. The uppermost bed of ore, and the nearest to the lake, has been uncovered for about thirty-five feet in length, by twenty-four feet in breadth, and a considerable mass of ore has been exposed. No walls have yet been reached, and I think it is probable that the uncovering has been extended on the face of the bed rather than across its out-crop. In the second and underlying bed a breadth of eighteen feet of ore has been uncovered, and can be traced by openings made on its course for a distance of upwards of 150 feet. In the third and lowest bed a well defined foot wall of gneiss has been struck, and a solid mass of ore is exposed measuring eighteen feet in width. The extreme distance between the openings on this property on the strike of the ore beds, is nearly one mile, and the distance between the top of the upper and the bottom of the lower bed of ore is about 300 yards. Several hundred tons of ore have been taken out, but operations have been chiefly confined to the determination of the extent of the deposits, which is now pretty satisfactorily known. An experimental shipment of the ore has been made to Cleveland, and it is reported to have given perfect satisfaction to the smelters, and it has further been ascertained that this ore will produce a quality of iron well suited for the manufacture of Bessemer steel. An analysis made by Dr. Harrington of a sample of the ore which I brought from this location, gave as follows:

Shipment of ore to Cleveland.

Analysis.

Metallic iron	65.62 per cent.
Titanic acid	2.83
Phosphoric acid	0.05
Sulphur	not determined.

Facility for mining and transport.

It may be further stated that the facilities for mining here are favorable; the position of the ore on a high hill affords easy and cheap drainage, and a ready means of disposing of the *debris*, and these mines can probably be worked for a considerable time before resorting to expensive underground operations. Respecting the facilities for the shipment of the ores a gentleman of long experience in matters pertaining to the transport of iron ores from Canada to the United States, and who has recently thoroughly examined the Christie's Lake deposits, writes me as follows:—"The facilities for transporting ore, either by rail or water, from this property to the Lehigh Valley and the western markets, are unusually favorable. The Ontario and Quebec railroad, now under construction, passes one and a-half miles north, and intersects the Kingston and Pembroke Railroad about eight miles west of the mine. This junction is thirty-four miles north of Kingston; about ten miles to the eastward it will intersect the Brockville and Ottawa Railroad at Perth." Five different routes are then given by which this ore can be forwarded to the St. Lawrence, and thence to any part of the United States. For present consideration the last or fifth only need be mentioned.

Route.

This is given as follows:—"In cars, per scow up Bob's Lake, and per Kingston and Pembroke Railroad, to Kingston, (25 miles); thence by canal barges or lake crafts, to Oswego, Fairhaven, Buffalo, or Cleveland. This would be the cheapest and most desirable route. The mine being situated at the base of a high hill, on the water's edge of Meyer's Lake, scows might be constructed to carry six or more cars, which could be run from the scow into the mine or open cutting; the same method could be adopted on reaching the Kingston and Pembroke Railroad, on the west side of Bob's Lake, which point is 25 miles from Kingston. The ore by this route would cost per ton :—

Cost of the ore delivered at Cleveland.

	Delivered at Cleveland, O.
Mining, in open cutting...............	$0.75
Loading in cars, in do.................	0.05
Towing up Bob's Lake.................	0.10
R.R. freight to Kingston (25 miles)	0.50
Lake freight to Cleveland............	0.70
Duty*..	0.40
Gold.....................	2.50
American currency at 10 per cent..	$2.75

Kingston ore docks.

At Kingston, where ore docks are being constructed by the Kingston and Pembroke Railroad Company, the ore can either be dumped into Erie canal barges for Oswego, &c., &c., or into lake schooners seeking return freights westward; three-fourths of these vessels discharge their western cargoes at Kingston, returning generally in ballast. Freights range from 64 cts. to 75 cts. per ton to Cleveland, including loading and discharging."

The accompanying plan and sections of the Dalhousie Mine are taken from drawings and measurements kindly furnished by Mr. Gerald C. Brown, M. E. The sections afford an excellent illustration of the character and mode of occurrence of the ore deposits.

Dalhousie Mines.

Plan and Sections.

Description of works.

Dalhousie Mine.—Before the spring of 1870, the shafts No. 1 and 2 (see plan) had been sunk to the depth of 35 and 30 feet respectively, and from between these two shafts the ore had been partly removed. The ore had likewise been removed on the south side of No. 1 Shaft, as far as the middle of the road. Between the months of May and October inclusive, of the year 1870, both of these shafts were sunk to between 60 and 70 feet, and the stopes were extended to the break on the south and nearly as far as No. 3 shaft on the north, and downwards to within 8 or 10 feet of the bottom of No. 1. Early in November the incoming waters from the fall rains overcame the power of two horses, working a derrick, to keep it out, the works consequently filled and remained full of water until the following June. Between November and February, 1871, the No. 3 shaft, being above the water level in Nos. 1 and 2, was sunk, and the stopes

* It is expected the duty will be repealed at an early date.

connected with it were worked to the extent shewn in the accompanying section. During the same fall, No. 4 shaft was begun and sunk to the depth of 22 feet. The yield of ore from May, 1870, until the end of February, 1871, was 3,850 tons of 2,240 lbs., costing, not including plant, $1.25 per ton, and including plant, $1.46 or 21 cents additional, The contract price of hauling the ore to Perth, during the winter of 1870–71, was $1.00 per 2,240 lbs. The ore contains no rock, and does not pass into, but separates easily from, the walls, which are smooth and well-defined. No work was done from the month of February, 1871, until the following month of June, when a horse-pump was put into No. 1, and this shaft and No. 2, and the stopes connected therewith, were further extended till towards the end of the year, when the water overcame the power of the horse pump and work was supended. During January and February of 1872 the drift was extended from No. 3 shaft to within twenty-five feet of No. 4 shaft. The production from January to the end of February, 1872, was sent to Perth in loads which averaged four and a quarter tons, at $1.05 per ton. During the spring and summer of 1872 the No. 4 shaft was sunk to ninety-four feet, and the stopes were afterwards extended to the dimensions shewn in the plan. The production from February, 1872, to the end of February, 1873, was forwarded to Perth at $1 per ton, in loads which averaged three and three quarter tons, thence to the Rideau canal at 60 cents; thence to Kingston at $1.25 to $1.50, and thence to Cleveland at from $1 to $1.50. The total production from 1870 to 1873, has been rather over 11,100 tons. The wages of the hands employed have varied from 80 to 90 cents per day, with board.

Yield of ore

Total production from 1870 to 1873.

Phosphate of Lime.—In my last Report (Report of Progress 1871-72) I dwelt at some length, on the phosphate of lime deposits in the townships of North Burgess, South Crosby and Bedford, and on page 124 of that Report some nineteen locations are mentioned in which work to a greater or less extent was being carried on. Respecting these, I have little further to state, except that in the greater number of them all work has since ceased; the only locations in which anything like systematic and profitable mining is at present in progress, are those worked by Mr. Anthony for an English company, on the tenth and twenty-first lots of the sixth concession of North Burgess (No. 8 and 13 of my former list), and by Mr. Alex. Cowan, on the eleventh and twelfth lots of the seventh concession of the same township, and the first lot of the seventeenth concession of Bedford, near Opinicon Lake, (Nos. 7 and 19 same list). These are perhaps amongst the largest and best defined deposits of apatite which have yet been discovered, and should these fail we can have little further to hope from discoveries of this mineral in the future. The reason given for the cessation of work in most of these locations is the very high rate of

Phosphate of lime.

freight to England, which cannot now be obtained for less than fifty shillings sterling per ton.

Plumbago.

Plumbago Mine.—In the township of North Elmsley, on the twenty-first lot of the sixth concession, a mine of plumbago has been for some time in operation, under the management of Mr. Munsey, who was formerly engaged at the Howse iron mine in Bedford. The plumbago occurs in thickly disseminated scales in a sandy, calcareous and quartzose rock, which in some places graduates into an impure limestone. It is undoubtedly a stratified deposit. At the mine the dip of the beds is slight, both to the north-west and north-east, thus forming a rather flat anticlinal. On breaking through the crown of the anticlinal, the miners came upon a soft, sandy and brownish-colored rock, which yielded a very large percentage of plumbago. The surface-opening is about ninety feet in diameter, and the excavation from ten to fifteen feet deep. Much of the plumbaginous rock, which was being mined at the time of my visit, was obtained at the rate of 40 cents per ton, being of an earthy and easily disintegrating character. From the mine to the mill at Oliver's Ferry the rate of carriage did not exceed 35 cents per ton. The extent and geological position of this deposit has not yet been determined.

Cost of mining

Freight

Process for dressing the plumbago.

The material, both hard and soft, is put through a ten stamp mill, and the produce—a mixture of sand, lime and plumbago—passes through three revolving buddles, which effect a tolerably complete separation. Thus, the material round the outer rim of the third buddle is composed of nearly pure plumbago, which is shovelled into shallow iron trays placed over a furnace. When sufficiently dry it is passed into a reverberatory chamber, where it is further freed from any sulphur or arsenic which may be present, and is then ready for *bolting.* This *bolting* is carried on in an upper story of the mill, to which the granular and cooled plumbago is carried by means of an elevator, and is finally there packed in clean flour barrels. The coarser portions are again ground, and, when sufficiently reduced, packed and sold for lubricating purposes. The demand for this purpose is considerable, and rapidly increasing.

Mica.

Mica.—The workable deposits of mica in North Burgess have already been mentioned in the *Geology of Canada*, and more recently by Mr. Gordon Broome, in the Report of Progress, 1870-1871, page 321. The chief and only worked deposit described by Mr. Broome, was that on the seventeenth lot of the ninth concession of North Burgess, which was last worked by Mr. Baker, of Perth. Last year I visited this location, and found that all work had been suspended. The ground in the vicinity of the openings or pits is covered by the refuse, and the spoil from the pits, and it was evident, that before work could be again resumed, a considerable outlay of money would be required in order to clear the ground of this *débris*, and put the mine into proper working order. The mica is still said to be abundant on both the sixteenth and seventeenth lots on the ninth range, but I do not think it can again be mined with the same profit as heretofore, as at present the demand for it is limited to comparatively large sizes. Should the demand, however, increase, these lots may yet become valuable. Mica is nearly always present in the veins and bed deposits of phosphate of lime, but for the most part only in small crystals, which are distributed along the sides of the beds or veins. In some localities it occurs in large crystals, but they are nearly always of too dark a color or too imperfect for economic use. Further, it is worthy of note that on the sixteenth and seventeenth lots of the ninth concession, "Baker's Mine," the mica is found free from phosphate of lime, in an earthy and easily decomposing pyroxenic rock. It is not a vein deposit, but apparently an extensive bed, striking south-westerly along the eastern shore of Pike Lake in North Burgess, into the township of North Crosby, where, on the seventeenth lot of the third concession, it was at one time worked to a slight extent by Mr. Poole, of Perth. There is little doubt that hitherto the best quality and largest sizes of mica have been obtained from within ten to twenty feet of the surface.

I have the honor to be, Sir,

Your obedient servant,

HENRY G. VENNOR.

Office of the Geological Survey of Canada,

May, 1873.

REPORT

OF OBSERVATIONS ON THE

CARBONIFEROUS SYSTEM OF NEW BRUNSWICK,

IN THE

COUNTIES OF QUEEN'S, SUNBURY AND A PORTION OF YORK.

BY

PROFESSOR L. W. BAILEY, A.M., AND MR. G. F. MATTHEW,

ASSISTED BY

MR. R. W. ELLS:

ADDRESSED TO

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

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

FREDERICTON, NEW BRUNSWICK, May, 1873.

SIR,—The following Report embraces the results of observations made during the past season by Mr. George F. Matthew and myself, assisted by Mr. R. W. Ells, on portions of the Carboniferous System and older strata in central New Brunswick, and has been prepared in pursuance of instructions which I received in June last.

Report by Dr. A. Gesner, 1838.

The first published Report on the coal formation in New Brunswick was made by Dr. A. Gesner in the year 1838. In this and the three following years he succeeded in determining its limits with some accuracy, embracing fully one-third of the entire area of the Province, and he likewise described the general lithological characters of the measures.

Coal seams of Grand Lake.

Ont-crops of coal had been discovered at several points; and from some of these, more particularly in the vicinity of Grand Lake, in Queen's county, it had been raised to a limited extent since 1825; but though the coal was of good quality, the seams were so thin that they offered no inducement for any extended investment of capital in their development. The proximity of the magnificent coal seams of Nova Scotia, however, encouraged the hope that other and thicker seams might be discovered at some lower level than had hitherto been reached in New Brunswick, and in 1837 it was determined to ascertain if possible, by boring, the existence or otherwise of such workable seams in the Grand Lake district. Operations conducted by a private company were accordingly instituted for the

Boring operations.

purpose on the left bank of Salmon River, about two miles north of its embouchure in the north-east arm of Grand Lake. The boring here was continued to a depth of 403 feet, but with the exception of one coal seam of one foot ten inches, near the surface, and which is supposed to be the same as that now generally worked, and a bed of "bituminous shale and coal" of eight feet thick, met with at a depth of 262 feet, no strata of any economic importance were reported.

One foot ten-inch coal seam.

The method of boring, however, was of an unsatisfactory character, and even supposing it to have been scrupulously and carefully conducted, was such as might easily have led to erroneous conclusions. Under these circumstances it was felt that before any reliable conclusions could be reached respecting the productive capacity of this coal field, further explorations by boring must be made. In pursuance of this view a second boring was begun in 1866 on Coal Creek, about five miles distant from the one on Salmon River, in a direction of west 20° south. This boring attained a depth of ninty-six feet, but failed to shew the existence of other seams beneath that to which the title of "the surface seam" had come to be applied. In 1870-1871, another boring equally unsuccessful was made at Salmon River to a depth of 217 feet, at a point about half a mile to the north of the first.

Unsatisfactory method of boring.

Notwithstanding these repeated failures, however, the belief was very general among those acquainted with the district, that other and thicker seams would eventually be found beneath that which had been opened and worked near the surface at so many different points. This belief found expression in the Local Legislature, and during its last session (1872) an appropriation of four thousand dollars was made for the purpose of again testing the question. At the same time application was made for such assistance on the part of the Geological Survey as might serve to guide the Government in the judicious expenditure of the money. It was with this object in view that I was directed in June last to proceed to examine the Grand Lake Coal Field.

Assistance from the Geological Survey.

In the maps which are being prepared to illustrate the geology of the region we have examined, we have availed ourselves of such material as could be furnished by the maps and surveys of the Provincial Crown Land Department, and we would here acknowledge our obligations to the officers of the department for their ready assistance and courtesy.

Maps.

The following sub-divisions of the Carboniferous system are the same as those proposed by Dr. Dawson and Sir W. E. Logan for the Carboniferous rock of Nova Scotia, with some unimportant modifications rendered necessary by the somewhat different associations and the greatly reduced thickness of the various groups of strata in the central Carboniferous area of New Brunswick. Thus Dr. Dawson's divisions: 2, Middle Coal formation, and 3, Millstone-grit series, are included in the present report

Subdivisions of the Carboniferous system.

under division II, Middle Carboniferous Formation; and division I, Lower Carboniferous Formation, includes Dr. Dawson's divisions 4 and 5, the Carboniferous Limestone, and the Lower Coal Measures.

Carboniferous System.

I. Lower Carboniferous Formation.
II. Middle Carboniferous Formation.
III. Upper Carboniferous Formation.

Lower Carboniferous Formation.

The general position of the Lower Carboniferous strata, as well as the features which they present in the area under consideration, has already been briefly described (Geology of Canada, Report of Progress, 1870–71, p. 204–206). A more careful study of portions of the formation, during the past season, enables us to make some additional observations.

Position and area of Lower Carboniferous rocks.

As stated in the Report above referred to, these Lower Carboniferous rocks in the great central Carboniferous area, are, for the most part, confined to the vicinity of the hills of older metamorphic rocks which border the latter, and among which are sediments of very different ages and great diversity of lithological characters. It is from the waste of these that the Carboniferous strata have been to a great extent made up, which accordingly exhibit a similar variety of colour and composition; in some cases, indeed, so nearly resembling the older rock as to be not easily distinguished. In consequence of this diversity, as well as from the extremely variable character, both as regards the thickness and succession of its different members, no one description can be given which would be generally applicable to the whole formation. In that part of the Province to which our observations during the past season have been confined, the Lower Carboniferous series presents important differences from its character where examined nearer the coast. Thus the Lower Carboniferous grey rocks, Dr. Dawson's sub-division 5, *Lower Coal Measures*, though well developed in the valley of the Kenebecasis river, appear to be entirely absent from the central Carboniferous area. The limestones also (No. 4 of Dawson) which form so prominent a feature in the Lower Carboniferous formation in Nova Scotia, and which frequently attain a considerable thickness in the southern counties of New Brunswick, here appear to be limited to small patches of thin irregular beds, both westward and eastward of the St. John River. The red conglomerates and sandstones, however, which accompany these limestones, are universally distributed wherever the Lower Carboniferous rocks are found, and the whole group has a very close lithological resemblance to that which underlies the Pictou coal measures, and which has been described by Sir W. E. Logan under the designation of Millstone-grit, and stated to correspond to No. IX. of Dr. Dawson's subdivision of Sir W. E. Logan's section of the

Variety of colour and composition.

Universal distribution of red conglomerates and sandstones.

Carboniferous rocks exposed on the Joggins shore of Nova Scotia. The Lower Carboniferous red sediments, which we have been examining during the past summer, have contributed a portion of the material from which the Middle and Upper Carboniferous formations of central New Brunswick have been built up, in the same way that the lithologically similar Millstone-grit in Nova Scotia has, according to Sir W. E. Logan, contributed an abundance of fragments to the conglomerates at the base of the coal measures near New Glasgow. We have as yet, however, met with no evidence which would justify the separation of the red conglomerates, &c., bordering the central Carboniferous area of New Brunswick from the Lower Carboniferous limestones with which they are associated: they are, therefore, both included in the following remarks, as members of the Lower Carboniferous formation.

Beds at the base of the formation.

The beds which, though not the very lowest, are those most commonly met with at the base of this formation are conglomerates, these latter consisting of large or medium sized, seldom well rounded, but mostly sub-angular fragments, which are derived from neighbouring ridges of older rocks. A narrow belt of these conglomerates spans the space between the St. Croix and Magaguadavic Rivers, at a distance of about five miles south of the European and North American railway. It crosses the St. Stephen and Woodstock road just south of Trout Brook, a small stream flowing into the St. Croix, and rises towards a rather prominent hill in the direction of the St. Andrews and Quebec railway, having a dip N. 20° W. $<$ 15°. In most of the beds of this belt the paste, which is usually sandy, but often argillaceous, is of a red colour; but in fragments observed about the sources of the Digdeguash, where the conglomerate belt crosses the St. Andrews and Quebec railway, the matrix was observed to be in rare instances of a grey colour. In both varieties the pebbles are chiefly fragments of argillite and fine sandstone; both flecked with scales of silvery mica on the layers, and varying in colour from apple-green to grey. Some beds have white quartz pebbles freely scattered through the paste, and there are occasionally fragments of jaspery blood-red hematite. The argillite and sandstone fragments which most abound in the conglomerates are similar to those of Devonian age (Cordaite slates) which cover a large area to the southward. Besides the greenish fragments, however, there are many pieces of red argillite and sandstone, not differing otherwise than in colour from the green. We have found no ledges outside of the conglomerate belt corresponding in colour to these red fragments. Their hue may have arisen from the same causes which have universally given a red colour to the paste of the Lower Carboniferous conglomerates, and to the accompanying shales.

Belt of conglomerates.

Character of the pebbles.

In the western portion of the above described belt, the red conglomerates are the only rocks met with. Beyond the Digdeguash River, however, in an easterly direction, the formation covers a wide space, and embraces a larger number of divisions. Between this latter stream and the Magaguadavic the exposures are but few, being limited for the most part to small ledges laid bare at two or three points in the bed of Upper Trout Brook. In the Brockaway Settlement these rocks again become more apparent. Their out-crop here bifurcates; one band, in connection with that above described, passes up the valley of the Magaguadavic and thence along that of its tributary, the North-east Branch, through the northern part of Harvey Settlement, beyond which it is continued, though somewhat interruptedly, to the St. John River north of Fredericton; while the other sweeps around the southern side of the great central Carboniferous area. In the two belts there are some noteworthy differences.

Exposures in Upper Trout Brook and Brockaway Settlement.

In the Report of Progress for 1866–69 (pages 179, 180) a general description of the more northerly belt, together with a map illustrating its distribution, has been given by Mr. Chas. Robb. A detailed notice of the latter on our part is therefore unnecessary. There are, however, one or two points not alluded to by Mr. Robb to which we would call attention as bearing upon the structure of other portions of the Carboniferous area examined by us. The most important of these refers to the great mass of feldspathic rocks described by Mr. Robb as associated with the ordinary Lower Carboniferous red sediments in the settlement of Harvey, and the apparent want of conformity between these two groups, as evidenced by the marks of erosion to which that last named had been subjected at some period antecedent to the deposition of the former. The facts bearing on this are well exhibited a few rods west of Harvey station, where the railway cutting at the base of the high hill which here overlooks Cranberry Lake, presents the following ascending section:—

Description by Mr. Chas. Robb.

Section.

	Feet.
Fine-grained and rubbly purple sandstones at base of cliff, including a one-foot bed of fine-grained feldspathic sandstone, with varying shades of green and purple. Exposed thickness about..................	17
Pale purplish-red and red, highly feldspathic beds (sometimes becoming yellowish or green, or variously marked with irregular bands and blotches which are nearly colourless) which at the base are mostly fine-grained and sometimes vesicular; but above become a coarse conglomerate or breccia, in which angular fragments, mostly of small size, consisting of fine red felsite mingled with those of a soft deep green and somewhat translucent mineral, are imbedded in a feldspathic paste containing a large admixture of similar greenish material. In some portions of the mass are thin layers in which the feldspathic rock is largely mixed with purple sandstone, similar to that of the beds below, the thickness of the whole being about......	40

Where the above measurements were made the conglomerates rest conformably upon the purple sandstones, which dip S. 20° E. $< 20°$; but a few yards to the westward the line of contact between the two becomes broken and irregular, the felsite breccias here resting upon the abruptly terminated edges of the arenaceous beds along a plane declining somewhat rapidly towards the foot of the cliff.

The latter from this point westward is mainly composed of the breccias, overlaid, however, towards the top and at the end of the hills by beds of purplish felsite or claystone, which is sometimes conspicuously divided into columns by a three-fold series of joints. The thickness of these felsites may be estimated at about.....................	150
	207

With few exceptions, the fragments contained in the conglomerate or breccia above described, as well as a large proportion of the matrix in which they are imbedded, are of one kind only, viz.: a hard, dense and fine-grained felsite, such as in some portions of the metamorphic region nearer the coast is associated with rocks much older than those of the Carboniferous system.

Such an accumulation of fragments of so uniform a character within so limited an area seems capable of explanation in two ways only, viz.: either upon the supposition that there exists in the vicinity some ridge or nucleus of older rocks from which the fragments may have come, or else that they are the result of an igneous ejection. Upon the whole we are inclined to regard the latter as the more probable explanation; for although there are in some portions of the area occupied by these fragmental rocks—as for instance on Bald Mountain, and in some of the hills which lie to the northward of Harvey Settlement—dense and fine-grained beds, not differing greatly from the fragments in question, yet they are not clearly separable from those which are undoubtedly Lower Carboniferous conglomerates, and the whole would appear to be of contemporaneous origin. Origin of the fragments composing the conglomerate.

It may be further remarked, that if the purple sandstones, which form the base of the above section, are really of Lower Carboniferous age, then, the felsite breccias which rest upon their eroded surface would appear to be of about the same age (or probably a little later) as the doleritic and amygdaloidal rocks, which near Fredricton, Boiestown, and elsewhere around the border of the Carboniferous area, are similarly associated with Lower Carboniferous sediments, a view first suggested by one of the authors in 1865, (See Observations on Geology of Southern New Brunswick, Fredericton, 1865, p. 99) nor are there wanting among the feldspathic beds themselves indications of at least a partially igneous origin; for besides being largely made up of angular fragments indicating a rapid accumulation, they are not unfrequently vesicular; the vesicles holding calcite, fluor spar, or delessite, and sometimes drawn out as it were into cylindrical or tubular forms, such as are often seen in ordinary amygdaloids. It seems difficult too, to account in any other way for the innumerable corrugations by which the higher beds are characterized and which resemble the effects of irregular flowing of semi-fluid matter, rather than such as would result from simple pressure upon beds previously horizontal. These corrugated beds are usually a feldspathic grit or claystone, Age of the felsite breccias. Corrugated strata.

finely and conspicuously banded with shades of grey, pink and purple, having small disseminated grains of limpid quartz, and small angular specks which may be decomposed crystals of feldspar. They are well exposed on the post-road to St. Stephens, just south of Harvey station, and in cuttings on the railway, two and a-half miles west of the latter dipping in opposite directions, and giving to the whole exposure the structure of a low anticlinal. They closely resemble beds to be presently described along the south border of the Carboniferous area.

Large size of the fragments in the breccia.

At Little's and Lister's mills, the latter about five miles south-west of Harvey station, similar felsite breccias occur. They are here remarkable for the large size of the imbedded fragments which sometimes attain a diameter of from two to three feet, and, as at Cranberry Lake, are almost wholly of fine-grained cherty felsite, imbedded in a soft, deep green or purplish-red matrix; with them occur also Lower Carboniferous sediments, more nearly approaching the usual type, being sandstone of a bright brick-red colour, (sometimes blotched and banded with grey,) and red conglomerates; but the relations of these to the first named beds are not very evident. Fragments of felsite are common in both; but while the red rocks, which are comparatively fine-grained, have for an exposed breadth of more than five hundred feet a uniform dip, S. < 60°; that of the felsite breccias, which probably overlie them, is extremely variable and irregular.

Pratt Brook and Wilson's Hill.

At the head of Pratt Brook, as well as in Harvey Settlement, at Wilson's Hill, the ordinary coarse red conglomerates of the Lower Carboniferous formation are separated from the grey grits at the base of the Middle coal formation only by thin beds of yellowish and grey sandstone or grit, which sometimes become reddish in the paste from an admixture of an imperfectly crystalline mineral resembling stilbite or heulandite.

Orthophyre hills.

In the belt of Lower Carboniferous rocks which borders the southern side of the Carboniferous area eastward of Brockaway Settlement, the strata are concealed in the low land about the Kedron Lakes, but again come into view in the upper part of the valley of the Piskahegan River, and its affluent Peltomà Brook. Here as well as on Shin Creek further eastward, the shales and the paste of the conglomerate have a bright Indian-red color, and the pebbles are of quite a different character from those of the corresponding member further west. Here they consist chiefly of blocks of the quartziferous orthophyres, which compose the bold range of hills extending along the south side of Shin Creek, and thence across to the Piskahegan; there are also many fragments of a grey trachytic rock which is found in situ in the latter stream, also of the dark red and purplish banded slates and of the pale grey or cream colored, fine-grained banded felsites of the same range. Pebbles of dark green dioritic schist and of black contorted slates are less frequently met with. Here as on the western border of Charlotte county, the rock fragments, both soft and hard, but especially the latter, which occur in the conglomerate are only slightly worn on the angles, rounded pebbles being of rare occurence.

These fragmental rocks and the shales which overlie them are well exposed in the bed of Piskahegan River, in Peltoma Settlement, and along the sides of Shin Creek. On both these streams there is also a fine breccia conglomerate, of deep red color weathering to orange-red, consisting of small angular pieces of dark red shale, imbedded in an argillaceous paste of paler hue. With it are associated beds of fire-clay, of amorphorus structure and bright Indian-red color, some of which contain sufficient oxide of iron to be of value as an ochre or "mineral paint." A few of the more slaty beds in this portion of the series hold poorly preserved remains of ferns, and a small *Cardiocarpum*, too obscure for identification. From the St. Croix River eastward many of the conglomerate beds weather into a somewhat vesicular rock owing to the abundance of calc-spar occupying cavities and crevices in the stone.

Fire-clay.

Fossil plants.

This calcareous character becomes more marked at about seven miles from the mouth of Shin Creek, where a band of impure concretionary limestone exists in the upper part of the conglomerate. On the same stream a higher member of the series makes its appearance resting upon the red shales. It belongs to the same horizon as the dolerite rocks along the northern border of the Carboniferous area; but occurs here as an olive colored amygdaloid, which in parts of its distribution is associated with beds of compact trap of similar greenish hues. The cavities in the former rock, which is generally highly feldspathic, and also contains much iron, are usually filled with calcite, though oftentimes with a dark colored chloritic mineral and less frequently either with vitreous quartz or hematite. Usually also the rock is porphyritic with crystals, sometimes of half an inch but usually not more than one quarter of an inch in length, of pale olive-grey or flesh-red feldspar: the joints of the amygdaloid and of the compact trap are ordinarily occupied by thin veins of hematite. No important change in the appearance of the Lower Carboniferous series was observed on the South Branch of the Oromocto River, into which the Shin Creek discharges, with the exception that, at about half a mile south of Blissville station, the members above enumerated are covered by pale purplish lilac-weathering felsites.

Concretionary limestone.

Amygdoloid and compact trap.

From the South Branch of the Oromocto River the out-crops of the Lower Carboniferous series pass through a low belt of wooded land to the head waters of the Nerepis River. Here there is a considerable area of red rocks, including an out-crop of well developed Lower Carboniferous limestone which occurs in the lower Clones Settlement, about one and a-half miles east of the saw-mill on Kelly's Brook. *Terebratula Sacculus, var: sufflata* is very common here in the limestone, as well as a small species

Limestones holding fossils.

of *Serpula*; there are also two or more species of small gasteropods, several lamellibranchs, including *Pterinœa* and a cast of a *Cucullœa*-like shell, a large *Orthoceras* is also quite common. Much of the rock is compact and of a reddish-grey color, but portions are of a more open texture, the interior of the shells and spaces between them being occupied by crystalline calcite. Numerous fragments of dark red shale and sandstone, and a few of red petrosilex, porphyritic with white calcite, occur with the limestone blocks, but the surface of the country at this out-crop is so densely covered with a young growth of trees that the relation of the limestone and arenaceous beds could not be determined. That portion of the Nerepis Valley which lies to the north of the range of Devonian slates in Petersville (Report of Progress, 1870-71, page 199) has been eroded to the depth of several hundred feet through the Lower Carboniferous rocks, exposing the slates above named in the bottom of the valley as well as along the base of the enclosing eminence, while patches of felsite, such as occur on the South Branch of the Oromocto, appear at intervals along the tops of the hills on the south side of the valley, and rise to the surface from beneath the coal measures on the north side.

Anticlinal folds.

In the intervening space there are one or more breaks or anticlinal folds, one of which at Lower Clones, exposing friable red sandstone, sweeps over a ridge of Pre-Carboniferous slates, of which a small area is exposed to view. This is about half a mile eastward of the Lower Carboniferous limestones described above. About three miles farther up the valley, the red rocks leave the main Nerepis stream and pass into the valley of Summer Hill Brook, one of its branches. At the junction of the two streams, a small area of Pre-Carboniferous slates is exposed. Above this point on the Nerepis, there are no exposures for the space of about a mile. Then for a quarter of a mile, following upward along the stream, the red measures of the Lower Carboniferous series form a low cliff on the left bank. Here dark red conglomerates rise from the stream in a low anticlinal to a height of eight feet, capped by a dark olive-grey and reddish doleritic amygdaloid in loose shelly layers. For a distance of half a mile further up, the stream flows through alluvial flats without rock exposures, and beyond that point outcrops of the conglomerate and grit pertaining to the barren measures at the base of the Middle Carboniferous formation begin to appear.

Doleritic amygdaloid.

Exposures on Summer Hill Brook.

Better exposures of the Lower Carboniferous series occur on Summer Hill Brook, above an out-crop of vertical Pre-Carboniferous slates at its mouth. The first ledges of the former series, which come into view here, are red conglomerates, full of grey calcareous nodules, and holding fragments, chiefly of grey Pre-Carboniferous slates, flesh-grey and dark maroon colored felsites dotted with crystals of pellucid quartz and calcite, also fragments of dark grey petrosilex, and pebbles of white quartz. The conglomerates show in the left bank of the stream, and are covered by beds of hardened red clay and shale, which in their turn are surmounted by a bed of red limestone, varying from six inches to two feet in thickness. In tracing these beds up the stream, the red shales which at first possess a thickness of ten feet, are in a distance of fifteen paces reduced to a few inches, permitting the limestone to rest almost directly upon the conglomerates. Two hundred paces further up the stream there is another bed of conglomerate resting on a second small out-crop of Pre-Carboniferous slates. Here, however, the conglomerate is grey and more calcareous. It is full of fragments of the slate, mingled with others of the hard purplish and flesh-grey felsite above described. And the paste of theconglomerate holds shells of the genus *Productus*. On the south side of the out-crop of pale green slates upon which these conglomerates rest, purple felsites similar to those seen elsewhere at the top of the Lower Carboniferous series appear, and rest against the slates. The felsites, which, alternately with doleritic amygdaloids and dolerites, are exposed for some distance up the stream, are mostly earthy in fracture, of a dark purplish-red color, and speckled with small white earthy spots of feldspar, and with grains of vitreous quartz; some masses, however, bear a close resemblance to the porphyries of Shin Creek, being denser, flesh-red in color, and having numerous imbedded crystals of pale red feldspar, and of glassy quartz scattered through the mass. Near the mill of Mr. John Corbitt, the felsites give place to dark purplish grey doleritic amygdaloids, more feldspathic than usual, which a short distance above the mill meet a third out-crop of slates, covered, after a space of about one hundred paces, by a thin sheet of dark red calcareous grit overlaid by a considerable mass of grey limestones, holding *Terebratula sacculus, var. sufflata* and a *Pterinæa*.

Fossiliferous conglomerates.

Grey fossiliferous limestones.

These beds are exposed about a quarter of a mile from the bridge at the Gagetown road. About two hundred paces up the hill to the eastward on this road, there is a small outlier of grey sandstones and shales, dipping N.W. $>$ 58°, beyond which the red rocks are again repeated and extend nearly to the top of Summer Hill, where they are capped by a doleritic amygdaloid, in all respects similar to that described as occurring on Shin Creek, except that the seams and veins of hematite are larger and more numerous.

Over all the belt of country from the Maine border to this point the Lower Carboniferous rocks have a low dip to the northward (seldom exceeding five degrees) or are quite horizontal. There is on this, as on the north side of the Carboniferous area, evidence of a want of conformability between the trappean and associated feldspathic beds, which occur at the summit of the Lower Carboniferous formation, and the coarser red sediments of the same formation, which underlie them. On Shin Creek the trappean members are separated by thirty feet, or more, of hardened clay, shales and sandstones, from the Lower Carboniferous conglomerate. At

Unconformability of the trappaan beds.

Wilson's near the Clones coal-crops, where the trappean beds are wanting, similar friable members may be seen to intervene between the measures of the Middle Coal formation and the red conglomerates. There are points on Summer Hill Brook and on the main branch of the Nerepis in Clones, where the trappean beds rest almost directly upon the Lower Carboniferous conglomerate. Other evidences of unconformability between these two groups in the Lower Carboniferous formation are also to be met with further eastward.

Lower Carboniferous rocks in New Jerusalem and Hibernia settlements.

Between the Gagetown road and the St. John's River, opposite Long Island, the belt of Lower Carboniferous red rocks occupies a somewhat wider area, being met with through the greater part of the flourishing settlements of New Jerusalem and Hibernia (or New Ireland.)

Fossils.

They here present much the same features as those described above as characterizing this formation to the westward of the same thoroughfare, the most conspicuous members being coarse red conglomerates, which underlie much of Jerusalem, and the purplish-grey light-weathering claystone. In Hibernia Settlement, thin beds of limestone occur, and on the farm of James McConnicky have been removed for calcination. These limestones, which in some parts are rather abundantly filled with shells of *Terebratula*, are overlaid by soft yellowish-grey shales, and underlaid by pale reddish-grey feldspathic grits or earthy felsites, which are partly kaolinized and filled with grains of vitreous quartz, and by red conglomerates; while from beneath the whole series appears a low ridge of slates of grey and dark-grey colors, sometimes shading into pink, red and purple, and which include also beds of dark-grey to black carbonaceous shale. These lower beds, which are glossy and somewhat unctuous and hold interlaminated veins of quartz, have a general southerly dip of 70°, but with many corrugations, while the overlying Carboniferous strata, though dipping in the same direction, do not reach a higher angle than 20°.

Repetition of the beds by faults.

The out-crops of the Lower Carboniferous formation, as seen on the west bank of the St. John River below Long Island, have been described in the Report of Progress for 1871, page 212; the general arrangement of the beds at this point being similar to those of Hibernia Settlement above noted. The greatly increased area which they here occupy is probably the result of a series of low folds, and possibly of one or more faults by which the beds are repeated. Along the valley of Little River, and again near its mouth, bright red Lower Carboniferous conglomerates may be seen at several points, as well as beds of claystone, the latter more dense and compact than those near Long Island, but both are too much obscured to make their relations evident.

Parish of Wickham.

Along the post-road adjoining the St. John River, in the parish of Wickham, the Lower Carboniferous rocks exposed to view are chiefly purple felsites with disseminated grains of quartz, in every way like those seen on the opposite side of the river in Hampstead, except that they are here more often highly inclined, usually at an angle of 20° but sometimes rising to 45°, and having a dip about N. 10° W. About the mouth of Washademoak Lake small ledges of Carboniferous red conglomerate appear, while a short distance in the rear or southward a considerable mass of reddish-grey limestone is exposed, forming a portion of the eminence known as Rush Hill. These limestones are like those previously described on the shore near Long Island, and like them contain shells of *Terebratula* in considerable numbers, and more rarely an *Orthoceras*. Here, however, the limestones appear to be the lowest member of the series present, being underlaid a few rods to the south by a heavy mass of dark green Huronian diorite. Out-crops of limestone, which are probably a continuation of the same belt, are also met with at several points further eastward, more especially near the county line on the southern part of Shannon Settlement, where they may be seen resting upon grey and green argillites of Devonian or Upper Silurian age, and are conformably covered by coarse red conglomerates, the limestones having an exposed thickness of about six feet. Both beds are well exposed about the head waters of a small stream flowing through the last named settlement, and entering the Washademoak at the head of Belyea's Cove. In descending this stream the conglomerates, which form a series of low bluffs, with a nearly uniform dip N. 25° E. $>$ 6°, were crossed for a distance of 1,511 yards measured from their first out crops; but in approaching Jones' mill there appear from beneath them thick beds of fine-grained flinty petrosilex, mostly of a pale grey color and weathering nearly white, but which exhibit also shades of flesh-red, grey and black, together with delicate bands of color which, if the result of sedimentation, indicate a northward dip of 60 °. These rocks have a surface breadth of about 400 yards: they are very like some of those met with among the hills which lie to the northward of Long Reach in King's county, and are probably of Upper Silurian age. A few rods further down the stream and below the mills, the red conglomerates again appear upon the right bank, but on the left there are other beds of petrosilex differing from those first described only in being conspicuously divided by a series of joints into prismatic blocks and columns, many of which are quite perfect. From Jones' mill to its mouth in Belyea's Cove, the stream flows only through meadows or low land without rock exposures.

Limestones of Rush Hill.

Huronian diorite.

Devonian or Upper Silurian rocks.

Perhaps the most interesting view of the rocks in this vicinity is that furnished by the shore of the Washademoak Lake, between Belyea's Cove and Craft's Cove. The western side of Belyea's Cove shows only ledges of laminated grey sandstones, which are a portion of the Middle Carboniferous formation, and are nearly horizontal, though with much false bedding. Similar beds also crown the hills on both sides of the cove, but beneath

Belyea's Cove to Craft's Cove.

them on the eastern side other beds are exposed which, both in color and lithological characters, resemble those of the Lower Carboniferous formation, viz.: bright red shales with thin beds of limestone, the latter with layers and nodules of bright red chalcedony.

Section.

The following ascending section, condensed from observations and measurements between the two coves, will serve to indicate the relations of these beds:—

	Feet
Bright red shales with grey marly layers and calcareous nodules, which at some points are replaced by thin beds of hard pale bluish and white nodular limestone, the latter containing much disseminated quartz, which is usually in small concretionary lumps, but sometimes in bands or layers conformable to the bedding. One of these layers attains a thickness of as much as two feet. This quartz, which is of a chalcedonic variety, is sometimes colorless, but usually some shade of red, and often a deep blood-red hue. In consequence of slight undulations, one of which discloses a small bed of brownish-red sandstone beneath the shales, the thickness of these, as exposed to view, varies considerably, but in the western part of the section, where it is greatest, is about	20

In following the shore to the eastward, the red shales, at a distance of about twenty paces, become reduced to an exposed thickness of about three feet, and are overlaid by the following beds dipping N. 15° W. $>$ 20°, and which are probably of the Middle Carboniferous formation.

	Feet
Grey sandstone with stigmariæ	10
Measures concealed	2
Black, rusty and carbonaceous shale	3
Soft bluish-grey rusty shale	10

No higher beds are visible at this point, but a little to the eastward, where the red shales and limestone are partly concealed by the beach, there are above them beds of grey conglomerates, holding many white quartz pebbles, succeeded by grey, flaggy sandstones, their dips being usually N. 30. E. from 2° to 10°, but with much false bedding, some thirty feet of these beds are exposed, but as similar rocks out-crop at intervals on the hills above, which cannot be less than one hundred and fifty feet high, their thickness must be much greater.

False bedding.

To the eastward of Belyea's Cove, the only rocks met with along the shores of the Washademoak are grey sandstones like the above, and which do not differ from the ordinary grey rocks of the Middle Carboniferous formation; but among the hills to the southward, Lower Carboniferous rocks are frequently met with, and at some points cover considerable areas. Such for example is the case in Henderson Settlement, three miles east of Shannon Settlement, where the red conglomerates, with some red shales, rise into prominent hills. A small stream flowing through this settlement, and entering the Washademoak at the head of Lewis Cove, in cutting through

Henderson Settlement.

these beds has also exposed the older rocks from which their materials have been derived. These in the lower part of the stream are a grey highly micaceous schistose rock having veins of white quartz, and in some parts approaching a genuine mica schist, being much like certain beds of rocks also exposed by the denudation of Lower Carboniferous strata in the valley of Hammond River in King's county. Near the mill, where these schists are directly overlaid by the red conglomerates, large unworn blocks of the schist may be seen imbedded in the conglomerate, in some cases from two to four feet in length. The dip of the overlying conglomerate beds is N. 80° W. < 3°.

A short distance farther up the stream they include some beds of deep red sandstone, and are overlaid by about twenty feet of deep brownish-red shales. These exposures are all to the south of the main mass of mica schists which are exposed upon the stream for a breadth of about six hundred paces. Beyond them in the same direction the bed of the stream is occupied by fine red sandstones which are conspicuously divided into two sets of joints by rectangular blocks from two to three feet in diameter, and dipping S. 80° W. < 2°. No other exposures are met with on the main stream, but on a small branch which enters the latter near the cross roads in Henderson Settlement, the coarse red conglomerates again appear at and above Shaw's mills. Here also they contain pebbles of mica schist, imbedded with others of diorite, petrosilex and slate, in a deep red sandy paste. Some of these pebbles may have come from an underlying series of feldspathic schists which come into view a short distance above the mill, where they are interstratified with a feldspathic sandstone of greyish and greenish-grey tints, which are in some parts clouded with shades of purple; others may have come from beds of fine-grained greenish-grey schistose diorite, not observed upon this branch, but exposed to view about three quarters of a mile to the south-west, where on a second branch of the same stream they are associated with similar feldspathic schists. From this point, which is on the main road to Belleisle Bay, to within 800 yards of where the boundary of King's county crosses the latter, the hills on either side are composed of red conglomerates dipping N. 35° W. < 6°. Beyond the county line the strata exposed are of Pre-Carboniferous age. Through the remaining portion of the parish of Wickham, within which the localities above described are included, as well as in that of Johnston, which lies immediately to the eastward, the opportunities afforded for the study of the Lower Carboniferous rocks are much less frequent than is the case to the westward. This is partly due to the fact that the country in this direction is but sparsely settled, but largely also to the fact that the formation itself has here evidently been subjected to great denudation, in consequence of which it is now represented only in limited and widely separated patches. A farther evidence of such denu-

Conglomerates with pebbles of diorite, petrosilex and mica schist.

Great denudation of the Lower Carboniferous rocks.

dation, and, at the same time, of the want of conformity between this formation and the succeeding members of the Carboniferous system, is to be found in the fact that the latter in this direction are often found resting directly on the older metamorphic hills, without the interposition of any red sediments whatever. Such for instance is the case in the settlement of Goshen, as well as along the Canaan river, and its tributaries on the southern side. There are, however, one or two points at which the Lower Carboniferous rocks are exposed to view, the most considerable being those of the Scotch and English Settlements, in the latter of which are good exposures of the conglomerates, as well as of the underlying limestones. The conglomerate beds, which may be seen in isolated patches on either of the streams, tributaries of Long Creek, which take their rise in this settlement, do not differ from the similar rocks seen to the westward. The limestones, however, seen only on the more southerly of these streams, and not far from the county line, are peculiar in containing a considerable admixture of dioritic material, distributed through portions of the rock in the form of thin shaly layers.

Limestone associated with dioritic material.

The source of this dioritic material is probably to be found in the waste of ridges of Huronian diorite, some of which are exposed a little to the southward at Pearson's mill, and through portions of the Irish Settlement in the adjoining county of King's. It is probably from a like source that the materials of certain conglomerates have been derived, which a few miles farther east cover a considerable area in the Snider Mountain Settlement. A portion of these are of a greenish-grey colour, containing pebbles of diorite, white quartz, and red slate in a dioritic paste, but others present the usual deep brownish-red tint so characteristic of the Lower Carboniferous formation. It is in the eastern part of this settlement that the rocks of this formation connect with those of the same age in the central and eastern parts of King's county, upon which our observations are still incomplete.

Snider Mountain Settlement.

Besides the areas to which the foregoing descriptions apply, and which in the form of two narrow belts mark, as has been stated, more or less continuously the rim or border of the great central Carboniferous area, there are several points over the interior of the latter, where the partial denudation of the Middle and Upper Carboniferous formation has exposed the underlying Lower Carboniferous strata. This is perhaps the case in the bed of Long Creek, near the junction of its two principal branches at McLean's mill, where certain greenish-grey rocks are exposed, which are more or less amygdaloidal and contain a considerable admixture of chlorite. They are here compact and tolerably homogeneous; but a few rods up the western branch, somewhat similar beds occur in the form of a conglomerate in which large fragments of amygdaloids, much like that first mentioned, are imbedded in a fine greenish-grey felspathic paste. In neither case,

McLean's mill.

however, do any distinctively Lower Carboniferous rocks occur in connection with these trappean beds, the only other rocks noticed in the vicinity being coarse grey and nearly horizontal sandstones, containing *Calamites* and *Sternbergiœ*, and which cover those first mentioned unconformably.

A second locality where beds which may be of Lower Carboniferous age thus exposed, is in the vicinity of Cumberland Bay, the more southerly of the two indentations at the eastern end of Grand Lake. About a mile southward of Cumberland Creek (and at its eastern end where it crosses the line of the projected great road from Grand Lake to New Canaan, somewhat closer to the creek,) is a long, and as compared with the generally low and flat character of the surrounding country, rather conspicuous ridge; it affords but few exposures of the rocks composing it, but judging from such as could be found, both at its eastern and western ends, as well as, from the debris with which it is thickly strewed, would appear to be almost entirely made up of purplish-grey claystones, in some parts fine-grained and homogeneous, but more frequently marked like the resembling beds described in preceding pages by the dissemination of particles of vitreous quartz through its mass, and sometimes assuming the aspect of a conglomerate. The country immediately surrounding it is mostly low and flat without rock exposures. **Cumberland Bay.**

Less doubtful exposures of Lower Carboniferous rocks presenting their usual aspect of bright red calcareous conglomerates and sandstones occur to the northward of Grand Lake, at and above the Forks of Newcastle River, and are more particularly described further on, in connection with the coal measures which here partly cover them.

Middle and Upper Carboniferous Formations.

The greater portion of the counties of Queen's and Sunbury, and also a portion of the adjoining county of York, is occupied by the series of grey rocks, including conglomerates, sandstones and shales, long since recognized by Dr. Gesner as the equivalent of the great coal formations of Britain and Nova Scotia. **Rocks of Queen's, Sunbury and York counties.**

In New Brunswick these grey rocks in various parts of their distribution include beds of coal which, though thin, are in some instances workable, and are accompanied by the usual assemblage of coal-measure plants. Full lists of these have been given in the (Report of Progress for 1870-71, pages 214–216.) The rocks which in the area we have examined during the past season appear to form the lowest member of the Middle or Productive Coal formation, consist of heavy masses of grey conglomerates and coarse grey quartzose grits, alternating with thin beds of rather coarse grey sandstone and sandy shale, the last named beds not unfrequently containing ill preserved remains of plants. In their coarse-

Resemblance to Millstone-grit series of Nova Scotia.

ness and general aspect, and in the absence of workable coal seams, these rocks resemble very nearly a portion of those to which in Nova Scotia the name Millstone-grit has been applied, and which they probably represent. In New Brunswick, however, they are clearly separable from the great mass of red Lower Carboniferous sediments which underlie them, and for which, or for a somewhat similar series in Nova Scotia the same term has been employed; while upwards they appear to graduate insensibly into those of the productive coal-measures. Indeed, except in the comparative unfrequency of fine sediments and their more silicious aspect—many of the beds being a coarse conglomerate made up of well rounded grains and pebbles of quartz imbedded in a grey sandy or feldspathic matrix—these lower grey beds are scarcely distinguishable from those which overlie them, and to which they appear to be generally conformable. They are, however, as a rule harder, and hence, having resisted to a greater extent the influence of denuding agencies, they rise into ridges which, though usually of inconsiderable height, have nevertheless exerted an important influence upon the surface drainage of the districts in which they occur. Such ridges are not unfrequently met with along the northwestern border of that portion of the Carboniferous area to which this report relates, and are not wanting over its interior, but along its southern margin they are for the most part inconspicuous. It is among the finer sediments which overlie the barren strata just described that the fossiliferous shales, underclays, and the associated coal seams are found, and which present the usual features observed in other coal measures. In this portion of the series also, beds of coarse character are by no means wanting, and where occurring alone, are not readily distinguished from those of the underlying barren measures, but besides being less common and of less thickness, they are also usually more variable in composition. They likewise resemble those beneath in the frequent occurrence of false bedding which to some extent is exhibited also by the associated sandstones which, though often more or less flaggy, are sometimes sufficiently massive and even-grained to be available for architectural purposes.

Fossils tree-trunks.

Both the conglomerates and sandstones abound with prostrate trunks of large trees, *Dadoxylon*, together with impressions of *Calamites Sigillaria*, and more rarely of *Lepidodendra*. The first named tree-trunks are usually mineralized through the infiltration of silica or sulphate of baryta or by conversion into a black crystalline calcite. The ferns which are abundant in the shales are regarded by Dr. Dawson as belonging to the Middle Carboniferous formation, though with an admixture of species pertaining to the Upper.

From the softer character of the productive measures they are less conspicuous than the underlying barren beds, and are usually met with in the hollows and depre sions between the ridges formed by the latter;

where the strata are horizontal, are exposed only in river sections. The overlying soils which have been derived from them necessarily partake of their characters, and are either very sandy or very clayey, and hence often unfit for successful cultivation, while large tracts, especially in the eastern part of Queen's and Sunbury counties, for like reasons, together with imperfect drainage, are occupied by extensive sand plains, swamps and barrens. Over many portions of the region we have examined the only strata exposed to view are the grey rocks which make up the bulk of the Middle Carboniferous formation. But others occur in which this color graduates into or is replaced by a purplish or purplish-red tint, which sometimes, more particularly in the finer beds becomes a deep red color. Beds exhibiting a similar bright color are occasionally found among the lower as well as the upper measures of the Middle Carboniferous series, yet the bulk of these red and purple strata are probably altogether above the productive measures, and appear to represent that portion of the Carboniferous system to which Dr. Dawson has applied the name of Upper or Newer Coal formation, though the thin limestone beds which are associated with them in Nova Scotia are apparently wanting in New Brunswick. Dr. Gesner has referred some of these beds to the New Red Sandstone series; but besides differing lithologically from the latter they are marked by the presence, in the finer layers, of *Cordaites*, *Calamites* and ferns, characteristic of the Carboniferous system. The Upper Carboniferous rocks being, like the strata of the Middle Carboniferous formation soft and imperfectly consolidated, have been in a like manner largely affected by denudation. Their debris, easily recognised by its peculiar color, has been widely spread, especially over the central and southern portions of the region examined by us, and has produced a soil on the older rocks considerably more fertile than they would otherwise possess.

Soils on the productive coal measures.

Upper or Newer Coal formation.

Details of Observations in Queen's and Sunbury Counties, East of the St. John River.

Though somewhat diversified by minor inequalities of surface, the most prominent topographical features of the above region may be described as embracing three parallel swells or ridges, separated by two correspond ing basins or depressions, of which the more northerly and broader one is occupied by Grand Lake, an irregular sheet of water, about twenty-five miles long, and from four to seven miles wide. The second, which is narrower and deeper, is occupied by the Washademoak Lake and River and its tributary, the Canaan. Both basins, at their western extremity, are connected with the St. John River by small but navigable channels. To the north-east the dividing ridges gradually disappear and the basins merge into an extensive and nearly level tract which forms a portion of the

Topographical features.

watershed between the St. John River and Northumberland Strait, and the greater part of which is wholly unsettled.

Grand Lake.

The shores of Grand Lake and of its affluents afford many facilities for the study of the rocks of the Carboniferous system. The most important of the tributary streams, both as regards size and the aid they afford in the study of the geological structure of the district, are Salmon and Newcastle Rivers. The former rises by numerous tributaries, mostly situated in the western part of Kent county, and the latter by two principal branches in the eastern part of Sunbury county, while both enter Grand Lake, by its north-east arm, at a distance of only six miles apart. A third stream, Coal Creek, enters the same arm at its north-eastern extremity; and along portions of its course also affords good exposures of the strata.

Salmon and New Castle Rivers.

Coal Creek.

Section on Newcastle River.

Newcastle River.—Of the sections afforded by the above mentioned stream the most interesting and instructive are those on Newcastle River, the course of which for much of its length, is nearly at right angles to the dip of the beds, which are inclined at low angles, and differ but little in relative hardness. They are exposed along the banks of the stream in an almost continuous series of bluffs, varying from twenty or thirty to two hundred feet in elevation, and exhibiting an almost unbroken succession from the rocks of the Lower Carboniferous series up to the principal coal-seams and their associated beds. As these sections are of much importance in their bearing on the relations of the different members of the Carboniferous system, as well as on the question of the thickness of the Middle Carboniferous series, and the probable productiveness of the Grand Lake coal field, we shall describe them with some minuteness.

Important sections.

As represented in the accompanying map, the junction of the two main branches of Newcastle River is situated about one mile, in a straight line, below the point where the south branch is crossed by the road leading to the Emigrant Settlement, in the parish of Northfield. Between the bridge and the Forks, and for about two miles from the latter up the North Branch, the rocks exposed to view belong to the Lower Carboniferous formation, and are in every way similar to those which have already been described in other parts of the Carboniferous area, being a series of bright red, more or less calcareous, conglomerates and sandstones, capped by heavy beds of hard grey feldspathic and ferruginous dolerite, which is often more or less vesicular.

Above the Forks, on both branches, the beds present a succession of low undulations. Their dip seldom exceeds four or five degrees, and they are often nearly horizontal. Southward of the Forks the inclination is more uniform, being S.E. $< 3°$ or $4°$. About 344 yards from the Forks, measured obliquely to the strike, a cliff, about one hundred feet in height, affords a good vertical section, showing the following succession and thickness of strata:

		Feet.
Lower Carboniferous.	Pale red conglomerate and sandstone at base of cliff	10
	Measures concealed	10
	Bright red, coarse crumbling shales	10
	Hard and compact fine-grained dolerite, of grey color	10
	Soft and crumbling, somewhat gravelly shales	25
	Measures partly concealed, but including beds of dark purplish-grey dolerite rock, which is more or less vesicular, the cavities being filled with a flesh-colored mineral resembling stilbite	10
	Measures concealed	20
	Doleritic rock, in part shaly, with seams and joints holding much red heulandite; the bedding distinct but much contorted......about	20
		115

The dolerite rocks which form the summit of this section represent the highest member of the Lower Carboniferous series, and may be regarded as the equivalents of the trappean rocks already described as occupying a similar horizon at Hampstead, and also near Fredericton and elsewhere around the border of the Carboniferous area. They are directly overlaid, a short distance below the section above described, by the coarse grey beds which form the base of the Middle Coal formation. Their relations to the latter are better shown in a second bluff about 344 yards south from the last, in which the following vertical and ascending section is exposed: Dolerite rocks.

		Feet.
Lower Carboniferous.	Measures concealed at base of cliff	60
	Grey and dark grey dolerite rock, similar to that of the above sections	20
Middle Carboniferous.	Brownish grey shaly sandstones	15
	Grey conglomerate and coarse grey grit	20
		115

In a bluff, a few rods further down the stream, the following ascending section is exposed:

		Feet.
Lower Carboniferous.	1. Red sandstone and conglomerate at base of cliff	30
	2. Compact and somewhat columnar dolerite, the seams of which are coated with bright red heulandite	30
Middle Carboniferous.	3. Grey sandy shales, coarse grey sandstones and grits	25
		85

Along this portion of the stream the inclination of the beds is uniformly to the southward. Though not exceeding two or three degrees, it is nevertheless sufficient to cause the gradual declension of the successive beds to and beneath the level of the river. Thus at a distance of 889 yards measured at right angles to the strike from the bluff last described, the cliffs, which are here about one hundred feet in height show only a succession of grey sandstones and conglomerates from base to summit.

First out-crops of coal in the Newcastle district.

From this point to where the main road leading to the Emigrant Settlement crosses Newcastle River, a similar ascending series is exposed in the cliffs along its banks, and about 382 yards beyond the bridge the first outcrops of coal in the Newcastle coal district appear.

In the last section above described the lower grey members of the Middle Carboniferous formation are separated from the red rocks which are referred to the Lower Carboniferous formation only by beds of doleritic rocks, while no appreciable discordance between them in their dip is observable. The felsites, however, which at other points described in the remarks on the Lower Carboniferous formation, appear to be the highest member of that series are here wanting. From the point where the doleritic rocks No. 2 of the above section, are first covered by the coarse grey beds which mark the base of the Middle Coal formation, to the bridge over Newcastle River on the Emigrant Settlement road, the distance measured along the stream is 3,000 yards, or in a straight line about 1,000 yards. The beds in this interval have never a higher dip than two or three degrees, while they are often nearly or quite horizontal, and the bridge may be taken as marking the upper limit of the barren grey measures.

Limit of the barren measures.

From the bridge the country on either side of the Newcastle Creek to its embouchure in Grand Lake, is everywhere occupied by strata of the Middle Carboniferous formation, (productive coal measures), and the coal croppings are quite numerous. Indeed at almost every point where irregularities of the surface or tributary streams afford facilities for working, excavations have been made, seldom failing to disclose the existence of coal at moderate depths. Where the overlying deposits exceed eight or ten feet in thickness these openings are usually by adits driven on a slope till the coal is reached, and then following the latter nearly horizontal. But when the seam is nearer the surface it is simply laid bare by stripping. It was hoped that the positions of the openings, particularly of the latter kind, might throw some light on the structure of the basin in which the seams are supposed to lie. In this, however, we were disappointed; the thickness of the measures above the coal appearing to vary for the most part simply with the accidents of denudation.

Numerous coal croppings.

Excavations.

Details of the principal excavations.

The following details of the principal excavations show the character and thickness of the measures in this coal field. The numbers attached correspond with those on the map:

Robert McDonald's.

No. 1. *Robert McDonald's.*—This opening is the first met with in descending Newcastle Creek from Emigrant Settlement road, from which it is about 360 yards distant.

	Feet	inches
Coal, partly covered by water...................		3
Coal shale...		2

	Feet.	Inches.
Coal	1	1
Coaly shale		1
Grey, somewhat shaly sandstone, partly concealed		
	1	7

No. 2. *Robert Libby's.*—This opening is about 417 yards south-west from No. 1, and on the opposite or right bank of the stream. Robert Libby's.

	Feet.	Inches.
Shaly coal	0	5
Grey clay	0	8
Shaly coal	0	6
Grey clay	0	8½
Coal softened by weathering	1	8
Coal shale	0	1½
Grey sandstone	5	0
Shale	2	0
	11	1

No. 3. Is an old adit now closed; its only interest arises from the fact that the coal-crop here, which is about 711 yards south-west from the last, is about ten feet above the level of the stream, while those in Nos. 1 and 2 were at and below that level. This may, perhaps, arise from a slight eastward inclination of the beds, which, however, is not apparent, or it may be caused by a fault; otherwise it would seem that there is more than one coal seam in this locality—a view which is supported by the marked differences in the thickness and character of the strata at the two first described out-crops. At No. 3, the coal-bed, the thickness of which we could not ascertain, is covered by ten feet of concealed measures, above which are ten feet of grey sandstones and six feet of gravel. Old adit.

No. 4. Here, on a small brook about 1,400 yards S. 10° W. from No. 3, and six feet above the level of Newcastle Creek, there are several openings from which a considerable quantity of coal has been removed. These openings are now abandoned, and no observations could be made on the character of the measures. Abandoned openings.

No. 5. *Stone's.*—This is on the creek, not far from No. 4, and has also been extensively worked, but like the latter is now abandoned. Stone's.

No. 6. *Kennedy's.*—This is also on the bank of the creek, about three-quarters of a mile south of No. 5. In both No. 5 and No. 6, the coal is of good quality. There are other openings along the Newcastle Creek, between No. 6 and Yeoman's Post Office in Newcastle Settlement. In the northern part of the settlement there are several openings, the most important of which is Kennedy's.

No. 7, *John Yeoman's.*—This, however, was closed at the time of our visit, and we are therefore without particulars. John Yeoman's

Principal workings in the district.

The principal workings now in progress in the district are in the western part of Newcastle Settlement, about 1,600 yards from Yeoman's Post Office. There are here twelve openings in a distance of 888 yards; they are all adits, driven first with a slight downward inclination and then nearly horizontally, and are along the south side of a slight valley or depression falling towards Newcastle Creek. The thickness of the coal in the most easterly of these openings is said to vary from one foot to eighteen inches. This is

Coal one foot to eighteen inches.

No. 8, *Coakley and Kennedy's.*

McMahon's.

No. 9, *MacMahon's.*—This is to the westward of No. 8, and was the only one being worked at the time of our visit. It shews:

Coal, including a six-inch parting..............2 feet 6 inches.

A better view of the measures is exposed at

O'Leary's.

No. 10, *O'Leary's.*—This is about 293 yards from No. 9, and exposes the following ascending section:

	Feet.	Inches.
Fire clay, thickness not known, but exposed for	4	0
Coal, of good quality	0	8
Shale	0	2
Coal, of which eighteen inches is good	2	4
Blue shale from	9 to 15	0

Along the road connecting the settlements of Newcastle and New Zion, there are numerous other openings, some of which are still being worked. Of these the two following are the most important:

Peter McKenzie's.

No. 11, *Peter McKenzie's.*—This is about 1,600 yards west from No. 10. The coal is stripped by the removal of about six feet of soil, and is said to be rather more than one foot four inches thick. As the trench was full of water no measurements could be made.

Coal one foot four inches.

John Maynard's.

No. 12, *John Maynard's.*—There are a number of openings here, most of them abandoned, but one of which shows the following ascending section:

	Feet	Inches.
Coal	0	6
Fire-clay	4	0 to 6 ft.
Black coal shale	0	2
Coal, with pyritous bands at top and somewhat shaly below	1	10 to 2 ft 3 in.
Yellow clay	6	0
Chocolate-colored clay	4	0

The coal from this opening is that generally employed for blacksmith's use. The seam dips E. 10° S. $< 2^{\circ}$-3°.

A second and scarcely less interesting series of openings has been made a few miles further south, in the vicinity of Grand Lake, and contiguous to the road from the mouth of Newcastle Creek to that of Little River. Of these the following are the most important:—

McMahon's, near the steamboat wharf.

No. 13. *MacMahon's.* This is near the steamboat wharf.—The coal here has been laid bare by stripping for a length of about forty feet. It is from two feet to two feet six inches thick, and rests upon white fire-clay. Above it is a similar material of which two inches only is white, and the remainder, from four to five feet, of a deep chocolate color. The seam rises slightly at the eastern end of the opening, and at the western end there is a low undulation, causing it to rise about two feet above its general level, while just beyond this bend the seam is abruptly cut off, as if by a fault, and is replaced by clay. The coal is of the variety locally designated fine or still water coal; it is much broken, but is well adapted for forge purposes. Coal seam two feet six inches.

About 340 yards west from No. 13, there are several more openings, the walls of which have fallen in. One of these is a level, about twelve feet below the surface; in the other the coal has been reached by stripping. Other openings.

No. 14. *Leonard Akerly's.*—This is a little to the westward of No. 13. The coal has been exposed by the removal of about three feet of chocolate-colored clay. It resembles in character that from No. 13, but the thickness of the seam is reduced to about one foot four inches. Further west about 177 yards, coal, probably the same seam, is again exposed, shewing a thickness of one foot six inches. It is underlaid by fire clay and covered by about three feet of yellow clay, with irregular pockets and thin seams of coal near the top, and succeeded by three feet of chocolate-colored clay and soil. The seam dips slightly to the north-west, in which direction, at a distance of about one hundred feet, it sinks to nine feet below the surface, and has been worked by a level. Leonard Akerly's. Coal seam, one foot six inches.

No. 15. *George Morrison's.*—This opening presents the following ascending section: George Morrison's.

	Feet.	Inches.
Fireclay	2	0
Coal of good quality (blacksmith's)	1	6 to 1·8
Shale and clay		8 " 10
Coal		6
Shale		6
Stratified gravel	10	0

The surface of the lower seam at this crop is slightly undulating, sinking a little to the westward where the upper or six-inch seam comes in. The latter appears to occupy a position similar to that of the upper seam in Akerly's opening, No. 14, and it is similarly broken and irregular. On its eastern extension, it becomes thinner and gradually disappears. In another opening, Richard Rogers', close to No. 15, the measures are much the same, except that the upper seam is less clearly defined, being represented only by several thin coaly layers mixed with shale, and covered by about three feet of sand and earth. Richard Rogers' opening.

Throughout the district bordering the Little River road, out-crops of

Scarcity of exposures.

the strata other than those exposed in the coal openings are very few, and such as do occur are of the ordinary grey sandstone in beds which are nearly if not quite horizontal. In approaching Little River, however, from the eastward, these are partly covered and concealed by purplish-red sandstones, which are probably of the Upper coal formation. At Flower's Cove and Little River, the grey beds again appear, being horizontal flaggy sandstones of an olive-grey color, and much stained by decomposing pyrites. Coal has been removed at several points here. The openings are, however, now abandoned, and we could procure no details of the character of the measures.

Abandoned openings.

Beyond Little River no out-crops of coal so far as we are aware have yet been observed, the grey beds being in this direction mostly covered and concealed by the purple and reddish beds of the Upper coal formation. In addition to the above openings there are a few others on Back Coal Mine Brook, a small stream flowing into the Newcastle River, nearly midway between Grand Lake and Newcastle Settlement. In these, two seams are exposed, the lower of which has a thickness of eighteen inches, while the upper is eight inches; the intervening rock is a blue, flaggy shale, containing numerous remains of ferns. Beneath the lower seam, which is covered by from twenty-five to thirty feet of earth, is a thick bed of pyritous white fire-clay, the whole rising in a direction a little south of west about 6 inches in twenty feet. These openings are indicated upon the map as No. 16.

Coal seams on Back Coal Mine Brook.

Pyritous fire-clay.

Salmon River.—The section of the coal measures afforded by Salmon River are altogether less instructive and less important than those of Newcastle Creek. The exposures along its banks are much fewer and the coal crops less frequent. There are, however, several out-crops from which considerable quantities of coal have been removed, and it was from near the mouth of this stream that the first coal found in New Brunswick was mined by the French, nearly two centuries ago. It is here also that the boring for coal was made in 1837.

First coal mining in New Brunswick 200 years ago.

The principal coal crops are those about Iron-bound Cove and near McDonald's Landing. At the first named point there are three openings: two of them are on James H. Hazelwood's land and close to what is known as Francis Landing.

Opening near Francis Landing.

The coal in one of these openings is fifteen and one half inches thick, and is about one and a-half feet above low water; while at the second, about twenty rods north-westward from the last, its thickness is one foot eight inches, and it is several feet above the same level. At the third opening, on Widow Arbuckle's land adjoining, the seam is as much as twelve feet above low water. The difference is probably due to faults, as the strata exposed upon the adjacent shore of the cove, which are coarse grey sandstones with much false bedding, do not show any appreciable

Coal seams fifteen and a half inches, and one foot eight inches.

inclination. The opening near MacDonald's Landing is about one and a-half miles to the rear or eastward of the left bank of the river, and has yielded coal of good quality; but, as it was not being worked when we visited it, we could procure no further particulars respecting it.

In ascending Salmon River from this point to the junction of Lake Stream, beyond which our observations have not extended, the only rocks met with were grey sandstones usually in nearly horizontal beds, but sometimes, as at MacDonald's Landing, having a south-easterly dip of about 5°. Most of the country intersected by this river is low and flat, and extensively covered with sand, and showing few rock exposures. The same is also true to a great extent of that on either side of the Gaspereau River which up to Evan Burpee's, a distance of about nine miles above its confluence with Salmon River, shows along its banks only low bluffs of coarse grey sandstone and conglomerate. These beds are largely made up of small quartz pebbles, and appear to correspond with the barren grey beds on the upper part of Newcastle Creek, described page 199. Between Newcastle River and Salmon River, there are but few points at which the rock formations are exposed to view, and such out-crops as do occur, are for the most part those of the soft red and purple beds, which appear to belong to the Upper coal formation. Some out-crops of the latter may be seen a little east of Newcastle Creek, not far from where it is crossed by the road to Emigrant Settlement, as well as in the Middle Land Settlement, Iron-bound Cove, and Salmon Creek Settlement; but it is in the latter, or rather along the course of Salmon Creek itself, that the best exposures are to be seen.

This stream, which empties into Salmon River about three miles below the mouth of the Gaspereau, takes its rise by two principal branches not very remote from each other, in the central part of the parish of Northfield.

It is upon the North Branch that the more interesting exposures are to be seen, including towards its head, where the stream again forks, a small out-crop of coal. The latter occurs upon the Little West Branch, west of its junction with the main stream of the North Branch, and presents the following ascending section:

Coal on the Little West Branch.

Coal and coal shale, partly covered by water	about	1 foot
Fire clay	"	1 " 6 in.
Shale	"	3 feet
Gravel	"	5 "
Stratified brown loam, with pebbles	"	10 "

About two and a-half miles up the North Branch is another crop, not visited by us, in which the seam is about fourteen inches thick, of good quality, with a one inch parting of coal shale.

Fourteen-inch coal seam.

On both these branches the rocks are grey, rather coarse and somewhat flaggy sandstones, with some conglomerates, and more rarely with beds of shale, their attitude being nearly horizontal. At the bridge where the two smaller streams unite to form the main North Branch, the dip is N. 70° E. < 2°. From this point to where the stream turning southward passes from Sunbury county into Queen's county, similar rocks are exposed along its banks in bluffs from ten to forty or fifty feet in height, being as before nearly flat, but usually with a low south-east dip, which sometimes rises to 6° or 8°. On the land of John Best a bed several feet thick of soft bluish shale overlying a bed of fire-clay appears beneath the sandstones which make the mass of the bluffs. Though not exposed upon the surface a bed of coal may be looked for here. 440 yards below the bridge, at the forks of the stream, there is also a low bluff of purple sandstone, apparently of the Upper Coal formation. The rocks which we think to be of this age are, however, better seen in the lower part of the stream, *i. e.*, between the county boundary and the point where the North and South Branches unite in Salmon Creek, and along the course of the latter. The transition from the grey to the red and purple beds is an abrupt one, being marked only by a narrow depression filled with debris, and which probably indicates the line of a fault. Just below this depression, where the bank is some thirty feet in height, the rocks at its base are soft purple-grey sandstones, and thin papery but somewhat sandy shales, which are nearly horizontal. The shales contain in considerable numbers fragments of *Calamites* and *Cordaites* and more rarely a fern, the latter being also but imperfectly preserved.

Fire-clay.

Fossil plants.

About two miles lower down a better view of similar strata may be seen on the main Salmon Creek, where a bluff about forty feet high exhibits the following ascending section:

Section on Salmon Creek.

	Ft.
Purple sandstone	3
Purple rubbly shale	4
Fine papery purple shale	3
Purple red sandstone	6
Purple shale, with thin beds of sandstone	20

The shales contain numerous remains of *Cordaites* and *Calamites*, while on the surface of the sandstone large fronds of ferns may sometimes be found, but usually in a poor state of preservation.

These fossil plants have been submitted to Principal Dawson, who has furnished the following note upon them:

Note by Dr. Dawson on the fossil plants.

"The plants from Salmon Creek and Cork Settlement, and a fossil labelled 'from the grey conglomerates' at Douglas Harbor, have a decided Upper Coal formation aspect. It is very possible therefore that the productive coal measures may underlie the beds containing them. In Nova Scotia such plants often occur several hundreds of feet above the highest workable coals, but as in New Brunswick, the whole formation seems to be thinner, they may be more closely associated with the Middle Coal measures.

The plants from the other localities have more the aspect of the Middle Coal formation, and some of them even of the Millstone-grit formation.

I give below a list of those that are determinable arranging them according to localities:" List of fossil plants.

Salmon Creek.

Calamites dubius, Artis. *Cordaites simplex.* Dawson.

Alethopteris nervosa, Goeppert.

Neuropteris Loshii, Brongn.

Pecopteris oreopteroides, Brongn. (or similar). *Lepidodendron.*

Neuropteris, a species of which I have specimens from Grand Lake, and from Sydney, Cape Breton, and possibly new; but I have not yet sufficient material for its description.

Cork Settlement.

Annularia sphenophylloides, Zenker.

A longifolia, Brongn.

Douglas Harbor.

Dadoxylon materiarium Dawson, labelled 'from grey conglomerate.'

Dadoxylon Acadianum, Dawson. The first of these species is characteristic of the Upper Coal formation, the second of the Middle Coal formation and Millstone grit.

Ferris Cove.

Calamites Cistii, Brongn.

Cordaites, borassifolia, Corda, specimens not well preserved.

Clones.

Cordaites, borassifolia, Corda.

Trigonocarpum.

Jemseg.

Lepidophloios (not determinable).

Coal Creek.—The interest which attaches to this stream arises from the numerous coal-openings along its banks, but chiefly from the information which it gives as to the probable shallowness here of the productive coal formations in this district. The openings are entirely confined to the lower portion of the stream, the first being about one and a-half miles, and the last about three miles above the bridge, at its mouth. They are evidently all in the same seam, the strata which form bluffs along the creeks have a slight inclination to the northward, just sufficient to free the levels of water; and consist, as far as could be seen, of a soft blue shale, crumbling readily on exposure, which is capped by about ten feet of soft grey and mostly thin-bedded sandstones, the shales being those from which most of Evidence of the thinness of the productive coal measures.

the fossil plants alluded to in a previous Report were obtained, (Report of Progress, 1870-71, page 214).

Mines worked forty years ago.

The mines at this locality were worked more than forty years ago by Messrs. Hersey and Matthew for a period of three years, during which time about 800 chaldrons of coal were taken out and shipped to Boston. The work was then suspended owing to a duty of $2.00 per ton being placed upon the coal by the United States Government. A few years since operations were again renewed by different parties, and considerable quantities of coal removed. It was here, also, that the ninety-six feet boring already mentioned was made in 1869, since when no further efforts have been made to develop the coal-seams, and the levels have for the most part fallen in. The only point at which a good view of the strata in this vicinity could be obtained was on the farm of William Hayes, four miles above the bridge, at the mouth of the stream. A bluff here shows the following ascending section :

Boring in 1869.

	Feet.	Inches.
Blue shale, of unknown thickness, being mostly beneath the level of the stream	—	—
Coal shale	2	0
Impure shaly coal	0	3
Grey shale, apparently about 20 feet in thickness, but partly concealed towards the top, where it is followed by a thin bed of coal. This is also partly concealed, but where uncovered shows a thickness of about 8 inches—thickness of whole	20	8
Grey shale	12	0
Grey sandstone to top of cliff......about	8	0
	42	11

The above beds have a scarcely perceptible inclination to the eastward. About three miles up the stream there is another exposure of similar sandstone forming a second bluff, but here these nearly horizontal beds may be seen to rest upon beds of bluish-grey and purplish-grey micaceous slates, which are exposed in irregular ridges by the partial removal of the overlying strata, and dip S. 70° E. < 70°. These rocks are the first of a succession of similar beds, embracing argillites of various shades, together with considerable masses of hard grey sandstone, which are exposed, at short intervals, for a distance of seven miles at least along the course of the stream. They are often spangled with scales of mica, and at some points are charged with pyrites, or much stained with oxide of iron. In these as in their other features they resemble the argillites met with on the St. John River, in portions of Hampstead and Enniskillen, and which, as elsewhere shown (Report of Progress, 1871, page 197), are probably of Devonian age. The occurrence of such strata at this point, in the very heart of the coal-basin and over so extensive an area, is very significant, and, as will readily be seen, has an important bearing upon all questions

Devonian rocks.

connected with the thickness and productive capacity of the latter. The lateral limits of this island, if it may be so termed, in the Carboniferous sea, we have been unable to determine, the country on either side of the stream being nearly flat and covered with forest.

Interesting sections of the strata around Grand Lake.

Grand Lake.—Although usually low, there are many points around the shores of Grand Lake where the strata are exposed to view, while occasionally they rise into bluffs, and show sections of considerable interest. Of these the most important are those which tend to illustrate the relations of the grey beds of the Productive or Middle Coal formation to the red and purple beds, supposed to represent the Upper or Newer Coal formation. These relations may be well seen at and near Scypher's Cove on the north side of the lake, and again at Ferris's Cove on its southern shore. Scypher's Cove is a small indentation about four miles west of the mouth of Little River. It has already been observed (page 204) that near the latter the purplish-red sandstones may be seen resting on the nearly horizontal grey sandstones of the Middle Coal formation; with this exception, the latter are the only rocks met with along this shore of the lake to the head of its north-east arm. In the opposite direction they also appear to be the surface rocks for some distance, but, the shore being low, few exposures are to be seen until Scypher's Cove is approached. Just east of the latter is another and smaller indentation, Butler's Cove; and between the two coves we find the following ascending section:

Scypher's and Butler's Coves.

Ascending section of strata.

1. Grey sandstones, like those of the coal measures, rather coarse and pebbly, and containing sigillaria and other large prostrate trunks of trees, some of which are 15 feet and more in length. There is much false bedding, and the stratification is obscure.
2. Measures concealed for 382 yards in a westerly direction, then an exposure of fine conglomerate or coarse grit of a grey color, slightly tinged with green. This tint appears to be due to the frequent occurrence of small fragments of pale green slate, which with similar fragments of grey and purple colors, and a little quartz, make up the rock. These fragments may have been derived from the abrasion of Pre-Carboniferous argillites. Twenty-six yards eastward, the same conglomerates become purplish-grey, and are covered by coarse purplish grits and sandstones, which are irregularly bedded, but have a slight westward inclination. Allowing to the conglomerate the same dip as that of the beds mentioned below, they may be roughly estimated as having a thickness of.................................. 3 ft. 0 in.
3. Purple sandstones like the last, but becoming in a distance of 800 yards, measured along a curve changing from west to west 20° south, deep purplish-red and then dark purple. The dip of the beds in the latter part being regular, S. 30° W. $< 2°$. In consequence of this inclination the beds in ascending order sink successively to the water level, showing in a distance of 622 yards a thickness of about.. 20 ft.

In a similar way higher beds come successively into view as follows:—

4. Coarse purple sandstone and conglomerate.. 12 ft.
5. Grey grit and conglomerate, similar in composition to No. 2, but coarser, partly concealed for four and a-half feet at the base, but with an exposed thickness of about twenty-five feet, the upper part becoming shaly........................ 30 ft.

6. Dark purple, shaly sandstone... 10 ft.
7. Grey conglomerate, dipping as before, and having a thickness of about.......... 12 ft.

Impressions of fossil plants and rain drops.

At some points there are thin beds of dark purple, papery shales associated with No. 6, which, together with the sandstones, contain a few impressions of *Calamites* and ferns, as well as of rain drops. The plants are similar to those of the purple beds of Salmon Creek upon which the observations of Dr. Dawson have been given.

Scypher's Cove.

The series of beds described in the foregoing section occupies a distance of about a quarter of a mile along the shore, extending quite to Scypher's Cove, on the eastern side of which the grey conglomerate (No. 7) appears in low vertical bluffs; a similar conglomerate bluff bounds the cove on its western side, the rock being coarse and crumbling, and made up mostly of small well rounded pebbles. A little to the westward, about 382 yards, purple beds again come into view, being rather coarse, shaly sandstones, overlying coarse, grey sandstones which are rusty and calcareous, and contain impressions of plants. A succession of similar beds is then met with; the sandstones, which vary from grey to olive-grey in color, and often contain trunks of trees, frequently alternating with and sometimes shading into the purple beds. The latter are also mostly sandstones, but half a mile westward of Scypher's Cove they include and are capped by a considerable thickness of soft, deep purplish-red shales. The beds along all this portion of the shore are nearly flat, or with very low undulations. The road which divides the upper and lower sets of grants on this side of the lake comes down to the shore here, and beyond it there is a curving beach thirteen hundred yards long, on which there are but few exposures of the subjacent rocks; but at its extremity they again form a conspicuous bluff twenty feet high. The lower five feet is composed of dark purplish-red sandstone, and the remainder of a rather coarse and rubbly chocolate-colored shale. The sandstones show much false bedding, they are also very variable in texture, and often pass into conglomerates, which are largely composed of well-rounded pebbles of chalcedonic quartz, with others of felsite, mica slate, etc. Similar chalcedonic pebbles are abundant in the materials of the beach, and are often brightly tinted, recalling the beds of this substance mentioned on page 192 as occurring in connection with the Lower Carboniferous rocks on the south shore of Washademoak Lake. Beyond this bluff, is another long narrow beach, shutting in the basin known as the Upper Keyhole, beyond which to Grand Point, a distance of two miles, the shore is similarly low and without rock exposures. On Grand Point, which is a long narrow spit mostly of shifting sand, projecting half way across the lake, a few flat beds of grey sandstone may be seen, containing trunks of fossil trees. Just beyond Grand Point is the Lower Keyhole, more commonly known as Douglas Harbor. On either side of its narrow entrance low ridges

Pebbles of chalcedonic quartz.

may be seen, composed of grey coarse conglomerates, much stained with iron, and like those of the bluff last described containing numerous pebbles of chalcedonic quartz, together with others of grey quartzite, slates of various colors, and fragments of sandstone, the latter scarcely harder than the enclosing rock. Coarse beds of sandstone also occur; both rocks are very irregularly bedded, and both contain numerous prostrate trunks of trees, which have usually been converted into black crystalline calcite. Similar beds also appear near the steamboat wharf, at the head of the harbour, but are there overlaid by coarse, purple sandstones which have a very slight easterly inclination.

Fossil tree-trunks changed into black crystalline calcite.

To the north and west of Douglas Harbour the country is low and level, and rock exposures are but rarely met with. It is probable, however, that most of this region is covered by the purple beds above described; fragments of them are abundant over its surface, while ledges of similar rocks occur at some points around the shores of Maquaspit and French Lakes. Better exposures of these rocks may be seen a few miles further north, on Little River in Sunbury county. They occur in a bluff, and in the bed of the river about three-quarters of a mile south of the point where the New Zion road crosses it, and according to Mr. Ells, who examined them, the beds consist of about four feet of very hard, dark purple sandstone, overlaid by a bed of reddish-purple shale of finer texture; the latter interstratified with thin beds of fine, purple sandstone, extending up the whole face of the cliff, which is from fifty to seventy feet in height. The bluffs extend along the stream for four hundred and fifty yards with good exposures; beyond which, to the New Zion road, but little can be seen. About the same distance north-east of the road is a second bluff fifteen feet high; but here the beds are grey sandstones and conglomerates with a southerly dip of two degrees. They contain numerous embedded trunks of trees. On Number Eighteen Stream, about three-quarters of a mile above the portage-road bridge, and about one and a-half miles from the New Zion road, is a seam of coal apparently about fourteen inches thick. Another small seam, or a continuation of the same, also crops out at a point about four miles further up.

Maquaspit and French Lakes.

Number Eighteen Stream.

Two coal-seams.

The highest point reached by Mr. Ells on the main stream of Little River, was eight miles above New Zion bridge, where in a high bank, known as Whet-stone Brow, grey coal shales, full of plant impressions, are exposed.

On the southern side of Grand Lake, the best exposures are towards its western end, and more particularly about Robertson's and White's Points and White's Cove. On Robertson's Cove, the rocks are chiefly a coarse grey conglomerate about twelve feet in thickness, which rests, near the water level, upon beds of grey sandstone; the first named rock being largely made up of slaty fragments of various shades of color, together

Rock on Robertson's Cove.

with some quartz and more rarely a pebble of granite, the whole inclosed in a sandy matrix, through which are also scattered numerous white particles, which appear chiefly to be a kaolinized feldspar. Similar conglomerates and sandstones may be seen along the beach westward of the point, and towards the outlet of the lake, and occasionally alternate with purple beds; but their relations to the latter are best seen in Robertson's Cove, a small indentation just east of Robertson's Point. There is here a series of vertical bluffs about thirty feet in height, which at their base show beds of soft purplish-red sandstone, separated by soft dark red shales from overlying coarse greenish-grey grits and conglomerates. These are similar to those of the Point, but are more pyritous and yellowish stained, and are further distinguished by containing three or four thin layers of coal, from one eighth to one-quarter of an inch in thickness. Along portions of the bluff, which has a length of over seven hundred yards, the grey beds which are nearly horizontal, though exhibiting much false bedding and some faults, appear to rest conformably upon the purple beds, into which they may also be seen to graduate, but at others small angular ridges or points of the purple beds project upwards into the grey, as though the latter had been deposited on their eroded surface.

Thin layers of coal.

White's or Ferris' Cove.

At White's or Ferris' Cove, two miles east of Robertson's, similar beds may again be seen, here forming bluffs about fifteen feet in height, at the base of which are bright purple and purplish-red beds, and above, sandstones and rather coarse conglomerates, which vary from grey to purplish-grey in color. Both here and at Robertson's Point the grey beds are characterized by a pale shade of green, and often look as if made up of granitic debris, or the waste of such chloritic and granitoid rocks as occur at some points along the shores of the Long Reach of the St. John River, and which have been elsewhere referred to the Huronian series (Report of Progress, 1870-71, page 113). Mingled with these materials of metamorphic origin, small pieces of unaltered sandstone are also met with, and occasionally small fragments of coal.

The two sets of beds above described, *i. e.*, the greenish-grey and purple, appear to border the whole southern side of Grand Lake, at least as far eastward as Cumberland Bay; the one or the other being the most prominent in accordance with slight undulations by which they have been affected. At Wiggins Cove they are well exposed in vertical bluffs, about twenty-five feet in height, of which the upper part is a soft rubbly chocolate-colored and somewhat marly shale, the base being a flaggy sandstone, similarly tinted. Along the shore west of Young's Cove they also form low bluffs (pale purplish-grey sandstones overlying grey pebbly sandstone) and contain ill-preserved remains of plants (*Calamites*, *Cordaites* and ferns,) similar to those of Salmon Creek.

Vertical bluffs at Wiggins Cove.

The most easterly point at which they have been observed is Branscombe's

Point at the mouth of Cumberland Bay, on the southern side of which they again form low cliffs, but do not present any features differing from those already noticed.

At the head of Cumberland Bay, and near where Cumberland Creek is crossed by the high road from Cox's Point and the North-west Arm, are a few ledges of dark grey, rather fine-grained sandstones, which are somewhat doleritic in aspect, and may be the equivalents of the doleritic rocks which near the Forks of Newcastle Creek constitute the highest beds of the Lower Carboniferous formation. The only other beds observed in this vicinity (excepting those of the claystone ridge south of Cumberland Creek, described in connection with the Lower Carboniferous formation, page 195) resemble those of the ordinary coal measures, being grey sandstone and conglomerates, the latter sometimes much stained with oxide of manganese.

Doleritic sandstones.

Conglomerates stained with oxside of manganese

Over the region which lies immediately to the southward of Grand Lake it is often difficult to infer the character of the subjacent strata, owing to the extent to which they have been covered by debris derived from the rocks of the Upper Coal formation which lies to the northward. It would seem, however, from such observations as we have been able to make, that the Upper Carboniferous rocks are for the most part confined to the vicinity of Grand Lake, not having been met with in situ along the shores of Washademoak Lake, nor through the low ground separating the two, in their central and eastern portions. To the westward in Cambridge, however, the Upper Coal formation covers a more considerable area, including the hills between Ferris' Cove and the depression of the Den Creek, as well as a portion of those overlooking the valley of the Jemseg. Here too, unless extensively faulted, they must have a considerable thickness, seeing that their upper beds, which are greenish-grey conglomerates, much like those of the cove last mentioned, though still nearly horizontal, are at an elevation of fully two hundred feet above the latter. Below the mouth of the Jemseg, and west of the road between it and the Narrows of Washademoak Lake, the slope of the hills exhibits repeated alternations of dark purplish-red to chocolate-colored slates, with grey and greenish sandstones, both nearly horizontal, and both containing numerous but ill-preserved remains of plants.

Cambridge.

The depression occupied by the Washademoak Lake and River contrasts with that of Grand Lake in being surrounded by much higher land, while the depression itself is at the same time narrower and deeper; it is also nearer the southern border of the coal field, and in consequence the strata have usually a low northward inclination, though still often nearly horizontal. They may be seen at many points both on the northern and southern shores of the Lake, but with the exception of the red calcareous beds at Belyea's Cove, noticed on page 192 as probably of Lower Carboniferous age, they appear to belong for the most part to the Middle Carboniferous for-

Washademoak Lake.

mation. This is indicated alike by their color, which is almost uniformly grey, as well as the occurrence of coal-seams at various points. One of these is said to occur at the Narrows (where the beds are coarse grey grits and conglomerates dipping a little east of north < 4° or 5°) and to have been struck in sinking a well, but no explorations have been made. Still further eastward another seam of coal has been exposed upon Long's Creek near its confluence with Washademoak River. It is on the land of Samuel Starkey, Esq., and was being proved at the time of our visit. Strata consisting of about 12 feet of sandstones, overlying grey shales, with *Calamites* and about one foot of impure shaly coal were exposed. The dip at the opening is W. 10° S. < 3°; but along the high-way near by, leading up to McLean's mill, the beds which are of similar character are nearly horizontal, though with much false bedding. At the mill mentioned, where they rest on chloritic rocks which have been described on page 194, they include a considerable mass of purple shales.

Reported coal-seam.

Coal-seam on Long's Creek.

It has been already remarked that in this portion of its distribution the coal measure series appears to have often but an inconsiderable thickness, forming indeed a mere capping to the older rocks. One instance of this has just been pointed out in the case of Long Creek. A similar occurrence may be seen higher up on the same stream, and in the Settlement of Goshen, where on the higher lands, the grey Carboniferous sandstones are the only beds visible, while the bed of the stream is composed of hard Pre-Carboniferous argillites; and again on the Canaan River, which joins the Washademoak at its eastern end, as well as on several of its northern and southern tributaries.

Thus about three miles below the mouth of the Canaan North Fork, the banks of the river, which are about thirty feet in height, are at the base composed of highly inclined Pre-Carboniferous argillites, upon the top of which, but in nearly horizontal layers, are about fifteen feet of grey Carboniferous sandstone, the inferior beds along the line of contact being all bent and flattened to the eastward, as if from the pressure of the superincumbent rocks.

Carboniferous sandstone on Pre-Carboniferous argillites

Mr. Ells ascended the Canaan North Fork, by wading, to a distance of eleven miles from its mouth. For nearly two miles up he observed Pre-Carboniferous beds consisting of grey argillites and quartzites, the former marked by darker colored bands and often containing white quartz. At some points these beds rise into bluffs completely denuded of overlying deposits, but at others capped by thin beds of sandstone, which are mostly grey and not readily distinguished from those of the productive coal formation, except that they are occasionally of a pale greenish tint like certain beds of the Upper Carboniferous formation. The view that they belong to this formation is supported by the occurrence at many points of purple sandstones and shales, much like those of Grand Lake, and which

Canaan North Fork.

contain similar fossils. These purple beds occasionally hold spherical concretions, and are at some points overlaid by beds of grey sandstone. Beneath them, on the upper part of the stream, shale and fire-clays were also observed, but no beds of coal. In its lower portion, and just north of the most northerly exposure of the argillites above mentioned, is a bed of breccia which is rusty and full of large and small angular pieces of mica schist, diorite, quartz and quartzite, without evident stratification, and looking as if poured over the subjacent rocks. This breccia may be of Lower Carboniferous age.

Breccia of mica schist, diorite, &c.

The dip of the slates on the North Fork is about N. 65° W. < 60°; that of the Carboniferous strata being very variable, but always low, usually at angles of only 2° or 3° and with much false bedding. Rocks similar to the latter were also observed by us on Alward Brook, which is not laid down on the Provincial map, but is a stream of considerable size running nearly parallel to the North Fork, and entering the Canaan River a little below the mouth of Thorn's Brook. The beds on Alward Brook are said to contain a thin seam of coal, but such, if really present, must at the time of our visit have been concealed beneath the water.

Alward Brook.

The rocks exposed along the streams which enter the Washademoak River on its southern side, (such as Rider's Brook, Porcupine Brook, &c.,) appear to belong entirely to the Middle Coal formation, being mostly grey sediments of a very coarse character, such as pebbly conglomerates and grits, often stained with oxide of manganese, but embracing also some finer beds, such as shales and fire-clays. The occurrence of the latter renders that of coal not improbable; but, though several of the streams which traverse this almost wholly unsettled district were examined, none was found.

Fire-clay.

We may conclude this review of the Carboniferous formation east of the St. John River by a brief reference to a series of beds which, though not within the limits to which our attention has been devoted during the past season, is yet deserving of notice in connection with the question of coal supply, the investigation of which was the principal object of our labors. The strata referred to occur near Dunsinane station, on the line of the European and North American railway, in the eastern portion of King's county. A short notice of these beds, not one, however, based upon any personal examination, together with an analysis of the associated coal, was given by one of the authors in 1865 in their "Observations on the Geology of Southern New Brunswick," and they were then considered to be probably of Lower Carboniferous age.

Strata near Dunsinane station.

A visit to the locality, however, since made, has shown that although the greater part of the valley in which these beds occur is occupied by rocks of the age in question, yet that these are here covered by an outlier of the true or productive coal measures. The ground in the vicinity being low and swampy as well as densely wooded, the opportunities afforded for a study of the formation are but scanty, and its extent and thickness are therefore still undetermined; but that it belongs to the Middle Carboniferous formation is apparent from the character of the rocks (grey sandstones and soft blue and grey shales) and also of the associated organic remains. In the shales there are numerous and well preserved impressions of *Calamites* and ferns, *Alethopteris lonchitica* being especially abundant.

Twenty-inch coal-seam.

Some eight or ten excavations have been made, and the coal-bed which is believed to be the same in all, has usually a thickness of twenty inches, though at some places including a one inch parting of coal shale.

At one of the pits the rock removed is a soft red shale. Excavation to a depth of about sixty feet failed to show the existence of other seams of coal.

Details of Observations in Queen's and Sunbury Counties, West of the St. John River.

The following observations on the Middle and Upper Carboniferous formations embrace a description of them as seen in the region watered by the Oromocto River and its tributaries, and in that bordering the St. John River in the neighbourhood of Gagetown. To these are added a few notes on portions of York county; chiefly along the line of the Fredericton Branch railway.

Exposures on the Nerepis River.

On page 188 the Lower Carboniferous strata were described as extending one and a quarter miles up the principal branch of the Nerepis River above Summer Hill Brook. Above the last out-crops of that series, the river runs through gravelly and alluvial land for a distance, measured along its course, of about one mile and a quarter, and affords a few exposures of the grey conglomerates and grits of the barren measures. For a further distance up the stream of about one and a quarter miles, the out-crops become more frequent, and the strata consist usually of coarse sandstones alternating with beds of conglomerate, of a grey color and abounding in thoroughly rolled pebbles of white quartz, with less numerous ones of hard grey slate and sandstone. The sandstones are also grey and olive-grey in color, and become more abundant in ascending the stream. The measures dip at a very low angle, and both sandstones and conglomerates shew much false bedding. At and above the point last described, the beds assume a different aspect, being largely derived from the Lower Carboniferous series. Grey and olive-grey sandstones are seen to alternate here with irregular layers of conglomerates made up of pebbles of red shale and limestone imbedded in a matrix, which in some places is a red mud, and in others is grey and more sandy. The limestone pebbles contain *Terebratula sacculus*, var *sufflata*,

Limestone pebbles holding fossils.

and an *Orthoceras.* These beds extend nearly to the mouth of Wilson's Brook, about a quarter of a mile. For a distance of three-quarters of a mile along the stream above Wilson's Brook there are no rock exposures; but the soil is a red clay abounding in several places with angular pieces of Lower Carboniferous red shales. Above this, grey sandstones with poorly preserved remains of large coal-measure plants shew in the bed of the stream, and the strata dip N. N. E. $< 2°$ or $3°$. At a distance of one hundred and seventy-seven yards further up, there are dark grey and black shales lying horizontally, and enclosing *Cordaites borassifolia, Cardiocarpum* (Sp.) ?, obscure ferns, and a carpolite (?). The same beds hold also a small species of *Naiadites.* 623 yards up the stream, above the exposure of black shales, are the out-crops of the Clones coal-seams.

Clones coal-seams.

Should coal-seams of sufficient importance to be economically worked be found here, two natural outlets for the product of the mines exist. One of these is to the eastward, through the valley of the Otnabog, which rises within a mile or two of the Clones coal-crops, crosses the Gagetown road and discharges into the River St. John; the outlet of the lake at the mouth of this stream being about ten miles from Clones. The other available approach is through the valley of the Nerepis River, near the source of which the seams lie. From Welsford station, on the Western Extension of the European and North American railway, there is an easy ascent along the Nerepis valley through a settled country in a north-easterly direction to the Clones coal-field; a distance of fourteen miles. The crops of some of the seams in this field were discovered about four years ago, but no attempt to ascertain the value of the seams was made until the summer of 1872. Then some small excavations were made in the left bank of the Nerepis River (near its source) just below the driving-dam, a mile and one eighth north of Mr. Hugh Wilson's house on the Upper Clones road.

Three-feet coal-seam.

The most considerable seam exposed was found to be about three feet in thickness, and to consist of:—

	Feet.	Inches.
Coal	1	0
Parting of grey clay	0	2
Coal .... 1 foot 8 inches to	1	10

It is a coking coal of good quality, and yields a light porous coke. This seam may be seen in a trench cut in the bank, about twenty-five yards below the dam, and it is here on a level with the bed of the brook. The seam is separated by an inch or two of shale from a roof of grey sandstone several feet in thickness; the rock beneath the coal could not be seen, being considerably beneath the water level. About twenty feet to the south of this trench, another has been made, exhibiting a seam which, on the edge of the bank, shows only a few inches of coal, but when followed a short distance into the hill becomes more compact, and attains a thickness of one foot. Like the first described, it is overlaid by an inch or two of shale covered by grey sandstone. After the completion of these examinations, which were made by Mr. G. F. Matthew, further explorations were made by Dr. W. S. Harding of St. John, and at a depth of about six feet beneath the smaller seams examined by Mr. Matthew, he found another which he estimates at two feet or more in thickness.

Examination by Mr. G. F. Matthew and Dr. W. S. Harding.

About twenty feet up the stream, above the uppermost of the two trenches, a square pit was made, and the top of the three-feet seam reached; but owing to the influx of water this opening was abandoned. A fourth excavation, made in the bed of the stream near the right bank, shewed the existence of a considerable seam of coal, which is probably the three feet seam, as it is on the line of strike of that bed.

The coal-seams exposed in these trenches and pits furnish data for a rough estimate of the direction and amount of dip of the strata. They incline to the north at an angle of about 13°, a dip considerably higher than has been observed in the strata exposed further down the brook, and to the south-westward of the coal-crops.

Going up the brook, from the points last described, for about fifty feet, indications of another seam were seen in the left bank, at the level of the pond below the gate of the driving-dam. Since Mr. Matthew's visit to this place, a twelve-inch seam has been exposed here by Dr. Harding and Mr. Andrew Corbitt. These gentlemen also had the water pumped out of the pond at the foot of the dam, and were thus enabled to examine a second seam which was found to lie at a depth of about four or five feet below that last mentioned, from which it is separated by beds of grey sandstone. The coal is a firm and brilliant, highly bituminous variety, and the bed is said to have a thickness of fourteen inches. The bottom of the hole, on the sides of which it appears, is filled with gravel; and as the water could not be kept out long enough to explore below the seam, it is not known whether any other seams appear here or not. From the abundance of grey shale thrown out on the bank opposite the dam, it is probable there are soft measures below the seam. It was the breaking up of this seam which led to the discovery of the coal at this place.

Exploration by Dr. Harding and Mr. Andrew Corbitt.

The relations of the coal-beds at the pond to those seen at the trenches and pits further down the stream is doubtful, if the dip of the measures seen in the latter is maintained in the intervening distance, and there are no faults breaking the continuity of the beds, the seams seen at the trenches should pass at a depth of six feet or more, beneath those visible at the pond. Further examination, however, is necessary to prove that the latter are not the seams seen at the lower excavations, repeated by a fault and downthrow of the measures on the south side; such breaks are of common occurrence along the south side of this coal-field.

Probable repetition of the seams by faults.

No other out-crops were discovered within half a mile of the dam, but on the Wilson road, about a mile to the west, there are coarse grey sandstones, having a northward dip of only three degrees; and on the Corbitt or Upper Clones road, one mile west of the Wilson road, there are ledges of similar sandstones with poorly preserved remains of plants. These are close to the base of the series; for at Wilson's they rest almost directly upon red indurated clays of Lower Carboniferous age.

The Nerepis River, above the driving-dam where the coal appears, becomes a small sluggish water-course, running through low land covered with drift deposits, and it affords no exposures of the subjacent sandstone and shales. At a distance of about two miles to the north it issues from a low tract of land, in which both the Otnabog and the Mercereau Brooks have their sources; the former flowing to the St. John River and the latter to the Oromocto. On both these latter streams out-crops of coal exist, but we could not find them owing to the high water in the streams. Between the point where the Otnabog is crossed by the Gagetown road and the marshes at its mouth, it is bordered for a distance of over three miles by bluffs of grey sandstone from ten to fifty feet high. The dip of these sandstones is usually about N. 30° E. $<$ 10°, declining at some points to three degrees. The strata are mostly coarse and occasionally pebbly with much false bedding, but are sometimes finer and somewhat flaggy with thin beds of shale.

Coal crop on the Otnabog and Mercereau Brooks.

Westward of the area to which the above remarks relate, the Carboniferous conglomerates rise into a somewhat elevated and uneven swell of land which where it crosses the old post-road from St. John to Fredericton, presents good exposures of grey pebbly beds and grits, in the hill known as Stony Ridge. The pebbles here are such as may have been derived from the slates and sandstones on the north side of the Carboniferous area, and are like those of the conglomerate of Tweedside, Cork Settlement and other ridges on its northern border. For a distance of one and a-half miles from the corner of the Lower Clones road, the northern slope of this ridge is covered with fine grey, shaly and flaggy sandstones of the productive coal measures, dipping northward at an angle of six degrees. Here they are crossed by the Mercereau Brook and extend down the course of the stream for about five miles, where they are covered by purple sandstone and shales, probably of the Upper Carboniferous formation. The stream appears to run along the contact of these with the productive measures, to within a mile of the bridge near Mercereau's, where it is again bordered by the grey beds of the latter. The measures here dip N. 20° W. $<$ 10°. They consist of grey sandstones underlaid by grey and dark shales, and include a small seam of coal at the water level, some of which has been used in a neighbouring forge.

"Stony Ridge."

Beyond the south branch of the Oromocto River the grey measures cover a considerable breadth, and extend up the North-west Branch beyond Hart's mills to the junction of the Fredericton branch with the European and North American railway. Here the beds are chiefly olive-grey thin bedded sandstones of the productive measures; but in going southward from the mills, grey conglomerates with intercalated sandstones form a long ridge sloping gently to the river. Behind this ridge the finer measures, including beds of soft olive-grey shale, are repeated, and in like manner slope northward from another ridge of conglomerate, southward of which only repetitions of these grey sandstones and conglomerates were seen to within a mile of Shin Creek, where red sediments of the Lower Carboniferous formation rise from beneath them along the northern slope of the valley of that stream. Throughout this tract of grey rocks the beds dip northward, at angles of from two to three degrees, varying in direction from N. to N. 20° W. Westward of the sources of Morancy Brook, which joins the North-west Oromocto on the south side a little below Tracy's mills, the grey rocks are coarser, and at Otter Brook the surface abounds with blocks of grey conglomerate and sandstones, and there are exposures of the latter dipping N. 20° E. $<15°$. In this part of the Carboniferous area the shales form but an insignificant part of the grey measures, and conglomerates with coarse sandstones and grits abound. Such is the condition also of the rock masses of the Middle Carboniferous formation south of the Little and the Great Oromocto Lakes, where the measures resume their normal dip of about four degrees or less to the northward. From Otter Creek westward they form the dividing ridge between the Magaguadavic and Oromocto waters. The character of the beds of this formation, as seen to the westward and northward of the Great Oromocto Lake, has been already described by Mr. Charles Robb, Report of Progress 1866-69, pp. 179–180. From the vicinity of Hartt's mills several tongues of grey sandstones of the Middle Carboniferous formation extend westwardly along the valley of the Oromocto, and may also be traced eastward of that stream in out-crops along Brizzly Creek and the small streams flowing in an opposite direction to the River St. John. One of these crosses Morancy Brook about two miles south from the road, along the south side of the Oromocto. This is probably the same band as that which crosses the North-west Oromocto, below the mouth of Hardwood Creek, where it contains a seam of coal of good quality about five inches thick resting on a bed of under-clay. Other grey sandstones of the type of those usually found in connection with the productive measures are exposed at the junction of Lyon's Stream with the main North-west Oromocto; and also on the Yoho, above and at the mouth of Porcupine Brook. Elsewhere the rocks observed in the flat valley extending from Great Oromocto Lake down the main North-west Branch below Tracy's mills, are purplish-red shales and lilac sandstones, of the Upper Carboniferous formation.

Conglomerate ridges.

Shin Creek, Tracy's mills and Otter Brook.

Hartt's mills.

Five-inch Coal-seam.

Tracy's mills.

No evidence has yet been obtained of the existence of the Upper Carboniferous formation west of the Great and Little Oromocto Lakes. A considerable area, however, on Lyon's Stream (the first northern feeder of the North-west branch of the Oromocto River) is occupied by purplish-red shales, and sandstones with lilac-red conglomerates at the base, which are judged to be of this series. A more southerly belt of those beds probably connected with that in the low lands on Lyon's Stream, opposite Otter Creek, covers the northern slope of the ridge of grey sandstones and conglomerates, already described as forming the divide between the valley of the North-west Branch of the Oromocto on the one hand, and Shin Creek and Peltoma Stream on the other. It runs out upon the North-west Branch at Hartt's mills, and the beds composing it dip northerly, at angles of from 3° to 5°. A parallel band of grey sandstones divides it from another area of purplish rocks which lies along the centre of the valley through which the North-west Branch flows. At several points the shales in this area have been eroded, exposing, especially in the valley of the river and along its banks, horizontal beds of grey thin-bedded sandstone. Similar purplish rocks extend along the road from Tracy's mill, and crop out along the Rusagonish River. They may also be seen along the line of the Fredericton Branch railway, both south and north of that stream, as well as in the vicinity of Fredericton itself. At Three-tree Creek, where the fos- **Three-tree Creek.** sils, a list of which is given on page 216, Report of Progress 1871, were found, the beds are massive even-grained sandstones. At the base, where they rest upon the fossiliferous shales, they are of a grey color, but above become clouded and banded with a purplish tint, and a few rods up the stream are covered by purplish-grey sandstones and sandy shales; the whole dipping N. 15° W. $<$ 10°. Near Rusagonish station similar purple beds are apparently overlaid by rather coarse purplish-red conglomerate, with pebbles of quartz and metamorphic rocks, dipping W. 20° N. $<$ 4°.

Through the district lying to the eastward of the Oromocto River, between that stream and the River St. John, the country is mostly uncleared, and there being but a few small streams, the opportunities for a study of its rock formation, apart from those already mentioned, are but meagre. Purplish-red rocks of the Upper Carboniferous formation show, however, extensively along the banks of Brizzly Brook, and judging from the charac- **Brizzly Brook.** ter of the soil, probably also over considerable areas to the west and south of Gagetown. To the northward of the latter, the only beds observed between it and Swan Creek, and upon this stream for one and a- **Swan Creek** half miles above the lake at its mouth, are grey grits and sandstones of the productive coal measures.

Thickness of the Middle and Upper Coal Formations.

To determine with any degree of accuracy the thickness of the several groups of strata included, in New Brunswick, in the above division of the Carboniferous system, is a task of much difficulty, arising partly from the unsettled character of much of the country over which they are distributed; but chiefly from the fact that over large areas, as already stated, the strata are nearly horizontal, and are only very rarely inclined at an angle of more than four or five degrees. In consequence of this slight inclination of the beds, and the general absence of prominent ridges, the opportunities afforded for their study are not numerous. And such exposures as do occur along the banks of the rivers and creeks, and upon the shores of the lakes, or in artificial excavations, generally afford a very partial view of the formation, while from the very variable character of the strata, even within short distances, and the exposures being separated by intervals more or less considerable, it becomes almost impossible to determine the relations to each other of the beds exposed in the various sections. Besides the difficulty in estimating the thickness of the coal formation, arising from the above causes, and also from the fact that it rests unconformably on all the older rocks, including the Lower Carboniferous formation, and therefore, though thin in some parts, may be much thicker in others, it is also impossible to say to what extent the beds have been affected by faults which are concealed by the general flatness of the country and its superificial covering of drift. In the foregoing details, however, their general succession has been presented, so far as our observations enable us to do so, and we may now offer such conclusions as seem warranted by these data as to the probable thickness and productive capacity of the region examined. The productive coal-measures not being separated by any well-defined line of demarcation either from the barren grey beds beneath, or from the strata of the Upper Coal formation above, no positive or exact statement can be given of their respective thickness. The barren measures are marked chiefly by the more frequent occurrence of coarse sediments, and especially silicious conglomerates, while the Upper Carboniferous formation seems to be indicated by the common occurrence of purple and other brightly tinted beds. So far as we are able to judge at present, the following estimate may be taken as approximately correct:

Partial view of the coal formations afforded by natural exposures or in excavations.

Difficulty in estimating the thickness of the coal formation.

Barren grey beds	200 feet
Productive measures	200 feet
Upper Coal formation	200 feet

Whole series exclusive of Lower Carboniferous formation 600 feet.

Making for the whole series exclusive of the Lower Carboniferous formation, a total thickness of only six hundred feet. And it is to be observed that the above may be regarded as the maximum thickness of the different members. At several points, and apparently over considerable areas, if not over the entire coal-field, the thickness must be much less. The occurrence of such islets of older rocks as that on the upper part of Coal Creek in the very centre of the coal basin, and again on the Canaan

River and its tributaries, to say nothing of the Lower Carboniferous outcrops both on Newcastle River and Cumberland Creek, certainly cannot be looked upon in any other light than as indicating an originally very uneven surface over the area in which the Carboniferous strata were deposited, and either that they never attained any considerable thickness, or else that they have suffered extensive denudation. That a large amount of erosion by glacial and atmospheric agencies has affected this area in common with other portions of the Province is certain; but as strata which, both lithologically and in the species of plants which they contain, correspond to those of the Upper Coal formation, are widely spread over the region, it may be doubted whether such erosion has anywhere removed much of the Middle or Productive Coal series. The coal measures as already stated lie unconformably on all the pre-existing formations, including the Lower Carboniferous series, and as these islets of older rocks represent the summits of hills or ridges, in the intervening troughs or hollows, the coal measures may occasionally have attained a much greater thickness. This supposition is of course possible, still when the very slight inclination of the Lower Carboniferous strata, not only around the border of the basin, but also over its interior on Newcastle Creek is considered, we cannot but think that the facts, so far as they are known, are unfavourable to the view that the coal formation has a greater thickness in any part of the area than that above given, or that extensive seams of coal are likely to be found beneath those which are now being worked at Grand Lake and elsewhere.

Probable amount of denudation.

Unconformity of the coal measures to pre-existing formations.

Improbability of extensive coal-seams beneath those already known.

While, however, our observations of the past year are certainly opposed to any opinion which would assign a great thickness to the coal formation within the region examined by us, or even to a belief in the occurrence of workable seams beneath that which has been so long known and removed near the surface in the Grand Lake district, it should not be forgotten that the area over which the surface seam may be presumed to extend is itself a large one, and that, even supposing the thickness of the seam to be nowhere greater than is shown in the openings already made, its possible yield of coal, more particularly when the facility with which it may be obtained is considered, is such as to confer upon it very considerable value. The following estimates based upon our explorations of the region may serve to render this more apparent.

Possible yield of coal from the "Surface seam"

The total area occupied by the rocks of the Middle and Upper Carboniferous formation in that portion of the Province which lies to the westward of the eastern boundaries of Queen's and Sunbury counties, (embracing the whole of Sunbury and portions of Queen's and York counties), and of which we have personally examined the larger portion, may be approximately estimated at 2854.6 square miles. Of this about one-third, or 952 square, miles is apparently covered by the coarse grey beds which form the

Total area of the Middle and Upper Carboniferous formations.

inferior portion of the Middle Carboniferous formation, and which, so far as known, are destitute of any workable coals; thus leaving a residue of about 1,900 square miles, over which productive seams may be reasonably looked for. We are not yet possessed of sufficient data to justify the assertion that the various out-crops of coal met with over this area and at widely separated points, (such as Clones, the Washademoak, Otnabog, Little River, Nashwaak River, etc.) belong to the same seam as those at Grand Lake, though there are facts which favor such a supposition; there is, however, no reason to doubt that those in the neighbourhood of the last named lake are all of the same seam, and that consequently the area over which it may be safely regarded as extending is a very considerable one. Thus the area of the Newcastle coal-field (adopting the position of the actual coal openings as marking its limits about thirty-two square miles; that of Salmon River as also about thirty-two square miles; while that of Coal Creek is about forty-eight square miles, making a total for the three of about one hundred and twelve square miles. Adopting twenty inches as the average thickness of the coal-seam, and 79.4 lbs. as the weight of a cubic foot of coal, (the specific gravity being 1.27) and deducting one-fourth for the areas occupied by Salmon River and Grand Lake, the total amount of coal within the areas in question would be (at the rate of 2,000 lbs. to the ton) not less than 154,948,147.2 tons.

Total area of Coal-seam.

Area probably larger than stated.

It is, however, to be observed that the true area of the coal-fields in question, and more particularly that of Newcastle River, is probably much larger than has been stated above; the line which has been chosen as marking its western limits really indicating only the point where the rocks of the Middle coal formation pass beneath those which form the highest member of the Carboniferous system, and under which they could probably be reached at no great depth. The occurrence of a coal-seam on Little River in Sunbury county, having about the same position and thickness as those of Newcastle, render this supposition highly probable. Moreover, the thickness of the coal-beds at Clones does not differ very greatly from that of the beds at Grand Lake, and it is not improbable that a large part of the area occupied by the productive measures, and more particularly where the Newer coal formation exists, is underlaid by the same seam. Supposing this to be the case, and deducting one-third for the area occupied by the barren measures at the base of the Middle Carboniferous formation, or rendered unavailable by being covered with lakes, the possible total yield of coal from a seam of twenty inches covering the remaining area would be not less than 3,510,436,357.12 tons. Setting aside, however, this supposition as confessedly based upon too imperfect data, we can still hardly doubt that the area over which the principal seam of coal in the Grand Lake region may be reasonably supposed to extend, is at least

Thickness of the Clones coal-beds.

Possible yield from a coal-seam twenty inches thick.

two or three times greater than that employed in the above calculations, and that therefore the estimate of its productive capacity may be fairly increased in a corresponding ratio.

History and results of earlier attempts to discover coal in the Grand Lake district.

In conclusion, it may be worth while to review more fully the history and results, already briefly stated in the first part of our report, of the earlier attempts to discover coal by boring in the Grand Lake district. The first and most important boring was that of 1837, which reached a depth of 403 feet, and of which a synopsis from the third report of Dr. Gesner to the Legislature of New Brunswick is given in an appendix. In the above depth, coal is indicated at several levels, but at two only, in quantities sufficient to be deserving of attention. The first was struck at a depth of twenty-one feet, and was one foot ten inches in thickness, being evidently that which is known as "the surface seam;" while the second, reported as eight feet of "bituminous shale and coal," was struck at the depth of 262 feet, the intervening strata being conglomerates, sandstones and shales, mostly grey but sometimes blue or red and marly, together with several beds of clay-ironstone, slate and a three feet bed of limestone. Considerable uncertainty has always attached to this record of a second seam of coal, and the confirmation of it has been the object sought in all subsequent borings. There is no doubt that the whole return of these borings, so far as the names applied to the strata penetrated are concerned, is untrustworthy and deceptive; many of these, such as the three feet bed of limestone immediately above the coal, and the beds of quartz and slate immediately below it, are not known to occur anywhere in the true coal measure rocks of the Province. There are, however, pebbles of such rocks in the coal measure conglomerates, and therefore if correctly named their occurrence in the boring would indicate that an horizon beneath the coal measures had been reached. The same remark will also apply to the beds of whinstone and limestone found at still lower depths, and to the "blue slate" with which the borings terminated. It is, however, quite impossible, judging from such specimens of the boring as have been submitted to us, and which are mostly in the state of a fine powder, to apply to them any such definite names as those alluded to, while the coa reported as associated with them at several levels, and of which there are but faint traces in the actual specimens, is only such as might readily have been washed from above, and have become mixed with the other materials in the process of sinking. It is certainly remarkable that limestones, red shales, slates, quartz and ironstone, all of which occur in rocks which at no great distance are known to underlie the coal measures, should have been reported here, and tends to confirm the conclusion already arrived at from surface indications, that the coal measures in this neighborhood are of no great thickness. It is also worthy of note that the depth assigned to the deeper bed of shale and coal, viz., 260 feet, exceeds but

First boring 403 feet.

Thickness of the coal measures not great.

little the estimate already given as probably that of the productive measures.

Second boring on Coal Creek; ninety-seven feet.

The second boring on Coal Creek, five miles above the head of Grand Lake, and between five and six miles from that above described, was made in 1866, and attained a depth of ninety-seven feet; but the drill having then become jammed in the hole, the work was abandoned, and has not since been renewed. It has already been stated that, at a distance of not more than five miles from this place, the older Pre-Carboniferous slates reach the surface, and are exposed over a considerable area.

Third boring 218 feet.

The third boring was commenced in May, 1870, about a mile to the north of that of 1837, but, owing to some difficulty amongst the members of the company, was carried to a depth of only 218 feet. At the depth of ninety-six feet from the surface, a thin seam of impure coal, about six inches thick, was found; otherwise these borings, as might be expected from their proximity, corresponded.

Convinced of the uncertainty attending all these operations and of the impossibility of reaching any definite conclusions from the study of the surface features of the region, I, in July last, recommended the Provincial Government to purchase a suitable apparatus to test the question by boring. In the first instance it was proposed to decide the matter by sinking a shaft in the vicinity of Newcastle. The amount appropriated for the purpose by the Legislature, however, was entirely inadequate to meet the cost of sinking a shaft of sufficient depth; and if in the depth to which it might have been carried, no seam had been reached, the question would have been no nearer solution than before, whereas by boring, while the result would be less costly and equally satisfactory at any one point, the apparatus employed could in the event of failure, be used to test the question at any number of other and widely separated localities.

Diamond-pointed rock-drill.

Duly considering these facts, the Government adopted my recommendation, and has purchased an American diamond-pointed rock drill. This is now in operation at Newcastle, and Mr. R. W. Ells has been directed to superintend the work, and to carefully observe and note the character of the rocks penetrated. We would only remark, in conclusion, with reference to the so called "surface-seam" and its yield of coal, that the careless and desultory mode of working, too generally adopted throughout the district, is such as to greatly depreciate its value, both by increasing the cost of production, and by rendering the supply variable and uncertain. No method whatever is followed, each man sinking on his own property and extracting only as much coal as he thinks proper, or as he has occasion to use, working the seam for a short time and then neglecting it, allowing the roof to tumble in, and thus necessitating considerable expense to clear it out or to run a new level. As regards the quality of the coal, it is not unfrequently contaminated with pyrites, and as brought to market,

Careless and desultory manner of working.

Quality of the coal.

there is often a considerable admixture of coal-shale; but when care is taken to have it thoroughly screened, this does not seriously impair its value, while at a number of points the coal is already free from such impurities, and of excellent quality. The cost of production is nearly as follows: Cost of production.

Cost of labor	Twenty dollars per month with maintenance.
Hauling	Six shillings per chaldron, or less, according to distance.
Freight to St. John	Six shillings per chaldron.
Wharfage	Ten cents per chaldron.

During the winter season, when the greater part of the mining is done, a considerable quantity of coal is hauled directly to Fredericton. The price of blacksmiths coal, delivered at St. John, varies from $4.50 to $7.00 per chaldron;* that of the "rapid coal," preferred for household use, being from $5 to $8.00.

ECONOMIC MINERALS.

Besides coal a few other minerals of economic importance were observed within the region to which this report relates, and may be mentioned here.

Iron Ores.—In the region about the sources of the Nerepis a large amount of iron is generally diffused through the strata. Veins of spathic iron from one to four inches in thickness occur in the lower beds of the St. John group, and according to Dr. Abraham Gesner, a large bed of hematite exists on one of the upper branches of the Nerepis stream, near Coot Hill on Head-line road. Iron Ores.

The overlying Devonian slates are also, in places, largely charged with spathic iron intimately mingled with the argillaceous and calcareous particles, of which they are to a great extent composed. The Lower Carboniferous rocks partake of this metalliferous character, but the ores observed were impure ochre and veins of hematite. On Summer Hill, in Jerusalem Settlement, the amygdaloid near the summit of this formation is often largely charged with veins of hematite varying from half an inch to a line in thickness, which traverse the rock both horizontally and vertically. Ochreous iron is freely disseminated through the fine soft beds of the series, in a number of places producing beds of ochreous earth, usually called mineral paint; such localities occur in Peltoma, on Shin Creek and on the branches of the Nerepis. Spathic iron. Hematite.

In the valley of Coal Creek, Queen's county, within the limits of the Newcastle coal-field, where this stream has been described as traversing an area of Pre-Carboniferous argillites, the coarse gravel forming the bed of the creek was at one point found to contain numerous well-

* The chaldron is a somewhat variable measure in New Brunswick. At Grand Lake it is about twenty-eight or twenty-nine hundred weight.

rounded masses or nodules of hematite, varying in size from that of a pea to two or three inches. Their source is unknown, for though the argillites in questions are here as elsewhere much stained with iron, no distinct veins of this mineral could be discovered. Similar nodules of hematite were also met with on Thorn Brook, one of the principal tributaries of Canaan River, but here they are probably derived from the dioritic rocks of the dark argillite series.

Limestones.

Limestones.—At a locality on the cross road from the Lower Clones road to Kelly's mill, there is an out-crop of Lower Carboniferous limestone. This rock has been calcined in former years to a considerable extent, but the kiln is now abandoned. The lime produced is said to have been strong and of good quality, but rather dark for finishing. There is another out-crop of limestone near Kelly's Stream, about a mile above the mill. At this point the rock is red in color, like a thin bed exposed on the side of Summer Hill Brook, near the forks of the North Clones Brook. On the former brook, about two hundred yards below the Gagetown Road, there are also some beds of grey limestone five feet or more in thickness.

In Hibernia Settlement, thin beds of limestone have been described, page 190 as occurring on the farm of James McConnicky, where they are also removed and calcined in considerable quantities. The product is said to be of fair, though not of the best, quality.

The other points at which limestones have been observed, and referred to in the earlier pages of this report, are the west shore of the St. John River, opposite Long Island, Rush Hill and Shannon Settlement, in the parish of Wickham, and the English Settlement in the parish of Johnston In each of these localities lime has been burnt to a greater or less extent, but only for local use, the product being inferior to that of the metamorphic limestone so abundant nearer the coast.

Fire-clay.

Fire-clays.—In describing the coal-crops of the Newcastle district, reference has been made to the beds of clay very generally associated with them, and some of which are true fire-clays. As is usual in other coal districts, the fire-clays are generally met with immediately beneath the seams of coal, and are to some extent indications of their presence, though sometimes they overlie them, or may even occur when the coal is altogether absent. Their thickness in the openings examined by us varies from a few inches to four feet or more. The colour of the clays in the Newcastle coal field is also very variable, some portions being yellowish from an admixture of ochreous iron, and therefore unsuited for the manufacture of fire-bricks, and others of a deep chocolate-brown color; but much of the clay is nearly white, and apparently free from both iron and sulphur. Considerable quantities of this clay have been removed at different times and shipped to St. John, where its employment was found to be generally satisfactory, but less attention has so far been devoted to it than its value would seem to justify.

Marble.—The limestones opposite Long Island, on the west side of the St. John River, have been at some points altered, apparently by the intrusion of dykes of dolerite, into an imperfect marble. Small blocks of the latter are of considerable beauty, taking readily a fine polish, and possessing a rich chocolate or purplish-grey color. A want of firmness, however, in the rock, and the occurrence of frequent flaws, render it difficult to obtain pieces sufficiently large for economical purposes. The beds at this point were opened several years since by Hon. S. L. Tilley, but for the reasons mentioned, the quarries have been abandoned. **Marble.**

Porphyries.—Some of considerable beauty are to be met with in the hill south of Shin Creek, they vary from a cream color to flesh-red and dark greyish-purple. Some of the schistose beds connected with them are handsomely banded with dark lilac and cream colored layers. **Prophyry.**

Jasper, Chalcedony, &c.—In connection with the red sandstones and shales of the Lower Carboniferous formation, there are at numerous places irregular layers and concretionary masses of red jasper, carnelian and chalcedony. At Lower Clones there is a fine close-grained brick-red petrosilex resembling jasper, porphyritic with crystals of calcite. On the shore of Washademoak Lake, between Belyea's and Taft's Coves, limestones associated with red shales of the Lower Carboniferous formation have been described as containing nodules and layers—and at one point a bed two feet thick—of chalcedonic quartz. Much of this rock is very beautiful, its color varying from cream color, through pink, to a rich red, these shades being sometimes distributed in bands. Pebbles derived from these, or similar beds, are common in some of the conglomerates of the coal measures, and are abundant in the beaches bordering the shores of Grand Lake. **Jasper, carnelian, and chalcedony.**

Fluor.—The feldspathic rocks at the summit of the Lower Carboniferous series in Harvey Settlement contain, as first pointed out by Mr. Chas. Robb, numerous small veins of fluor. At Lister's mills, on the northeast branch of the Magaguadavic, two varieties of this mineral occur, viz., a deep purple and rich emerald green; both well crystallized and associated in veins with quartz and white calcite. In the museum of the University of New Brunswick is a specimen of nearly pure dark purple granular fluor from this neighbourhood, over six inches in diameter, but the exact locality from which it was obtained is not known. **Fluor-spar.**

Building Stones.—The sandstones of the coal measures are usually too irregularly bedded and of too coarse a character to yield good building materials. At some points, however, the beds are thicker and more massive, and blocks of large size are readily removed. This is the case for instance, at Three Tree Creek, four miles east of Fredericton Junction, and immediately adjacent to the Fredericton Branch railway, also on Salmon River, whence the materials for the construction of several of the **Building Stones.**

public buildings in the city of Fredericton were obtained. They often contain nodules of pyrites, which on exposure, produce by alteration to oxide of iron, rusty brown spots, or even a disintegration of the rock itself; but otherwise they are very durable, and are said to withstand fire much better than granite or marble.

I have the honor to be,

Sir,

Your most obedient servant,

(Signed,) L. W. BAILEY.

APPENDIX.

RETURN OF BORINGS OF THE SALMON RIVER COAL MINES FROM Dr. A. GESNER'S 3RD. REPORT TO THE LEGISLATURE OF NEW BRUNSWICK.

Section of strata bored through near Salmon River.

	Ft.	In.
Vegetable soil	1	0
Sand and gravel	6	2
Broken shale and clay	4	7
Shale with impressions of ferns, &c.	9	5
Bituminous Coal	1	10
Marly Clay	1	0
Do and shale	2	0
Shales	7	0
Shaly sandstone	1	0
Sandstone (blue grit)	32	0
Conglomerate	3	8
Shale (*with a little coal*)	4	6
Sandstone and conglomerate	0	8
Conglomerate	8	0
Shale with thin seams of coal	3	8
Sandstone and shale	2	6
Conglomerate and sandstone	1	0
Sandstone and shale	1	0
Conglomerate	13	0
Sandstone (blue grit)	2	0
Grey sandstone	5	0
Sandstone and shale	2	0
Do interstratified	2	0
Sandstone (blue grit)	6	0
Sandstone, shale and fire-clay	1	0
Do and red marl	1	0
Slate clay and sandstone	2	0
Shaly sandstone and marl	1	0
Red and blue shaly marl	6	0
Marly shale and sandstone	1	0
Sandstone (blue grit)	9	0
Sandstone *with 1 inch of coal*	1	0
Conglomerate	1	0
Sandstone and shale	1	0
Conglomerate	4	0
Shale and conglomerate	1	0
Conglomerate *with a little coal*	2	0
Do and sandstone	1	0
Shale	2	0
Red marly and blue shale	1	0
Red marly shale	5	0
Red and blue sandstone	1	0
Sandstone (blue grit)	39	0
Clay ironstone	2	0
Quartz and pyrites	3	0
Clay ironstone	1	0
Conglomerate	1	0
Shale and quartz	1	0
Conglomerate	1	0
Clay ironstone	3	0
Shale and quartz	1	0
Clay ironstone	4	0
Shale	1	0
Limestone	3	0
Conglomerate	2	0
Clay ironstone	4	0
Quartz and shale	3	0
Clay ironstone	13	0
Slate and quartz	1	0
Clay ironstone	4	0
Argillo-ferruginous limestone	1	0
Shale, with vegetable impressions	2	0
Bituminous shale and coal	8	0
Quartz, slate, ironstone and fire clay	1	0
Clay ironstone	3	0
Do with slate and quartz	1	0
Slate, shale and *coal*	1	0
Slate, quartz and shale	4	0
Slate, shale and ironstone	1	0
Clay ironstone	5	0
Do (very red color)	1	0
Do with *coal*	1	0
Do	4	0
Sandy shale and slate clay	1	0
Clay ironstone	1	0
Whin-stone	1	0
Sandstone and *coal*	1	0
Coarse sandstone	10	0
Sandstone, shale and *coal*	1	0
Clay ironstone	3	8
Coarse sandstone	1	0
Bituminous shale	1	0
Coarse sandstone with quartz	2	0
Shale and quartz	4	0
Shale and coal	1	0
Hard blue shale	1	0
Sandy shale and klingel	2	0
Coarse sandstone	6	0
Soft blue shale	2	0
Clay ironstone and sandstone	1	0
Soft shale	6	6
Coarse sandstone	6	0
Soft blue shale	1	5
Coarse sandstone	4	2
Soft shale	4	11
Sandstone	0	6
Soft shale	2	0
Coarse sandstone	2	1
Mundic (pyrites)	0	9
Limestone	0	6
Shale and freestone balls	6	4
Fine sandstone	2	8
Coarse sandstone	1	8
Sandstone (blue grit)	15	0
Limestone	2	1
Shale	1	8
Sandstone	3	6
Ironstone	4	11
Shale	0	8
Ironstone	1	0
Shale	0	5
Ironstone	2	6
Shale	2	8
Ironstone	5	7
Grey Slate	1	8
	402	9

REPORT

OF OPERATIONS IN BORING FOR COAL WITH THE DIAMOND-POINTED

STEAM DRILL

AT

NEWCASTLE BRIDGE, QUEEN'S COUNTY, NEW BRUNSWICK.

BY

MR. R. W. ELLS,

ADDRESSED TO

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

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

FREDERICTON, 26th April, 1873.

SIR,—In accordance with instructions received from you in November last, I proceeded to Grand Lake, New Brunswick, to take charge of the boring operations about to be carried on there with the Diamond Drill. The spot selected by the Directors of the Company, in whose hands the drill was placed by the Government of New Brunswick, was at Newcastle Bridge, on the slope of the hill rising southward from the Newcastle Creek, and about eighty rods from the stream. Owing to neglect on the part of the Drill Company in sending the drill, many parts were found to be wanting when it was set up, and much valuable time was lost in sending to New York for a core lifter and solid bit, and in obtaining from St. John other parts of the machinery that should have been sent with the drill at first. After some three weeks delay in waiting for the articles to arrive from New York, we received the core lifter, and at once determined to carry on our operations with the core bit until the solid bit might come to hand.

Instructions.

Selection of site.

Loss of time owing to deficiencies in the machinery.

From the broken nature of the rock at the place selected, we found on boring that the core lifter would not work; the cores being so shattered as to make it impossible to raise them from the hole. From the fact also that the core bit would not work in soft shale and fire-clay, we were compelled to suspend operations till the solid bit arrived from New York, which was not till the middle of December; and on the 19th of that month we again commenced boring, using the solid bit.

Broken nature of the rocks.

Delays incident to starting the machinery, rendered our average of boring for the first three days only eleven feet per day; but the difficulties being got over, on the fourth day we bored thirty-two feet five

Ninety-five feet bored in five days.

inches, thus making a depth of ninety-five feet for the first five days boring. At this depth we struck a fissure in the rock, and the water that should have come to the surface, to bring up the borings, passed off at a lower level, and necessitated the drawing of the rods, in order that the leak might be stopped. This we partly succeeded in doing, by pouring down sawdust, and the water again coming to the surface we again proceeded with the boring to the depth of 109½ feet, when the borings again failed us. Our farther attempts at stopping the fissure partially succeeded, and we obtained borings again to the depth of 124 feet. At this depth, owing probably to striking another fissure, the borings failed us again, and several days more were spent in efforts to stop the leak, in which we were again partially successful. On the 3rd January, we again obtained borings, and continued our operations to the depth of 140 feet, when we struck a band of dark oily shale—the intervening distance from forty feet comprising grey sandstone of different degrees of fineness. At the depth of 162 feet the borings failed us entirely; and we were compelled to lay aside the solid bit and resort to the hollow bit, for the purpose of obtaining cores. By the 11th January we had reached a depth of 170 feet 2 inches, when we again attempted to use the solid bit. From the carelessness again of the Drill Company in sending the solid bit, we found on using it that it was one eighth of an inch larger in diameter than the hollow bit, so that in resorting to its use again, it could not easily follow the hole previously made by the hollow bit, and, becoming jammed, two of the diamonds of the outer circle were knocked out and lost down the hole. In the attempts to recover the diamonds much of the packing that had been used to stop the leaks became loosed from the fissures by the frequent drawings of the rods, and falling on the bottom, it so covered the diamonds that it was impossible to recover them.

Leak carrying away the borings.

Dark oily shale struck at 104 feet.

Diamonds knocked out of the bit and lost down the bore-hole.

Doubt existing in the minds of some of the Directors of the Company as to the diamonds being in the hole, they instructed the Engineer to put in the hollow bit again, and resume boring. It was found, however, in attempting to bore again, that the diamonds were on the bottom, and on bringing up the bit a number of the diamonds in it were found to be destroyed by their action upon those in the bottom. This necessitated the abandoning of the hole.

Hole abandoned at 170 feet 2 inches.

Much of the difficulty and delay in this boring arose from an insufficient supply of water to keep the pump running, in order that the borings might be driven up to the surface of the hole, the spring which we used having become, from the depth of the snow and the severe cold, quite unequal to supply the demand. Delays were also caused by the want of materials to repair damages on the spot; and the impossibility of communicating with Fredericton, thirty-one miles distant, owing to the state of the roads, rendered it difficult to obtain them when wanted.

Causes of difficulties and delays met with.

On abandoning the hole, a meeting of the Directors was called, and it was again decided to commence operations, near the bank of the stream, about eighty rods north of the first location. The place selected by the Directors was very bad: by the side of a small pond where the rock was very much broken and leaks almost sure to occur; and though both the Engineer and myself pointed out this fact to them, it was decided to go on with the boring in that spot. The engine house and drill were moved down, and the borer set up again, ready for work by the 17th of February.

Commencement of a second boring.

In our first day's boring, we struck a leak at fourteen feet from the surface. The next day was spent in packing the hole with fire-clay—cement not being obtainable—resulting in an apparent stoppage of the fissure, so that we resumed boring on the 19th. The borings again gradually failed us, till at the depth of forty-four feet we were again obliged to lay aside the solid bit from the entire absence of the borings. The hole was then rimed out, and an iron pipe inserted to the depth of seventeen feet; but owing to the want of proper riming apparatus, it was found impossible to get it farther down. Efforts were then made to stop the hole by filling it with cement and boring over again, but owing to the poor quality of the cement employed, this work was ineffectual. The Directors then resolved to finish the boring with the hollow or core bit. This process is necessarily slow; the jamming of the cores in the barrel of the rods preventing the easy passage of water down, for washing away the borings, necessitating the drawing of the rods every few feet, for the purpose of cleaning the bit. Pieces of core and pebbles from conglomerate remain in the hole after drawing the rods, and these, as soon as the bit begins to revolve on them, tear out or break off the diamonds, necessitating their frequent replacing or re-setting.

Fissure struck, causing leakage.

Difficulty in inserting pipes.

On the 25th of March we had reached a depth of 154 feet, and finding the wear of the bits from the loss of the diamonds to be so great, the Directors determined to again attempt to stop the leak by cementing the hole with the best quality of cement. Thinking the leak was near the top, the hole was cemented to the depth of only forty-five feet; but on boring out the cement again, the leak was still found to exist. The hollow bit was again resumed on the 11th of April—much time having been lost in sending for more diamonds—and the boring continued. At the depth of 160 feet, a large mineral spring was struck, which, when the rods were out of the hole, flowed over the top at the rate of about twenty gallons per minute; but when the rods were down, even with the additional water thrown over the hole by the full force of the pump, it could not be brought to the surface, showing that the fissure by which the water escaped must have been very large. By the sixteenth of April we had reached the depth of 190½ feet, and our supply of diamonds being again completely exhausted, work had to be suspended till more could be ordered.

Depth reached.

Large artesian spring struck at 160 feet.

Work suspended at 190½ feet for want of diamonds.

The last core brought up was of a grey shale, very similar to that overlying the surface seam of coal in the vicinity.

Breaking up of the cores.

From the breaking up of the cores into short pieces, either from the vibration of the rods or the broken nature of the rock, and from the fact that the pieces of core, acting on one another, wear away very rapidly, it is impossible to obtain a full section of the different strata passed through; in boring with the solid bit, however, the boring coming at once to the surface, any change in the nature of the rock can be at once observed.

Much delay occurred in our boring from the want of suitable hoisting gear, thus rendering the drawing of rods a very slow process; also from the ordering of only sufficient diamonds to meet the actual requirements of the time, as on several occasions we had to suspend operations till they could be sent from New York.

Inappropriate location of the drill.

Had the drill been located at first in an appropriate place, much delay and expense would probably have been avoided, as the boring of a 500 feet hole under favorable circumstances ought to require but a short time.

Owing to the opening of regular communication again between Newcastle Bridge and Fredericton, and the fact that cores could be as well examined in one place as the other, it has been decided that, during the continuation of the boring, the cores should be sent to Fredericton for examination. The Engineer in charge of the drill will take care of, and label each piece as it is brought up, and will send the samples to Fredericton weekly; he will also keep a daily record of the progress made, and submit it from time to time with the borings.

I have the honor to be,

Sir,

(Signed,) Your obedient servant,

R. W. ELLS.

Description of the "Diamond Drill."

The drill in use in the Grand Lake boring is the so-styled "American diamond-pointed steam drill," driven by a steam engine of seven-horse power, and doing its work by means of a metal bit, set in its lower surface with black diamonds. The bits are of two kinds: hollow and solid. The first consists of a hollow cylinder of metal, the diameter of the bore being about one and one-quarter inches, with the diamonds set in the inner and outer edges, and distributed over the intervening surface, so as to cut a complete ring in the rock, the core passing up the inside of the rods. The bit screws in to a core lifter, or hollow cylinder of metal with two steel slides, working in dove-tailed shelving grooves, which when the bit is

Bits.

Core lifter.

boring remain flush with the inner surface of the cylinder ; but in drawing the rods, they slide down and grasp the core, breaking it off and lifting it with the rods.

The core lifter is screwed to the end of a hollow rod called the core barrel, eight feet in length, and the boring rods are screwed on the upper end. The boring rods are in lengths of ten and twelve feet, and are connected by means of screw couplings. Owing to the rush of water forced down the rods for the purpose of washing away the borings, there is a tendency to drive the cores to the mouth of the bit where, when the rock is soft or broken, and the cores in pieces, they are ground up. The pieces of core also revolving on one another wear away, so that it is almost impossible to obtain a perfect section of the rock passed through. The jamming of the cores in the core barrel also prevents the easy passage of the water to wash away the borings, so that the drill cannot be driven at its full speed ; and also renders it necessary to draw the rods very frequently to clear the bit, thus making the rate of progress very slow. Core barrel.

In the solid bit the entire lower surface is set with diamonds, so that every part of the metal is protected from the wear of the rock. The rock for the entire size of the hole is ground up fine, and the borings are washed up by the ascending current of water, which in its descent passes through the bottom of the bit by means of four small holes; the borings being brought at once to the surface, any change in the rock passed through is instantly seen. As there is no occasion for drawing the rods, the progress is very rapid; the fastest speed made by us in hard grey sandstone being three feet in twenty-five minutes, allowing for delays in screwing on rods, running back gear, &c. A speed of five or six feet per hour should be made under favorable circumstances. The solid bit, not requiring a core lifter, is screwed directly on the core barrel. The solid bit. Rate of boring.

The boring rods in which the bits are screwed are hollow, and a constant stream of water is forced down them by means of a steam pump of two-horse power. This is necessary in order to clear away the borings as fast as made, as well as to keep the bits cool. The rods are driven round at a speed of about 600 revolutions per minute; but, of course, this speed can be regulated to suit the nature of the rock. The stream of water passing down the rods is driven up outside and out at the top of the hole ; any fissures passed through allow the water to escape, so that in boring with the solid bit, the sides of the hole must be perfectly tight. The hollow bit will not work in soft or very broken rock, since the core lifters cannot act upon the cores to lift them ; and neither of the bits will work in sand or clay, unless very stiff, owing to the body of the ascending water destroying the sides of the hole. Rods.

In running the drill, but two men are necessary—the engineer and fireman ; the engine consumes about three barrels of coal during the 24 hours.

A suitable house, 18 feet by 20, can be erected at a cost of $100 to $150 ; the cost of this will depend on the season. It should be placed near a large spring, or in some place where a plentiful supply of water can be obtained for the use of the pump.

The following is a record of the borings in the Grand Lake coal field at Newcastle Bridge, Queen's county, New Brunswick.

Record of boring No. 1. 170 feet 2 inches.

1872.		BORING No. 1.	Ft.	In.
December	19.	Fine-grained shaly sandstone	4.	0
		Coal shale, ½ inch coal	1.	0
		Do 2 inch do	2.	0
	20.	Do do	6.	0
		Do with pyrites (very hard)	3.	1
		Bituminous shale	0.	4
		Solid coal, surface seam	1.	10
		Bituminous shale and impure coal	0.	10
		Fine clay	4.	6
	21.	Fine shaly sandstone	4.	9
		Fine coal shale	3.	0
		Shale and fine clay, with iron pyrites	2.	9
	23.	Fine-grained greenish sandstone	1.	0
		Do Do with shale	2.	0
		Do Do Do and fire clay	1.	0
		Dark, brown, and greenish shale	2.	0
		Hard grey shale, with fine clay	3.	0
		Fine-grained sandstone, (grey micaceous)	6.	8
		Do Do	3.	0
		Olive-green sandstone	1.	0
		Fine-grained grey sandstone	6.	9
	24.	Do do (micaceous)	3.	0
	26.	Do do	10.	0
	27.	Do do (micaceous)	27.	0
		Do do	6.	0
	28.	Do do (micaceous)	2.	0
	29.	No borings	4.	8
	30.	Greenish-grey sandstone	9.	3
1873.	31.	do (coarse grit)	3.	0
January.	4.	Grey sandstone, micaceous, with coarse bands	9.	10
	6.	Do do with iron pyrites	6.	2
	8.	Hard, dark grey shale (oily), with thin seams of coaly matter	3.	8
		Grey coal shale	5.	4
	9.	Fine-grained grey sandstone, (micaceous)	5.	5
	10.	No borings	7.	9
		Fine-grained grey sandstone, (micaceous)	8.	0
			170	2

BORING No. 2.

Commenced in rock at seventy feet lower level than the first.

Record of boring No. 2. 190 feet 6 inches.

1873.			Ft.	In.
February	17.	Shelly grey sandstone	4.	0
		Fire-clay, grey shale and sandstone	2.	3
		Grey sandstone and fire clay	1.	0
		Yellowish grey sandstone, (micaceous)	3.	2
		Do do (fine grit)	2.	3
	19.	Fine grey sandstone (micaceous)	1.	0
		Yellowish grey sandstone and fire clay	10.	8
		Grey conglomerate	1.	3
		Yellowish grey sandstone, (micaceous)	2.	0
		Dark grey sandstone, do	1.	3
	20.	Grey conglomerate	1.	2
		Grey sandstone	1.	0
		Grey conglomerate	1.	0
March	14.	Fine grey sandstone	5.	5
	15.	Coarse grey sandstone	20.	6
	16.	Fine grey sandstone, the last two feet containing fossils and iron pyrites	18.	9
	17.	Grey shale (slate of Matthew)	6.	4
		Grey sandstone, (micaceous)	1.	3
		Grey shale, do	3.	5
	18.	Grey sandstone	1.	0
		Grey conglomerate	1.	3
	19.	Fine grey sandstone	18.	9
	20.	Coarse quartz grit	2.	5
	21.	Grey shale	2.	0
		Grey sandstone	3.	6
	22.	Dark grey shale	4.	0
		Fine-grained grey sandstone	6.	4
		Shaly grey sandstone	1.	8
		Fine shale	7.	7
	24.	Fine grey sandstone, (micaceous and pyritous,) with seams of fire clay	5.	4
		Fine grey sandstone	9.	3
		Fine grey sandstone (fossils and iron pyrites)	4.	7
	25.	Coarse grey sandstone	3.	3
		Coarse grey sandstone, with fossils and iron pyrites, band of conglomerate	1.	9
April	11.	Greenish grey sandstone, very fine	8.	4
	12.	Do do do (micaceous)	9.	6
	14.	Coarse grey grit	10.	5
	15.	Fine dark-grey sandstone	5.	3
	16.	Grey conglomerate	1.	0
		Grey shale	1.	8
			190.	6

R. W. ELLS.

REPORT

ON THE

COAL MINES OF THE EASTERN OR SYDNEY COAL FIELD OF CAPE BRETON, N.S.

BY

MR. CHARLES ROBB C.E.;

ADDRESSED TO

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

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, May, 1873.

Instructions.

SIR,—Having in the course of last summer received instructions from you to continue the survey and examination of the Cape Breton Coal Fields, which was commenced in 1870 by the late Mr. Edward Hartley, and having from various circumstances, beyond my control, been prevented proceeding thither until the end of August, I devoted the remainder of the season suitable for field-work to a preliminary survey or general reconnaissance of the principal area occupied by the productive coal measures; and to the collection of materials for an accurate topographical map, and for a report on the various collieries at present in operation in the eastern or Sydney Coal Field.

Map and report.

Geological structure.

In the prosecution of this work I have made many observations and measurements bearing upon the geological structure of the region; but, however useful these may be in the future, they can scarcely be regarded as sufficiently precise or comprehensive to justify any detailed statements on this point upon the present occasion.

Maps, charts and records made use of.

In the preparation of a map upon a sufficiently large scale to form a basis for the determination of the structure of the coal field, I have availed myself, so far as regards the coast lines, of Admiral Bayfield's charts, which at Sydney Harbor and some other points I have verified in many of the minutest details by triangulation and otherwise. For a portion of the coast-line, and also of the interior of the country adjacent thereto, as well as for the contours, and for the course of certain of the coal seams, I am indebted to the records—kindly lent to me by the gentlemen interested—of elaborate surveys made by Professor J. P. Lesley, in 1862 and 1863, for various private companies; and by Mr. B. S. Lyman of Philadelphia, in 1865, for Marshall Bourinot, Esq., of Sydney. I have also to

Acknowledgement of assistance and information.

express my obligations to Messrs. Wm. A. Hendry, Deputy Commissioner of Crown Lands, R. H. Brown, Manager of Sydney Mines, H. Poole, late Manager of Caledonia Mines, E. T. Moseley of Sydney, F. N. Gisborne and A. J. Hill, for access to maps and plans of the various properties in which they are interested, and for much collateral information.

In every instance where advantage has been taken of surveys previously made, I have been careful to verify and connect these, and to fix the positions of the various pits and works, and the crops of the principal seams by bearings and measurements between prominent points. For these purposes also, and for establishing the heights at many points, I have made use of the plans and profiles of the Glasgow and Cape Breton and of the International railways, at present in operation and connecting some of the collieries with Sydney Harbor; also of the projected and surveyed railroad line to Louisbourg.

This map, embracing the whole known area of the productive coal measures in this district, and drawn to a scale of four inches to a mile, is now completed, with the exception of some minor details.

Scope of present report.

For reasons already stated, and in compliance with your request, I propose to devote the following report to a description of the various collieries now in operation in the eastern Coal Field of Cape Breton, and to the economical considerations suggested in connection with the future development of this most important coal field. On these points some details which were collected by Mr. Hartley, and referred to in your Summary Report for 1870–71, will be embodied with my own observations.*

Without, therefore, on the present occasion entering into any details in regard to the geological structure or topographical features of the region of which this coal-field forms a part, I shall merely give such a slight sketch of these as seems to be necessary in connection with the consideration of the economic questions to be noticed in this Report.

General Remarks on the Eastern or Sydney Coal Field.

Area occupied by the productive coal measures.

The land area occupied by the productive coal measures in the eastern or Sydney Coal Field may, so far as now known, be estimated at 200 square miles, being about thirty-two miles in length from north-west to south-east, by about six miles in width. It is limited on three sides by the Atlantic Ocean; and towards the south-west by the out-crop of the subjacent Lower Carboniferous rocks. This area forms the southern

* Much information on this subject, in a popular and practical form, is contained in Brown's "Coal Fields of Cape Breton," London, 1871; Rutherford's "Coal Fields of Nova Scotia," Newcastle-upon-Tyne, 1871; Dr. Dawson's Acadian Geology," London, 1868; and How's "Mineralogy of Nova Scotia," Halifax, 1869.

extremity of an extensive trough or basin, which is for the most part hidden under the waters of the ocean, and which has been corrugated by numerous subordinate folds, bringing the same coal seams repeatedly to the surface along the north-east coast of the Island, under the most favorable conditions and circumstances for their extraction and shipment.

Good harbours.

The whole coast is deeply indented by bays and channels approximately coinciding with the axes of these folds, and affording in the sea cliffs numerous natural sections of the strata, and exposures of the coal seams. Some of these bays also constitute excellent harbors, one of which—Sydney Harbor—situated towards the centre of the district, ranks among the finest and most commodious on the Atlantic coast of North America. The cliffs are generally from thirty to eighty feet high, standing perpendicularly and frequently overhanging the sea; and the country inland is of a gently rolling character, the highest altitudes rarely exceeding 150 feet.

Height and character of the country.

Louisbourg Harbour.

Such natural advantages, combined with its highly favorable geographical position, point to this district as probably the most important in the Dominion for the supply of fuel to the numerous steamers navigating the Atlantic. During the few months of winter, when the more northerly harbors are closed or obstructed by ice, a railway only about twenty-two miles in length, will connect many of the collieries with Louisbourg, which is also a fine harbor, and is said to be open and safe throughout the whole year.

Aggregate thickness of coal seams.

The aggregate thickness of coal in workable seams outcropping on the shore, and for the most part exposed in the bays and cliffs, is from forty to fifty feet; the seams vary from three to nine feet in thickness; they generally dip at a very low angle, and appear to be very little affected by faults or disturbances. As the strata all dip seaward, much of the coal will be available in the sub-marine as well as in the land areas. From experience at one of the collieries, to be hereafter described, it has been fully established, that with due caution and care these sub-marine areas may be worked to a large extent.

Sub-marine areas.

Character and quality of the coal.

The coal is of the bituminous or soft variety, with comparatively little diversity in the quality of the different seams; all of which yield a coal exceedingly well adapted for general purposes, while that of some of them is specially applicable to the manufacture of gas. Much of it will compare very favorably with the best English coal. As compared with the Pictou coal, regarding which very full details have been given by Mr. Hartley in the Report of the Geological Survey for 1869, it is characterized on the whole, by a greater proportion of combustible matter, and a smaller proportion of ash; but on the other hand it usually contains a greater amount of sulphur.

COLLIERIES IN OPERATION.

I shall proceed to give some details regarding the condition of the various productive coal mines in this district at the time of my visit, (October, 1872,) and also of those at which works were in progress and expected to be in a condition for raising coal for the market during the present season. For conciseness and to facilitate comparison, I have tabulated such of the more prominent and important features at each colliery as would conveniently admit of this arrangement. Tables.

The first table contains a list of the collieries to which reference is made, with the names of the proprietors and managers, the date of commencement, the extent of the properties, the number of men, horses, and steam-engines employed, the total production, and the amount of capital invested in works. It may be remarked, however, that from various causes, none of the thirteen coal mines enumerated are at present worked to their full capacity.

In the second table a description is given of the various seams worked, analyses of the coal from each seam, and the depth and extent of the workings, &c. Of the series of analyses given in the table, some were made several years ago, and are here compiled from various authentic records, chiefly contained in the works referred to on page Others are taken from examinations more recently made, and not hitherto published, but communicated to me by the proprietors of the various collieries. A series of samples from twelve different collieries, collected by myself last season, and believed to represent the average quality of the coal in each, have been submitted to Dr. B. J. Harrington, Chemist to the Geological Survey, for proximate analysis; the results of which are given in Table II., while his accompanying remarks are introduced under their appropriate headings in the text.

The details given in this Report are to be understood only as relating to those seams which are actually worked on the several areas; and the quantities of coal stated as underlying them are only such as are estimated to exist in these worked seams. Mr. Brown, in his "Coal Fields and Coal Trade of Cape Breton," gives for most of the areas referred to in this Report an estimate of the total amount of coal contained in all the workable seams underlying each.

The method of estimating the quantity of coals in the several areas is as follows: The weight of a cubic foot of water being 62:5 pounds, the average specific gravity of the coal 1·3; the number of superficial feet in an acre, 43,560, and the number of pounds to a gross ton, 2,240. Estimation of quantities.

Then $\frac{62{\cdot}5\times1{\cdot}3\times43{,}560}{2{,}240} = 1{,}580$ tons per acre of one foot thickness. Allowing for irregularities, and for coal which for various reasons is not available, 1,500 tons is assumed as the contents of an acre of coal one foot thick, which, multiplied by the number of acres in the area, and by the thickness of the seam in feet, gives the total contents.

Bearings.

The bearings given in this Report and in the Table are stated in relation to the magnetic meridian; the variation of the compass for the year in which the observations were made being 26° 10′ West.

I. The Sydney Mines.

Of all the coal mines in Cape Breton the Sydney Mines are not only the first established, but by far the most extensive and important. In 1827 these mines came under the exclusive control of the General Mining Association, a London company, who now hold under lease in the district more than 30,000 acres, which are for the most part underlaid by large workable seams of coal. From 1827 to the present time this company have worked their mines regularly aud systematically, and in the most skilful and economical manner. From 1785 to 1827 the Sydney Mines had been worked sometimes by Government, and sometimes by various individuals and companies; but always in a very desultory and imperfect way. Mr. Richard Brown, the late manager of the General Mining Association, states that the yield of coal from these mines during that period had been 275,000 tons; only a little more than half what ought to have been produced according to the area over which the workings extended. The total quantity of coal which has been sold from these mines since 1827 is given in Table I.

Operations since 1827.

Yield of the Sydny Mines from 1785-1827.

Seams to which mining operations have been confined.

Although other and important seams crop out within the area owned by the Association, mining operations have been confined to three, known respectively as the Sydney Main seam, the Lloyd's Cove seam, and the Indian Cove seam. Of these the Sydney Main seam is the only one now mined, and is also the one which has been by far the most extensively worked in past years.

Sections of seams.

The following sections of the Lloyd's Cove and Indian Cove seams are taken from Mr. Brown's elaborate section of the strata at this locality. The former is 728 feet of vertical distance above the main seam, and the latter 460 feet beneath it.

Lloyd's Cove Seam.

	Ft.	In.
Coal	2	0
Clay	0	2
Coal	0	6
Clay	0	1
Coal	3	6
Total thickness	6	3

Indian Cove Seam.

	Ft.	In.
Coal	0	8
Shale	0	1
Coal	4	0
Total thickness	4	9

These seams were worked to a small extent a few years ago by the Association, about eighteen acres of the former, and ten acres of the latter having been partially taken out; but they were abandoned in consequence of their comparatively inferior quality, and the capability of the Main seam to supply all present demands.

Sydney Main seam.

The Sydney Main seam is a solid compact seam of from five feet six inches to six feet in thickness, and of nearly homogeneous character throughout. It dips N. 60° E. < 4° 45′ or one in twelve. Over an extent of about 1000 acres of the land area, and about 3,200 acres of the sub-marine area belonging to the Association, the seam is five feet nine inches thick. Over 2,154 acres it is four feet thick. Of the land and sub-marine area first named, together 4,200 acres, the coal has been mined over 867 acres only. Over seventy-five acres of this area the pillars have been taken out, while in the remaining 792 acres they are still standing. The sub marine workings have extended over seventy-four acres, with a minimum thickness of eighty fathoms between them and the sea bottom. After deducting the amount of coal extracted as per tabular statement, and that mined previously to 1827, there remains of available coal in this seam 38,300,000 tons.

Thickness.

Area mined

Quantity of coal in the seam still available.

In addition to the remarks given in the Table, I append the following detailed statements relative to the quality of this coal, as carefully tested and analyzed by Professor Henry How of King's College, Windsor, in 1871.

Quality from examination and analysis by Professor How.

COMPOSITION OF AVERAGE SAMPLES OF THE WHOLE SEAM OF COAL.

By Medium Coking.		By Fast Coking.	
Moisture	3.04	Total volatile matters	37.48
Volatile combustible matter	31.14	Coke	62.52
Fixed carbon	61.50		
Ash (reddish-brown)	4.32		100.00
		Theoretical evaporative power 7.98 lb.	
	100.00	By Slow Coking.	
		Total volatile matters	29.70
		Coke	70.30
Coke per cent	65.82		100.00
Theoretical evaporative power	8.45	Theoretical evaporative power 9.06 lb.	

Mean coke per cent	66.21
Mean theoretical evaporative power	8.49
Ash per cent	4.32
Sulphur per cent	1.24
Specific gravity of average samples	1.30
Calculated weight of one cubic foot, unbroken	81.10
" " " " " broken	54.50
Space for one ton, 2240 lb., on stowage (Economic Weight)	41.10 cubic feet

COMPOSITION OF ASH.

Sand and clay	29.57
Peroxide of Iron	51.33
Alumina	4.84
Sulphate of lime	10.98
Lime	3.05

Magnesia	0 23
Phosphoric Acid, decided traces	
Manganese, traces	
Chlorine, traces	
	100.00

GAS RETURNS.

BY G. BUIST, ESQ., MANAGER OF HALIFAX GAS WORKS.

Gas (average of 4 tests) per ton of 2240 lbs..............8200 cubic feet.
Coke " " " " " ....1295 lb., of good quality.
Illuminating power of gas (average of 6 tests)..........8 candles.

The details above given explain the well known high favor in which this coal has been held for upwards of forty years for domestic use, and also for steam producing by those who have employed it carefully.

The mean theoretical evaporative power, or number of pounds of boiling water which should be evaporated by one pound of coal, 8.49, compares very favorably with the actual power of British coals, as found in the Navy Trials in which I assisted; these were:—

Average of	37	samples from	Wales	9.05 lb.
"	17	" "	Newcastle	8.37 lb.
"	28	" "	Lancashire	7.94 lb.
"	8	" "	Scotland	7.70 lb.
"	8	" "	Derbyshire	7.58 lb.

This fact alone would always have been significant as indicating that the Sydney coal should prove a good steam coal; but, since late experiments have shewn that, when burnt in proper furnaces, the bituminous coals have been found to give no smoke, and to have an evaporative power even superior to that of Welsh steam-coals, it is now of the highest importance. It is necessary to draw attention in this connection to the resemblance of the Sydney coal to those bituminous coals which gave these results, in containing a low percentage of ash........The Director of Naval Construction at Brest reported to the French Minister of Marine (about 1860) "that the steam power of Sydney coal is little inferior to that of Cardiff and equals that of Newcastle coal."

"With respect to the amount of sulphur, I find that, after deducting the harmless sulphur in the sulphate of lime of the ash, there remains but 1.24 per cent., or less than the average in 37 Welsh and 28 Lancashire coals, which is 1.42 in both cases, and in 8 from Scotland which is 1.45, so that this coal will compare favorably in this respect with these from abroad, some of which are highly esteemed for steam purposes."

Remarks by Dr. Harrington.

Dr. Harrington appends the following remarks to the analysis of the sample of Sydney Mines coal analyzed by him:—"A compact coal, breaking with a rather rough fracture. Contains a little mineral charcoal, and has numerous thin leaves of carbonate of lime, running at right angles to the bedding. It contains a good deal of visible pyrites disseminated through it, and gives a reddish-grey ash."

SURFACE WORKS.—The coal is reached by vertical shafts or pits sunk successively further to the dip as the seam becomes exhausted within a convenient distance from the shaft. The first shaft was 200 feet, and the second 300 feet in depth. Both these shafts are now abandoned, and the workings filled with water ; but the coal of the pillars, in those connected with the second shaft, is still available, as well as that in a barrier fifty yards in thickness, which has been left to protect the newer workings. **Shafts.**

Now, and for many years back, the coal is brought to the surface by a shaft called the Queen or C Pit. It is 360 feet deep and 1360 yards from the crop of the seam, between which and the shaft, as well as 1100 yards to the dip, most of the available coal has been worked out, to an average breadth of nearly a mile. In this area, however, with the exception of the seventy-five acres above mentioned, nearly all the pillars are still standing.

This colliery is capable of yielding at the rate of upwards of 700 tons per day ; at the time of my visit it was supplying 570 tons per day. **Yield.**

In connection with the Queen or C pit, which is thirteen feet in diameter, there is a pumping shaft, eleven feet in diameter ; these are both used as downcast shafts, and there is also a separate ventilating or upcast shaft, eight feet in diameter.

The distance of underground haulage from the principal working faces to reach these pits having become so great (now upwards of three quarters of a mile) another set of shafts has been recently commenced 1320 yards further to the dip, which will reach the Main seam at a depth of 630 feet from the surface. These shafts are called the *New Winning*, and are designed chiefly to command the Association's extensive sub-marine area adjacent to the Sydney Mines. Unfortunately in sinking them a great influx of water has been met with at the depth of 300 feet, which the small steam-engines temporarily used for the work have proved inadequate to overcome ; and the operations have in consequence been suspended until the magnificent and powerful pumping engines, designed for the permanent drainage of the mine, can be brought into action. These engines, and the other machinery connected with this colliery, all of which is of the most perfect and substantial description, are the exact counterpart of those which have been recently erected by the General Mining Association at the Foord Pit of the Albion Mines at Pictou, and have been minutely described by Mr. Hartley in his report (Geology of Canada) Report of Progress 1869-70, pp. 87-89. Further recapitulation of details is, therefore, unnecessary, except to note that here the pumps are 20 inches instead of 18 inches in diameter. **Underground haulage.** **Engines and other machinery.**

The machinery at the Queen Pit Colliery consists of a pumping engine of 150 horse-power, 50 inch cylinder and 7 feet stroke, giving 6 feet stroke on the pump, 20 inches in diameter, which makes 13 lifts per **Machinery at the Queen Pit.**

minute and raises 90 gallons per lift; this is capable of keeping the mine dry by twelve hours pumping. The steam is supplied to this engine by four plain cylindrical boilers, 7 feet in diameter and 20 feet long, with egg ends. There are four more ready to set up, each 6 feet in diameter and 30 feet long. There is also a winding engine, 32-inch cylinder and 6 feet stroke, 35 lbs. pressure on the boiler, or about 80 nominal horse-power, furnished with steam by three cylindrical boilers, 6 feet in diameter, and 25 feet long, with egg ends. In the same battery are four similarly shaped boilers, 5 feet in diameter, and 25 feet long, for the supply of the underground slope engines. The winding engine is furnished with a 4-inch flat wire rope, working over a 10 feet drum, and is capable of bringing to the surface two *tubs* (as the small underground cars are called) or one ton in less than a minute. The arrangement of shutes, screens, and railway at bank are of the most substantial and perfect description. The screens have thin quarter-inch gratings, and about *one-eighth* of all the coal taken directly from the mine passes through these screens in the shape of *slack*, only a small proportion of which is saleable.

During the winter, when the miners work about half time, and the coal is not immediately required for shipment, it is *banked*. The bank usually contains about 25,000 tons. The coal is drawn by the winding engine while in regular operation up an incline from the bank foot to shutes, by which it is deposited in certain regulated proportions on the screens, along with the coal freshly extracted from the pit. From the effect of atmospheric influences combined with extra handliug and moving, *one-fourth* of all the bank coal is in the state of *slack*.

Railway.

The coal produced at this colliery is conveyed to the loading-ground or wharf at North Sydney by a substantial railway, four miles in length, with self-acting incline at the wharf end, owned of course by the Association. The gauge of this railway is four feet eight and a half inches, with rails of 56 pounds to the yard. The road is equipped with 174 waggons, each capable of containing an English (Newcastle) chaldron, or fifty-three hundred weight, and constructed to open at the bottom; and four locomotives of 16, 17, 27, and 30 tons respectively; the heavier engines draw thirty cars per train, and consume altogether in this service about seventy tons of coal per month.

Wharf.

The wharf is irregular in shape, capable of accommodating and loading eight vessels at a time, drawing from 14 to 22 feet of water. Ample and safe accommodation is afforded in the harbor near the wharf for loading, by means of lighters, vessels of a greater draught. The average amount of coal which the present works and appliances are capable of producing and shipping may be stated to be 550 tons per day, or upwards of 150,000 tons per annum, which will be increased threefold when those at the New Winning are brought into operation.*

There is a good foundry and machine shop, built of brick, attached to this colliery, furnished with several large lathes, planing and screw-cutting machines, boring mill, and all machinery requisite for the construction and repair of steam-engines and of all the implements required about the mines. The foundry engine is of 40 horse-power, with two cylindrical boilers, 6 feet in diameter, and 30 feet long, and an auxiliary boiler, about 3 feet 6 inches in diameter, consuming in all about seventy tons of coal per month. Foundry and machine shop.

UNDERGROUND WORKS.—The style of working which has been adopted in this colliery since the commencement (as in all the others in this district) is what is well known under the name of the *pillar and bord* or *post and stall* system; the only modification introduced having been the enlargement of the pillars as the seam is worked further to the dip. System of working. From the bottom of the Queen Pit access is obtained to the dip workings by two slopes, diverging, although nearly on the full dip; one commanding the northern, and the other the southern part of the workings. These inclines or *engine slopes* are over 1000 yards in length each, and are cut seven feet wide for three sets of rails, forming rail or tramways of two feet guage, with suitable crossing places. The rails are of wrought iron, 32 pounds to the yard; and the slopes are worked by two pairs of horizontal stationery engines, about 30 horse-power each pair, supplied with steam from the boilers on the surface, and drawing the trains of tubs by a wire rope. The tubs or small waggons used in the mine are built for the most part of sheet iron, although some are of wood; they contain on an average 9⅓ cwt. each, and the train usually consists of about twenty tubs.

From the main slopes levels are extended on either side in a direction nearly north and south magnetic. These levels are 6 feet wide and 5½ feet high, and are also laid with a similar description of rails, over which the tubs are drawn by horses. The dimensions of the bords and pillars have varied at different parts of the works, the size of the pillars, as already stated, having been increased as the works progressed further to the dip. At present the bords or working-places are 16½ feet wide, driven on the level and parallel to the main roads, and the pillars are left from 30 to 40 yards long by 14 yards wide. The gate roads, 6 feet wide, from the main levels to the working places, are driven about 20° off the true dip, or N. 80° E. There is no regular cleat to this coal seam, but it is found to work best in the direction and manner indicated. The coal is

* This calculation is based on the assumption of a regular yield throughout the whole year. In reality the miners only work about half time in winter, and hence the production during the shipping season is occasionally much greater than the average.

cut in the usual way by holing in the bottom of the seam, shearing in the sides, and bringing down partly by wedges set in a parting, about two feet from the bottom, and partly by blasting with gunpowder. Of all the coal mined at this colliery, probably about 20 per cent, or one-fifth, is in the state of *slack:* and as only a very small proportion of this finds a market (the proportion of large to that of small coal sold being as 23 to 1) most of that made underground is allowed to remain there.

Slack coal

Ventilation.—The ventilation of this colliery is effected by means of a furnace with 30 square feet area of grate, through which also the exhaust steam from the slope engines is conveyed to the surface. The volume of air set in motion through the workings by this furnace amounts to 28,500 cubic feet per minute. The air is drawn from above through the queen or cage pit shaft and the pumping shaft, down the engine planes, and back through the workings, guided by proper doors and stoppings, to the furnace, from which it is discharged into the upcast shaft, used exclusively for ventilating purposes.

Ventilation.

So far as I can learn no faults or troubles have been met with in these workings; but occasionally portions of the roof have fallen in, and have caused disaster and loss of life, such portions being apparently occupied by the spreading roots of erect trees.

PRODUCTION.—The average annual production of coal for the market from Sydney Mines, for the last fifteen years, is 104,428 tons. It is largely exported to the United States and the neighboring Provinces, chiefly for domestic purposes. The selling price for many years has been $2.25, per ton with 10 per cent. discount on orders for more than 2,500 tons.

Production and price

II. LINGAN MINES.

These mines were first opened by the General Mining Association in 1854, upon an extensive and valuable tract of about fourteen square miles, bounded on the east by the shores of Indian Bay and Lingan Basin, and on the west by Sydney Harbor. This tract is underlaid throughout its entire length (six miles) by several very important seams of coal, which will be found to extend in a workable condition under the sub-marine area of ten square miles also leased by the Association.

Eight workable seams have been found and proved on this area, comprising an aggregate thickness of not less than forty feet of good coal, besides several others which have been discovered by boring and trial pits, but whose precise dimensions are unknown. On the present occasion I shall confine myself to a notice of only two of these seams, on which collieries have been established.

Forty feet of good coal.

The Lingan colliery is situated on the north shore of Indian Bay, about twelve miles from Sydney. The mine is opened by a slope on a seam eight feet eight inches in thickness, called the Lingan Main seam, dipping N. 32° E. < 12°–16°. At a height of five feet eight inches from the floor of the seam, as will be found mentioned in the description, Table II., a clay parting occurs, which at its out-crop in the cliffs at Indian Bay is only one inch in thickness, but at the working slope, half a mile west, has increased to fifteen inches, and in a further similar distance west attains a thickness of eight feet, splitting the seam into two, the lower portion alone being there worked, and still maintaining its original thickness, whilst the parting forms the roof. Taking the lower bench only of this seam as available for working, the land and sea areas of the seam in the Lingan tract may be estimated to contain 73,800,000 tons of coal, of which, supposing seventy acres to have been partially worked over, there will remain about 73,000,000 tons.

Quantity of coal available.

The Lingan mine coal is highly esteemed; and is specially adapted for the manufacture of gas, for which purpose it is largely exported to Boston and New York, and formerly also to Halifax; it is said to yield not less than 9,700 cubic feet of gas per ton. Owing to the occurrence of a pyritous band about two inches in thickness, and fourteen inches from the roof, the coal, after being mined, has to be carefully screened and hand-picked before shipment, to free it from this deleterious ingredient. This coal is also much esteemed for blacksmiths purposes, and for the quality of its coke.

Pyritous band.

As regards its character as a steam coal, Professor How remarks:— "The ash is very low in all parts of the seam, the average of the whole being only 3·06 per cent. This gives great evaporative power to the coal, and hence, according to late results, it should be valuable for steam purposes. The mean of all my experiments gives for the theoretical evaporative power of the coal 9·19 lbs. as the amount of boiling water which should be evaporated by one pound of coal. This is somewhat above the practical result, even from Welsh steam coals, in our British navy steam trials, which gave the highest weight, viz., 9·05 lbs. As it is now known that bituminous coal can be made to give, without smoke, greater heating power than Welsh steam coals, when their ash is low, a bituminous coal like this of Lingan assumes a new value. . . . I find that the average percentage of ash from fourteen analyses of North of England coal is 3·77, while the Lingan gives only 3·06 per cent., so that, in proper furnaces, it ought to prove a very good steam coal indeed."

Report by Professor How.

Dr. Harrington's remarks on the sample of coal from this mine, submitted by me, are as follows:—" This is a clear, bright coal, and contains a considerable quantity of mineral charcoal, but no visible pyrites. On account of the small amount of ash, as well as of sulphur (as compared with the other coals examined), it may be considered as the best of all the samples of Cape Breton coal which have been submitted to me for

Remarks by Dr. Harrington.

analysis. It could scarcely be said to coke, but swelled up into a light porous mass. The ash is of a light grey color, with a slight reddish tint."

Without pausing to notice the earlier workings at Lingan mines, I shall proceed to describe the present state of the colliery.

SURFACE WORKS.—The coal obtained in this mine is brought to the surface by a slope sunk from the crop on the full dip of the seam, and to a length of 704 yards, extending about 66 yards under the sea. This main slope is laid for the most part with a double track railway, two feet gauge, worked by a wire rope connected with the winding engine at the surface, which also raises the water from the levels below the sea to the adit. This is a high pressure engine of 40 horse-power, 28-inch cylinder, and 6 feet stroke, working the pump, and two drums on one shaft. The arrangements are adequate to a production of 300 tons a day.

Slope.

Engine.

From the slope and bank the coal is conveyed to Lingan Harbor, distant about one mile, by a good railway, running straight, and with uniform, descending grade, with self-acting incline 342 yards from the wharf upwards. The railway is 3 feet 6½ inches gauge, laid with T rails, 35 to 65 pounds to the yard. The rolling stock consists of 100 waggons, carrying two tons each; and an English-made saddle-tank locomotive engine of 9 tons weight.

Railway.

The depth of water at the wharf at Lingan Harbor is 16 feet at low, and 20 feet at high, tide, but this depth has to be acquired and maintained by dredging, and the harbor is rather difficult of access for vessels of any considerable draught. The wharf is provided with three shutes, and in conjunction with the railway, as at present equipped, is capable of shipping 600 tons per day, or double the present maximum production of the mine.

Wharf.

For harbor and wharf service a small tug-steamer and steam dredging machine are owned by the Association and employed in connection with this colliery. The tug consumes about two tons of coal per day when in full work.

Tug-steamer.

UNDERGROUND WORKS.—These are regulated on the pillar and bord system, as at Sydney mines. As already noted, access is obtained to the underground works by a slope from the crop, provided with a railway, and commanded by a stationary steam-engine at the surface. The slope is 8 feet wide. From it, levels 6 feet wide are extended S.E. and N.W. on the strike of the seam, at distances of 110, 220, 440 and 704 yards respectively from the crop. The first and second levels are about one mile in length, extending to the sea; the first affording a natural drainage to the mine to that depth, the slope being about midway between the sea and the end of the level. The coal to the rise of the first level, and that between the first and second levels, has been for the most part worked out; in the other workings the pillars are still left standing. The dimen-

Workings.

sions of the pillars vary according to the depth, being 5 yards square at the upper, and 22 yards by 5 yards, at the lower levels. The working places are turned to suit the cleat of the coal, and vary from 5 to 6 yards in width.

The main slope and levels are laid with T rails, 22 pounds per yard; and the gate-roads and working places, with bridge rails, 16 pounds per yard. The number of tubs at present in use is seventy; capacity half a ton each. Six of these are hoisted at once with a single rope, and eight or nine when worked with two ropes; the average number drawn to the surface per day is 700. In the pillar workings the *slack* is left in the mine, in the rooms it is brought to the surface. I may here remark that, although the workings have been extended some distance under the sea, there is no difficulty in draining the mine. Two pumps, 8 inches and 6 inches in diameter respectively, with 4 feet stroke and 16 strokes per minute, fixed in the lower levels, and worked by the stationary engine at the pit head, are found amply sufficient to keep the mine clear of water. Drainage. That portion of the workings belonging to the sub-marine area accumulates only one ton of water per day; an important fact with reference to the practicability of working such areas.

Ventilation.—There is very little gas in this mine except in the deep workings, and by simple precautions all danger from this source is obviated. The air passes down the engine incline and through the workings, and returns by an upcast slope, about 40 or 50 yards to the north, commanded Ventilation. by a furnace with about 30 feet of grate surface, discharging by a shaft 27 feet deep, and chimney, 32 feet high and 9 feet square. The average quantity of air set in motion through the mine is 15,500 cubic feet per minute.

PRODUCTION.—The average annual production of coal at this mine during the last fifteen years has been 29,744 tons; but it is capable, even with the present appliances, of supplying three times that amount if Production and price. required. In the fall of 1866, not less than 8,000 tons were shipped in one month. The selling price has hitherto been $1.75 per ton, or fifty cents less than the Sydney coal.

BARRASOIS AND BRIDGEPORT MINES.

Although this Report is intended to refer only to such collieries as were actually in operation at the time of my visit, I may here give a brief notice of two other localities where operations have been carried on by the General Mining Association, but which are at present suspended. The first of these is the Barrasois Mine, opened on the Lingan Barrasois mine. tract, close to the sea shore, and two miles west from Lingan mine, on a seam overlying the Lingan main seam by 457 feet vertical thickness. These workings were instituted for the purpose of securing possession of one of the five square miles sea areas connected with the Lingan tract.

Barrasois seam. The Barrasois seam is ten feet eight inches thick, of which, however, two feet at the height of six feet from the floor consist of a fire-clay parting, probably rendering the lower bench only workable. It dips N. 30° E. < 12°–15°. Slopes. A pair of slopes, 7 feet by 6 feet, have been driven 374 yards in a direction somewhat to the north of the true dip, in order to reach the sea within the shortest distance; Levels. and levels have been driven eighty-eight yards to the east, and forty-four yards to the west of the slope, to win the sea area only. Quality of the coal. The coal is of excellent quality—best adapted for domestic purposes—but little of it has been mined, and no record seems to have been kept as to quantity or disposal.

The General Mining Association have also worked to some extent on their Bridgeport tract of two square miles, situated on the south shore of Indian Bay. Bridgeport mine. This mine was in operation for twelve years ending in 1842, when it was abandoned, owing to the reduction in the demand, and want of facilities for shipping. The following brief description of these works is from Mr. Brown's "Coal Fields of Cape Breton," p. 85:— Extract from Mr. Brown's "Coal Fields of Cape Breton." "A level was driven from the outcrop along the strike of the seam, now known as the "Phelan seam." As the level proceeded to the southward pits were sunk at intervals of about a quarter of a mile, from which the coal was raised by horse gins. At the face of the cliff the seam consisted of an upper bed, Thickness of the seam. three feet in thickness, and a lower bed, five feet three inches in thickness, separated by a four-inch layer of shale; but, as the level advanced, the layer of shale gradually increased, until, at the distance of half a mile from the shore, it attained a thickness of 28 feet. Beyond this point it rapidly declined, and, at a trial bore-hole, 300 yards to the dip of the level, it was found to be only fourteen inches thick, the upper bed of coal being three feet six inches, and the lower six feet in thickness. In the first instance the coal was brought out of the level and boated off to vessels at anchor in the open bay; Railway. but in 1833 a light railway, two miles in length, was laid from the pit along the sand beach to the harbor, which was adapted only for vessels drawing 11 feet of water when loaded. Quality of the Bridgeport coal. The Bridgeport is a good domestic fuel, but not equal to the Sydney coal; on the other hand it is more valuable as a gas coal, yielding nearly 10,000 cubic feet of gas per ton. Its constituents by analysis are:

Volatile Matter	33·20
Fixed Carbon	61·39
Ash	5·41
	100·00

This is a very valuable tract, as it is underlaid not only by the seam referred to, but by others of great importance, particularly the Ross seam, to be hereafter noticed, lying at a vertical depth of 210 feet below the

Phelan seam. The opening of the International railway, which crosses the area about half a mile inland from the old works, will afford a convenient outlet to an excellent wharf and harbor.

Quantity of coal in the Bridgeport tract.

The quantity of coal contained in this tract in the seam which has been partially opened may be estimated at 12,600,000 tons, and the total quantity raised and sold at 156,000 tons.

III. Victoria Mine.

This mine was established in 1867 to work a sub marine area of four square miles on the east side of Sydney Harbor, access to which is obtained from the west end of the Lingan tract of the General Mining Association, where within a breadth not exceeding one mile, measured at right angles to the strike, probably all the coal seams of the district, with an aggregate thickness of over fifty feet of coal, crop out in the cliffs, dipping to the north at an angle of about 40°. These have been fully described by Dr. Dawson in a Report dated August 29th, 1868, a summary of which is given in Mr. Rutherford's "Coal Fields of Nova Scotia," pages 40 and 48. Probably at least six of these seams, representing an aggregate thickness of about thirty-six feet of coal, are of workable dimensions and conditions; and the breadth of the area is such that, with the high dip specified, and provided no faults intervene, all the coal which could be economically extracted from these seams will be included within the area. Most of them will, no doubt, be traced in connection with those found at and in the vicinity of the Lingan and Barrasois mines, although in different conditions.

Number and thickness of the seams.

The Victoria Mine is upon a seam which has hitherto been called (from the name of the person who originally worked it) the Ross seam*. It is six feet ten inches thick, but yields in working only five feet six inches of good clean coal, with roof and floor of unexceptionable quality. The quantity of coal within the area in this seam, and to a depth of 4,000 feet, which may, perhaps, be regarded as the limit to which it can be economically worked, is 15,550,000 tons, of which only 55,960 tons have been extracted.

Quality of the Victoria Mine coal.

The quality of this coal, as will be seen by the analyses in Table II. is excellent; and this is further corroborated by the fact that, with the exception of the Sydney Mines coal, it has always commanded a higher price than that of any other colliery in the district. It is chiefly used for household and steam purposes, and is not considered good for gas. Dr. Dawson, in giving his analysis of this coal, adds:—"The coke is vesicular and of excellent quality, and leaves very little ash; so that, on

Coke.

* As there is another important seam of coal in this district, which has been long known as the *Ross seam*, and which cannot be regarded as identical, I propose that the one here referred to should be designated by the name of the *Victoria seam*.

the whole, this may be regarded as one of the finest coals in Cape Breton for any of the uses to which bituminous coal is applied." The slack coal is also excellent for blacksmiths purposes.

Old workings.

The mine is now worked by a slope upon the full dip of the seam N. 30° W. $<$ 38° 30′, situated seventy or eighty yards from the sea shore. It was first opened by a slope which was carried down 320 feet, 282 yards to the west of the one now used, and some bords were worked; but having too little cover, and being in danger of invasion by the sea, these workings had to be abandoned. It may be remarked, however, that, although there is a connection between the new and old workings, no perceptible increase of water has been experienced, and the mine suffers little or no inconvenience from this cause.

Engines.

Boilers.

SURFACE WORKS.—The new slope above referred to was opened in 1870, and is worked by two horizontal steam engines, coupled directly to one shaft carrying winding drums, 10 feet in diameter, with wire rope 1¼ inches diameter. These engines are of about 120 nominal horse-power, having 22-inch cylinders, and 4 feet 6 inches stroke, with 50 revolutions per minute, and 30 lbs. of steam on the boiler, being of course calculated to work to much greater depths than now attained. The boilers are seven in number, plain cylindrical, 3 feet in diameter and 36 feet long; of which, however, only three are at present required. The tubs, carrying about one ton each, are hoisted two at a time on a species of trolley, cage or carriage, constructed to suit the steep angle of dip, and running on the slope railway; this cage is also in part constructed as a water tub to drain the deep workings. By these arrangements two tubs of coal can be brought to the surface in three minutes, or forty per hour, equal to a production of 500 tons per day, although from various causes the production has hitherto been limited to a maximum of 100 tons per day. The total quantity sold in 1872 was only 20,000 tons.

Daily production.

Pumping machinery.

At the New Works a pair of pumping engines have been erected, although not yet brought into regular operation. They are direct-acting condensing engines of about 50 horse-power, with inverted cylinders, 22-inches in diameter, and 20 inches stroke, working at a reduced speed a plunger pump, 11 inches in diameter and 6 feet stroke; and designed to lift the water the entire height from the lowest workings to the surface, The mine, however, makes very little water in the lower levels, (although under the sea) except what percolates along the coal seam from the old workings. Here a horizontal high pressure engine, cylinder 12 inches in diameter and 4½ feet stroke, geared 3 to 1, works a plunger pump, 8 inches in diameter and 4½ feet stroke, giving 16 strokes per minute, which draws the water (forty gallons per minute) from a depth of 309 feet, and in conjunction with the water tub at the new slope, drains the mine in twelve hours working. There are also a pair of small auxiliary steam engines, 8-inch cylinder and 16-inch stroke, for hoisting the bank coal, &c. The coal from this mine makes about one fourth *slack*, which is all either sold or used on the works.

No shipping place being available in the immediate vicinity of the mine, the coal is conveyed over a railway to a point three and a half miles higher up the harbor, and immediately within the South Bar, where a commodious wharf has been erected. Both railway and wharf belong exclusively to the company, and were completed only three years ago: no considerable quantity of coal having been previously shipped by the company. The railway is of the usual English, or 4 feet 8½-inch gauge, with T rails, 45 pounds to the yard. It is furnished with thirty-two coal waggons, (and there are ten more in course of construction) each capable of carrying five tons, and opening at the bottom with double doors; also one tank locomotive, 16½ tons in weight, sufficiently powerful to draw eighteen or twenty loaded cars at a fair speed. The wharf is five hundred feet long, with five shutes for loading, and at low tide can accommodate at one time four vessels, drawing 28 feet of water, and two of lighter draught, say 10 feet

Shipping place.

Railway and wharf.

Waggons.

The new slope—15 feet by 9 feet, with two tracks, 4 feet 6 inches gauge—is now about 850 feet in depth, measured on the angle of dip, with air courses, 8 feet by 5½ feet, thirty feet distant on each side.

UNDERGROUND WORKS.—The levels are all driven to the west of the slope, as, until a considerable depth is attained, they cannot be extended far in the opposite direction without encroaching on the land area belonging to the General Mining Association. There are three main levels, 7 or 8 feet wide, each about 420 yards in length; the lowest being laid with a substantial railway, 2 feet gauge, with bridge rails, 15 pounds to the yard. All the coal extracted in the upper levels is shot down to the lowest, to be hauled on the railway to the cage at the foot of the engine slope, either directly or on the counterbalance system, as described by Mr. Hartley in his Report (Geology of Canada, 1869, page 93.) The bords extend over 400 square yards, worked out, but the pillars left standing. The size of pillars and bords has varied considerably, and need not here be minutely detailed. The former are generally 23 yards long and 8 yards wide; and the rooms, 6 yards wide, are driven about S. 30° W., the cleat being N. 75° W.

Levels.

System of working.

In working this seam the average thickness of good coal taken out is five feet six inches; the lower six inches, being of inferior quality, is left in. A remarkable peculiarity in the mechanical structure of this coal is, that owing to its peculiar toughness and the fact that the cleat runs almost parallel with the direction of the seam, (both being due probably to the compressing forces which have thrown the seam to such an unusually high angle) the coal comes out in long and comparatively thin parallel

Direction of the cleat.

blocks, sometimes more than six feet in length. Another noteworthy feature, which may also be connected with, and throw light upon the geological structure, is that three or four heavy rolls or corrugations have been encountered, extending through all the workings to the rise, and dipping at an angle of 30° to the east, rendering it necessary to cut down portions of the roof at the points where they occurred, and in one instance thus admitting water from the old workings. A large mass of very hard tough sandstone intercepted the coal at the end of the lower level, but was found to be of very inconsiderable thickness, and on cutting through it, the seam was seen to have increased to ten or twelve feet in thickness for a certain distance. Similar phenomena have been found to occur in connection with the Block House seam, which will be hereafter more specially referred to.

Corrugations or rolls.

Sandstone interrupting the coal.

Ventilation.—There is a considerable amount of gas developed in this mine, and in some places to an extent which renders great caution necessary; but naked lights are systematically employed, except in the morning, when some of the rooms have to be examined with a safety lamp; and no accidents have occurred from this cause except such as are directly attributable to carelessness.

Gas.

Until very recently no special arrangements for artificial ventilation were employed, but an underground furnace has lately been introduced in the upper end of one of the slopes, thirty feet west of the engine slope, which, by means of two upcast vertical shafts, furnished with chimneys, effectually ventilates the mine.

Arrangements for ventilation.

PRODUCTION.—The average annual production of this mine during the three years since the railway and wharf were brought into operation, is 14,900 tons. This has been chiefly sold in the British Provinces for domestic and steam purposes. The selling price hitherto has been $2.00 for large, and ninety cents for *slack.* The *slack* is all sold or otherwise utilized.

Production and price.

IV. INTERNATIONAL MINE AND RAILWAY.

The International Coal and Railway Company of New York, acquired in 1863 an area of four square miles, situated about half-way between Sydney Harbor and Cow Bay, about the centre of the Glace Bay basin, and adjoining the Bridgeport area of the General Mining Association. The breadth of this property is not less than three miles in the very heart of the productive coal measures; and it is underlaid by at least four most important seams, with an aggregate thickness of twenty-two feet of workable coal; affording scope for the establishment of several collieries; and as the angle of dip is very moderate, the lowest seam which crops out on the property (the Ross seam), will be reached at 240 yards beneath the crop of the highest. Hitherto mining operations

Twenty-two feet of workable coal.

have been confined to the Harbor seam, being that nearest the centre of the basin, or the highest in the area; its thickness is from five feet six inches to six feet of good coal; and it has been proved to extend entirely across the area, or over two miles at its out-crop. I estimate the quantity of coal contained in this seam on the property, at 5,000,000 tons, of which, only about 340,000 tons have as yet been extracted. Thickness of the Harbor seam.

The quality of this coal is excellent, although hitherto perhaps worked too near the crop; it bears the character of being unusually hard, compact and free from sulphur and shale. It has been chiefly used for the manufacture of gas, for which purpose it has been largely exported to New York, and it is said to yield 10,000 cubic feet of 16-candle gas, and 1,470 lbs. of good coke to the ton. It is also held in high estimation as a steam coal, making a strong, hot fire, and is certified equal to the best West Hartley (North of England) steam coal; although the clinker is somewhat apt to adhere to the furnace bars. Quality of the coal. Gas. Clinker.

The mine was first opened under the name of the Union Mine, five years before the present company came into possession, by a level driven on the seam from the base of the cliff at the sea shore; at 176 yards inland, this level is connected with a slope, 150 yards in length, to the crop. A second level was also carried south 400 yards at a distance of about eighty yards to the dip from the former, and workings to the rise, to the extent of seven acres, on the pillar and bord system, were carried on systematically and economically, but no pillars extracted. The drainage was effected by means of a horse-power pump which raised the water from the lower level to the sea level. The great obstacle to the success of these operations was the want of a proper shipping place. Old workings.

On the International Company coming into possession, their attention was first directed to remedying this defect by building, in conjunction with a new colliery on a more extensive and permanent scale, a railway to Sydney Harbor, and a wharf which should at the same time accommodate all the other collieries in the vicinity and along the line. From various causes, however, which it is unnecessary here to detail, it was not until the autumn of 1870, that these works were completed and put into operation. Productive work at the colliery was also suspended during the greater part of 1872, and resumed in September of that year. International Company. Railway and wharf.

Surface Works.—The new colliery is situated at the distance of 700 yards from the old slope, or half a mile from the shore. A vertical shaft, 14 feet 6 inches by 6 feet 6 inches, has been sunk 96 feet deep, or 16 feet below the water-level of the seam; and by bratticing off in equal divisions this shaft is used for winding, pumping and ventilating purposes. The arrangements at the pit-head are very complete and substantial. The tubs, each containing half a ton of coal, are raised to the surface at the rate of 1,200 per day by two horizontal high-pressure engines coupled; Shaft. Engines.

with 16-inch cylinders, and 3 feet 6-inch stroke. The steam is supplied by two cylindrical boilers, respectively 3 feet and 5 feet in diameter and 25 feet long. The winding drums are 6 feet in diameter, with 1-inch round steel wire rope. The present arrangements are adequate to a production of 600 tons per day; but the actual production at the time of my visit was 200 tons from the pit and 150 tons from the bank.

Daily production.

In connection with the surface works at this colliery there is a good machine and repair shop built of brick, 60 feet by 36 feet, and two engine sheds 40 feet long; the repair shop is provided with all suitable tools, and the motive power is supplied by a horizontal engine, 12-inch cylinder and 2 feet stroke; there is also a turn-table for the railway.

Buildings.

INTERNATIONAL RAILWAY.

International Railway.

From the above described colliery to Sydney Harbour a railway twelve miles in length, and a commodious wharf at the terminus on the harbor, have been constructed by the company, and are now in regular operation. The railway is 4 feet 8½ inches gauge, laid with rails, 56 pounds to the yard, connected by wrought-iron fish-plates, and in every respect built and equipped in the best modern style. The grades are very light not exceeding 1 in 200 with, and 1 in 160 against the traffic. A great part of this railway, as in many similar instances, is ballasted with the *slack*, or small coal from the mine; but although admirably adapted for this purpose, it is to be regretted that a better application has not hitherto been found for such valuable material.

Slack coal used for ballast on the railway.

Cars.

The International railway is stocked at present with 200 cars, opening at the bottom, each capable of carrying five tons of coal, and three English-made tank locomotives, with six wheels coupled, and of 25 tons loaded weight. These engines are each capable of making three trips per day, drawing 35 cars or 175 tons of coal each trip, with an expenditure of 24 bushels, or one ton of coal. At the terminus on Sydney Harbor is a turn-table and engine house, offices, &c.

Locomotives.

The wharf is situated about one and three quarters of a mile from the town of Sydney, and is 1,000 feet in length by 35 feet wide, with three tracks, and seven sets of turn-tables, windlasses, shutes, &c., capable of loading, at low tide, seven vessels at once, with a draught of water up to 30 feet.

Wharf.

UNDERGROUND WORKS.—As these have only recently been instituted at the new colliery, and as I have already briefly described the old works there is not much to be recorded respecting the former. The new and old works are connected on one of the levels. The system adopted is to drive level, or nearly level, bords north and south 6 yards wide, with pillars 8 yards wide and 22 yards long, with full rise headways, and incline

System of working.

horse-roads. There are at present about 200 tubs in the mine, holding half a ton each. The railways underground are of 2 feet 8 inches gauge, mostly laid with strap rails or flat bars, $2\frac{1}{2}$ inches by $\frac{5}{8}$ of an inch. The *slack* made in the mine amounts to about one-fifth of the whole, only a small proportion of which is saleable under present circumstances. **Underground railways.**

Drainage.—For drainage (below water level) a small direct-acting pump was erected at the bottom of the shaft, supplied with steam from the boilers at the surface. This requires 14 hours pumping per day to drain the mine, but a larger and more perfect ("Cameron Special") 8-inch pump, worked on the same system, was in readiness and about to be applied at the time of my visit. **Drainage.**

Ventilation.—The ventilation of this mine hitherto has been attended with no difficulty, and no furnace stoppings, or other special appliances for this purpose have been required, the natural currents of air generated by the arrangement of slopes, shafts, and levels, being found to be adequate for this purpose. **Appliances for Ventilation.**

Production.—The average annual quantity of coal raised and sold from this colliery for the last four years is 27,175 tons. As already stated it has hitherto been chiefly exported to New York, for the manufacture of gas at the Manhattan Gas Company's works. The selling price delivered free on board at the International wharf, averaged last season $1.75 per ton. **Production and price of the coal.**

V. Little Glace Bay Mines.

These works were commenced in 1858, by Mr. E. P. Archbold, of Sydney, now of Halifax, who leased an area of 1640 acres, or over two and a half square miles, and transferred it in 1861 to the Little Glace Bay Company, chiefly composed of Halifax capitalists, who have worked the mines with little intermission and more or less profitably ever since. For some time previous to the abrogation of the Reciprocity Treaty between the British Provinces and the United States, these operations are said to have been conducted so successfully as to have enabled the directors to pay dividends of 40 per cent. to the shareholders. Since that time, owing to the limitation of the market, the works have not been so vigorously prosecuted, although capable of producing, even with no greater amount of openings and appliances than already exist, nearly double the average annual production hitherto. **Dividends of 40 per cent.**

This area is situated about sixteen miles from Sydney, adjoining to the east that of the International Company, and is most favorably situated both as regards its position in the coal field and facilities for shipment. It embraces the entire land out-crop of the Hub seam, the central or uppermost and the thickest of the series; and a large proportion of that of the Harbor seam, besides being underlaid, at a maximum depth not exceeding 700 feet from that last named, by three thick workable seams, and at a somewhat greater depth, not yet determined, by two others of importance. These seams represent an aggregate thickness of not less than 42 feet of good, workable coal.

Forty-two feet of workable coal.

Thickness of the Hub seam

The total thickness of the Hub seam is nine feet ten inches, of which the upper portion, one foot eight inches thick, being of inferior quality is not taken out except in the main level. The land area underlaid by this seam is about 150 acres, of which probably 57 acres have been partially worked out, leaving an available amount of 1,248,000 tons, besides the pillars, none of which have been robbed. The Harbor seam, five feet six inches thick, includes 970 acres, of which, supposing twenty-eight to have been worked out, there will remain 7,820,000 tons besides the pillars. These seams dip, at the point where they are worked, N. 60° E. < 4° 40' or 1 in 12.

Thickness of the Harbor seam.

The coal produced from these seams has been chiefly used for gas and steam; that from the Hub seam being specially adapted for gas, for which purpose it has been for many years used by the Halifax Gas Company, and exported to the United States. It yields nearly 10,000 cubic feet per ton of 15-candle gas, contains an exceedingly small proportion of ash, and makes an excellent coke. The *slack* coal, amounting to about one-fifth of the whole, is much esteemed for blacksmiths uses, and is all saleable. The coal from the Harbor seam is characterized by the presence of a somewhat greater proportion of ash, but in other respects is equally good with that of the Hub. The following is an extract from an official report on the quality of these coals, made at Halifax on behalf of the Admiralty:—

Gas.

Slack.

Ash.

H. M. S. "Duncan,"
Halifax, 12th April, 1867.

Report by Chief Engineer Edward O. Crichton, H.M.S. "Duncan."

Description of Coal.	Percentage of Clinker	Ash.	Smoke.
Harbor Vein.	6.79	2.12	Dark brown, and considerable in quantity.
Hub "	4.28	1.63	Light brown, and considerable in quantity.

Both of these coals light up quickly, raise steam fast, burn well and cleanly, and generate steam well. They produce a very moderate amount of clinker and ash. The smoke from the Harbor vein coal is considerably more than that from the Hub vein, and much darker. The deposit of soot is considerable in both kinds.

Tested for carbon, the Harbor vein coal contains 83.5 per cent., and the Hub vein 80.9 per cent., and therefore in this respect are nearly equal to Welsh; which is further corroborated by the fact that the average daily expenditure of Welsh and Glace Bay coal in the lathe-room boiler is as nearly as possible alike, the Harbor vein having slightly the advantage of the Hub vein.

Being similar in their nature to North of England coal, they are not liable to make *smalls* nor *dust;* and would therefore stand trans-shipment without much deterioration.

I am therefore of opinion that both of the coals are well suited for the use of H.M.S. ships, particularly if treated in the same way as ordered by the Admiralty respecting English coals, viz: mixed with Welsh in proper proportions."

(Signed,)

EDWARD O. CRICHTON,
Chief Engineer.

SURFACE WORKS.—The Hub seam was opened for regular working in the first instance by a slope situated 100 yards from the shore at the west side of Little Glace Bay. This slope, which is 12 feet wide by 5 feet high, Slope. with double track railway, is 400 feet in length, driven through the rock at an incline of 1 in 4 to cut the seam 100 feet vertically beneath the surface, and 300 yards from the crop. Levels have been driven on either side Levels. of this slope to win the coal to the rise. Recently a vertical winding shaft, 13 feet by 9 feet, has been sunk to cut the seam 200 yards further to the dip, and 500 yards north from the slope. This shaft is 129 feet deep; it Shafts. is connected by levels with the former workings, and at both points separate shafts have been sunk for pumping and ventilation. For working the slope there are two horizontal high-pressure engines coupled, the combined power of which may be about 30 horse-power. A separate pumping engine Engines of 18 horse-power, originally used at the slope, has been transferred to the new pits to serve both for pumping and winding. The steam for these engines is supplied by four plain cylindrical boilers, 3 feet in diameter Boilers. and 30 feet long. There is a repair shop with a small auxiliary engine at the slope works. A railway one and a third mile in length from the Railway. new pits, and about one mile from the old works, connects this colliery with the harbor at the mouth of Little Glace Bay Brook. It is of the usual English, or 4 feet 8½ inches guage, laid with rails weighing 45 pounds per yard, and is equipped with 48 waggons, each capable of carrying 4 tons, and one 13-ton locomotive tank engine.

On the Harbor seam the workings have hitherto been reached from the Workings on the Harbor seam. surface by two shafts, 27 feet and 40 feet deep respectively, but the amount of work done at these pits, being so near the crop, has been comparatively limited, and has been almost discontinued so far as the production of coal is concerned. Only one shaft is now in use for pumping purposes, by means of an 18-horse-power steam engine. This colliery is within 60 or 70 yards of the wharf, and the coal produced was loaded into the vessels direct from the tubs. For more extensive and systematic working on this seam, the company have recently instituted operations, not yet completed, for a new winning, by a set of vertical shafts, 500 yards from the crop and about half a mile from the harbor. These shafts, one for pumping and one for hoisting, at the distance of 100 feet apart, are designed to cut the seam at a depth of 230feet.

New Shafts.

Harbor.

The harbor, which has been artificially formed at an expense (up to the present date) of £23,000, is safe, accessible and commodious; being protected by two long parallel piers of crib-work, filled with stone. It has an area of at least six acres, and is capable of accommodating 30 or 40 vessels; and there are 800 feet of wharf frontage for vessels drawing up to 17 feet of water; and this depth can be easily increased to 21 feet. The wharf is furnished with shutes, &c., capable of loading four vessels at once, besides four extra shipping berths. The present arrangement at the pits, railway and wharf are adequate to the production and shipment, when in full operation, of not less than 1,009 tons per day of twelve hours, and this quantity could easily be increased if required. A small screw tug steamer, with engine 16-inch cylinder and 4 feet stroke, or about 35 horse-power, is maintained by the Little Glace Bay Company for the accommodation of vessels entering or leaving the harbor; also a small steam dredging machine.

Wharf accommodation.

Tug-boat.

UNDERGROUND WORKS.—These works although skilfully and judiciously designed and executed are somewhat varied and irregular in their character, and a detailed description of all their parts is unnecessary. From the new shaft on the Hub seam levels have been driven north 400 yards and south 333 yards. At the old slope, levels have also been extended north and south to connect with the above; the main or horse levels, for a double railway track, are 12 feet, and the water levels 7 feet wide. The coal is extracted on the pillar and bord system; the working rooms being 16 feet wide, and the pillars 12 by 15 feet. The extent to which the workings on this seam are carried may be estimated at 60 acres, although all this area is by no means worked out, and no pillars have been extracted. The coal in the Hub seam is so easily wrought that one man can take out on an average six and a half cubic yards per day, and little or no timbering is required.

Levels.

System of working.

On the Harbor seam, as already stated, the workings are of very limited extent. From the pumping-shaft a level has been driven to the north 264 yards; and the coal has been worked to the rise from this level, which is eighty yards from the crop. The dimensions of bords and pillars are the same as those in the Hub seam workings. The quality of the water raised from the Harbor seam at this shaft is deserving of notice, being impregnated to an unusual extent with sulphate of iron, which, on exposure to the air, oxydizes and is precipitated in the form of a dense yellow powder (peroxide of iron).

Mineral water.

PRODUTCION.—The coal from the Little Glace Bay colliery is mostly exported to New York, Boston and Halifax, for the manufacture of gas and for other purposes. The average annual sale for the last ten years has been 49,629 tons; and the selling price at the wharf is $1.75 for round, and $1.00 for *slack* coal. Production and price of the coal

VI. CALEDONIA MINE.

The property on which this colliery has been opened is situated about sixteen miles from Sydney, adjoining to the east that of the Little Glace Bay Company, and comprises 875 acres of land and 632 acres of sea area, the latter being covered by the waters of Glace Bay and Lake. It is underlaid, within an easily accessible depth, by about five workable coal seams, the united thickness of which may be stated as twenty-four feet of solid coal; and there are other important seams lying at a greater depth. Operations were commenced here in 1866, and have been continued uninterruptedly ever since by an association of Boston capitalists, under the superintendence of Mr. Henry Poole, a most intelligent and experienced scientific and practical mining engineer and geologist, who has planned and carried out the whole arrangements at this colliery with great skill and success. Twenty-four feet of Coal.

The only seam worked on the property is that styled the Phelan seam, dipping N. 27° E. $< 5° 45'$, or 1 in 10, and averaging eight feet three inches in thickness; although, owing to the badness of the roof, eighteen inches of the top coal is not taken out. The area underlaid by this seam on the Caledonia property is about 900 acres, and, deducting the area already worked, the coal which it contains is 6,205,000 tons on land, and 2,940,000 tons under water. The quality of the coal at this mine is such as to render it advantageously applicable to all purposes for which bituminous coal is usually employed. The proportion of ash, however, is in excess of most of the Cape Breton coals, and detracts somewhat from its value as a steam coal. Phelan seam. Quality of the Coal.

SURFACE WORKS.—A pair of shafts have been sunk to cut the coal, fifty-six yards from the crop, at a depth of 186 feet from the surface, which is eighty feet above the level of the sea. The cage-pit is 11 feet square, and the pumping-shaft 8 feet in diameter. There is also an upcast shaft, 10 feet in diameter and 90 feet deep, with chimney or cupola 30 feet high, situated 330 yards to the rear of the cage-pit. Shafts.

The winding machinery consists of a double-cylinder horizontal high-pressure engine, with 11-inch cylinders and 2 feet stroke, with connected link motion; the crank shaft is geared 1 to 4 with the drum shaft, carrying drums 6 feet in diameter, with flat wire rope 4½ inches by ⅝ of an inch. The cage is constructed to carry two tubs at a time, each containing about half a ton of coal; and the winding machinery is capable of raising Winding machinery.

700 tubs, equal to 350 tons per day of ten hours, although at the time of my visit the mine was only producing at the rate of 145 tons per day. The pumping engine has a single horizontal cylinder, 12 inches in diameter and 2 feet 6 inches stroke, with pumps $7\frac{3}{4}$ and $8\frac{3}{4}$ inches in diameter for the lower and upper lifts respectively, and 4 feet stroke, the lower lift being 120 and the upper 66 feet. The engine speed is geared down to 15 strokes per minute on the pump, or in the ratio of 5 to 1. By these arrangements the mine is kept dry by eight hours pumping per day. Four plain cylindrical boilers, 2 feet 6 inches in diameter and 30 feet long, supply steam at 40 lbs. pressure to both engines. For working the bank a small auxiliary or donkey engine is employed; there is also a 6 horse-power horizontal engine for driving circular saws and other machinery.

Pumping engine.

Railway.

From the pit head the coal, after passing over the screens, drops into large waggons, by which it is conveyed over a good railway, two and a quarter miles in length, to the wharf at Port Caledonia. For one half of this distance there is an incline of 1 in 78 with, and for a quarter of a mile 1 in 200 against the traffic. The gauge of the railway is 4 feet $8\frac{1}{2}$ inches, and the weight of the rails 41 pounds per yard. The number of coal waggons at present in use is seventy, and the capacity of each, six tons. For working the line a 15-ton tank locomotive, by Neilson of Glasgow, with 10-inch cylinders, 20-inch stroke, and four driving wheels coupled, is employed. The harbor of Port Caledonia, at which the produce of this mine is shipped, is formed by an artificial cut at the east angle of Glace Bay and Lake, with piers of crib-work loaded with stone, 80 feet apart at the mouth, and 120 feet at the wharf or shipping place, and extending 400 yards from the wharf into the sea. The wharf is provided with three shipping places, two loading shutes, and a steam crane, and is capable of accommodating vessels drawing up to 17 feet of water. A small propeller tug of 45 horse-power, and a steam dredge of about 15 horse-power, are employed in connection with this harbor.

Locomotive.

Harbor.

Wharf.

Steam-tug.

System of working.

UNDERGROUND WORKS.—These are conducted on the usual pillar and bord system. The levels, 9 feet wide, are extended 570 yards on either side of the pits; and the workings, which have been hitherto for the most part to the rise, extend over a breadth of 240 yards. The bords or working rooms are 6 yards wide; the pillars, of which a few have been extracted, are 20 yards long and 8 yards wide, with crosscuts 6 feet wide and 30 yards apart. The coal has a very distinct and regular cleat by which the direction of the working faces is regulated.*

Cleat.

There is in this mine from one to one and a-half miles of railway under-

* It is worthy of remark as a point of scientific interest that the direction of the cleat here, as in some other instances which have come under my observation in Cape Breton, coincides with that of the joints of the overlying sandstones.

ground, the gauge of which is two feet. The form and weight of rails is: for level roads the T rail 18 pounds per yard; and for the rooms, the bridge rail, 14 pounds per yard. The number of tubs at present employed is 180. The *slack* coal amounts to one-fifth of the whole, and only a small proportion of it finds a market; the disposal of the remainder, after ballasting the railroad, &c., becoming a source of expense. *Slack coal.*

Ventilation.—This mine yields a considerable amount of gas, and its ventilation, which has been carefully attended to, is effected by means of a furnace in connection with the up-cast shaft. As the surface railway passes over a part of the workings, a barrier of 50 yards in width is left for the support of the ground on which it is laid, and the ventilating furnace is placed immediately behind the barrier. The grate surface is 42 square feet, and the average quantity of air set in motion is 25,000 cubic feet. The air passing down by the pumping and winding shafts is split at the pit bottom, passes along by the water level and round by the working faces at the furnace, and is thence discharged by the upcast shaft. To obviate the inconvenience arising from the use of the pumping shaft as a downcast in winter, a headway to the crop is in progress, which will be used for this purpose. Gas. Ventilating furnace.

PRODUCTION.—The coal from this mine is principally used for gas and steam purposes, and also largely for lime-burning; it is said to have yielded at the gas works at Cambridge near Boston, as high as 9,700 to 10,250 cubic feet of 16-candle gas per ton. For all these purposes it is for the most part exported to the New England States, although last year a considerable quantity was consigned to St. John, New Brunswick. The average annual quantity sold for the last four years is 30,647 tons, and the selling price $1.75 per ton for round, and 75 cents for *slack*. Production and price of the coal.

VII. RESERVE MINE.

This is the name which has been given to a colliery recently opened upon an area lying to the south of and immediately adjoining the Bridgeport tract of the General Mining Association. It is situated ten miles from the town and harbor of Sydney, with which it is connected by the Glasgow and Cape Breton railway, owned by the same company, who have also erected a very commodious and substantial wharf at their terminus at Sydney.

The Reserve area is 640 acres or one square mile in extent, and is underlaid by all the most important coal seams of the district with the exception of the Hub and Harbor seams. The Back Pit, Phelan, and Ross seams, of the thickness respectively of four feet six inches, six feet, and five feet six inches of workable coal, crop out on the property, which has an average general elevation of about 160 feet above the level of the Seams on the Reserve mine area.

Slopes.

sea. Works were commenced in May, 1871, by two slopes from the crop of the Phelan seam, dipping N. 58° E. $< 5^\circ 20'$, one of which has already reached a depth of 810 feet measured on the dip, and has produced a very considerable amount of coal for the market, 38,752 tons having been raised and 27,802 tons sold. The success which has attended this and many similar enterprises instituted within the last few years in Cape Breton, both in opening up new collieries and building lines of railway to afford an outlet for their produce, is mainly due to the energy and enterprise of F. N. Gisborne, Esq., the manager of the mine, the results of which are nowhere more strikingly manifested than at this spot, which from being, less than two years ago, in the midst of a trackless wilderness is now converted into the seat of an active and progressive industry.

Quality of the coal.

The Phelan seam, a description of which is given in Table II., is the only one as yet opened on this property, in which it underlies an area of 470 acres, containing about 4,220,000 tons of coal, and the proportion hitherto extracted is comparatively trifling. The top bench, four feet two inches thick, is uniform and of the quality given in the table; the lower part of the seam, two feet thick, is not quite so good, some stone having to be picked out. A marked improvement in the quality is noted, as might be expected, as the seam has been worked further from the surface; hitherto it has been chiefly used for steam producing purposes. The quality and composition of the coal from this mine may be judged by reference to the following analyses and practical tests of average samples; the first made at the Royal School of Mines, London, and the second, at the Manhattan Gas Works, New York.

I.

Volatile matter	36·26
Coke	62·74
Water	1·00
	100·00
Carbon	77·41
Hydrogen	5·47
Oxygen and nitrogen	9·30
Sulphur	2·47
Water	1·00
Ash	4·35
	100·00

II.

Volatile matter	34·50
Fixed carbon	59·50
Ash	6·00
	100·00
Charge, 2,240 lbs., time, 3 h. 50 m.	
Maximum yield per ton	9,950 feet
Illuminating power at 9,500 ft.	13·17 candles
Coke per ton, 38 bushels	1,520 lbs.
Gas purified by one bushel of lime	2,380 feet

Note by Dr. Harrington

Dr. Harrington remarks, in reference to the sample of coal from the Reserve Mine, analyzed by him: "This is a bright, tolerably firm coal, breaking with irregular fracture. It contains a few layers of interposed mineral charcoal and thin seams of sulphuret of iron, and gives a reddish-grey ash. Some of the sulphur in this, as well as in most of the other coals, must exist either in an uncombined condition, or else combined with the organic constituents of the coal, judging from the amount of ash."

SURFACE WORKS.—The main slope is worked by an English-made horizontal high-pressure steam engine of about 60 nominal horse-power, of the most improved construction, with 22-inch cylinder and 3 feet 8-inch stroke, geared 1 to 3 with the winding shaft, on which drums, 5 feet 8 inches diameter, are mounted and set in action by friction gearing. The rope is of steel wire, 2½ inches in circumference. Five boilers, 3 feet in diameter and 30 feet long, supply the required steam to this engine, and to a steam pump set in the bottom of the slope; the slope engine also affords power for a machine shop well stocked with tools. From the ground already opened up, these works are adequate to a production of 300 tons per day; but the motive power and other appliances are calculated for a much greater production when the seam is worked further to the dip. Surface works.

UNDERGROUND WORKS.—The principal slope, as already mentioned, has been carried down 810 feet on the full dip of the seam. From this, at the distance of 203 yards from the surface, a level has been driven N. 29° W., or nearly on the course of the seam 333 yards; in the opposite direction this level has been extended 160 yards to meet the eastern slope. Below this, two other levels, twenty-one yards apart, have been commenced, and a few working rooms turned out of each. The area thus worked over amounts to 8,000 square yards, or about one and a half acre, but of course, the pillars are yet untouched. The gauge of the railway under ground is 2 feet 2½ inches; and the capacity of the tubs employed is 24.4 cubic feet. The proportion of *slack* produced is about one-fourth of the whole. As the works hitherto have been mostly near the crop of the seam, no special arrangements for ventilation have been found necessary. Underground works.

PRODUCTION.—At the time of my visit the average daily production from the pit was 165 tons, besides about the same quantity from the bank. The company anticipate shipping at least 80,000 tons from this mine during this year. The coal is conveyed to Sydney over the Glasgow and Cape Breton railway, by a branch about three-quarters of a mile in length from the Reserve mine. As this line has been constructed for the purpose of accommodating several collieries, I shall defer the detailed account of it until some of the adjacent collieries have been described. Production.

VIII. LORWAY AND EMERY MINES.

The mining areas called respectively the Lorway and Emery, the former of two square miles and the latter of one square mile, have recently been combined under one management, and operations on both conducted by an association of English capitalists, styled the Lorway Coal Company of London, under the superintendence of F. N. Gisborne, Esq., of Sydney. These areas adjoin the Reserve mine, and are both traversed by the main line of the Glasgow and Cape Breton railway and its branches. Management.

Seams.

This extensive property is underlaid by at least three important workable seams, which have been proved either on or in the immediate vicinity of the areas referred to. The uppermost of these is the Ross seam, from five to six feet thick, underlaying about 200 acres in the Emery area, and containing approximately 1,650,000 tons of coal. The next is the Lorway seam, four feet four inches thick, of excellent coal, about 350 feet below the Ross, and underlying 1,565 acres of the united areas, and containing about 10,000,000 tons. The third, called the Gardiner seam, at an easily accessible depth, with four feet nine inches of coal, will underlie the whole three square miles, containing in the aggregate 13,680,000 tons. Between the Ross and Lorway, and also underlying the Gardiner seam, there is abundant evidence that other seams probably of workable size and good quality, although hitherto undeveloped, will yet be made available.

Quality of the coal.

From the three above named seams, although hitherto worked only at the crop, the quality of the coals is such that it may be predicted that they will always command the highest prices. The analyses of the Ross and Gardiner coals are given in the table, and further particulars respecting them will be found in the notices of the mines where they have been worked and tested.

Shafts.

LORWAY MINE.—Mining operations were commenced by Mr .Gisborne, on the Lorway area, in 1871, by sinking shafts to cut the seam at depths respectively of sixty-six and two hundred and sixty-five feet. The former, which is situated towards the west end of the area, has been brought into successful operation, the workings having developed at the depth stated a seam of uniformly good coal four feet thick, dipping N. 5° 1′ E. < 5° 22′ or 1 in 10¾. The latter called the East pit, where, by boring, the seam is found to have increased to four feet four inches, is not yet completed, its progress being impeded by a great influx of water. The Western pit, 11 feet by 9 feet, bratticed, intended to serve both for rise and dip working, is fully equipped for the production of coal, and has already yielded 1,478 tons chiefly obtained in making the preliminary openings. Levels, 9 feet by 4½ feet, have been driven thirty yards on either side of the shaft N. 85° E., and working places turned 16 feet wide, with pillars 66 feet by 24 feet. The water in this pit is easily drained by a 7-inch steam pump at the bottom, and hitherto no special appliances for ventilation have been required, circulation of air being establised by means of an upcast shaft near the crop. The winding engine at this pit is of 12-inch cylinder and 2 feet stroke, with two plain cylindrical boilers 3 feet in diameter and 30 feet long; the speed being reduced by gearing in the proportion of 32 to 72. The winding drums are 6 feet in diameter. The capacity of the tubs is about 9 cwt., the gauge of the underground railway, 2 feet 7½ inches. A short branch, about three hundred yards in length, connects this colliery with the main line of the Glasgow and Cape Breton railway.

Ventilation.

Plant and machinery.

The eastern pits, designed to cut the seam at from 250 to 280 feet from the surface, are now sunk 100 feet. Two small steam engines of 10 and 16 horse-power respectively, are employed for hoisting the material and draining the shaft, the latter being effected by two steam pumps 7 inches diameter and 12 inches stroke. This colliery will connect with the main line of the Glasgow and Cape Breton railway by a short branch 660 yards in length.

EMERY MINE.—On the Emery area mining operations were commenced in the autumn of 1872, by sinking a slope on the Ross seam. I understand that they have been prosecuted with remarkable vigor during the winter; and that such progress has been made as will render this colliery productive during the present year. The coal excavated in sinking the slope is reported to be of excellent quality. It is intended to equip this colliery with machinery and plant the counterpart of those supplied to the Reserve mine, which in general conditions as regards the size, dip and direction of the seam, &c., it greatly resembles. The slope is in immediate proximity to the Reserve branch of the Glasgow and Cape Breton railway.

The combined Lorway and Emery collieries are confidently expected, provided the Lorway East pit can be brought into operation in time, to yield 80,000 tons of coal this season.

Anticipated yield.

GLASGOW AND CAPE BRETON RAILWAY.

I shall here introduce a slight notice of the Glasgow and Cape Breton railway, a work which has been undertaken and carried out with remarkable vigor in connection with these recent mining operations, and prosecuted chiefly by the same enterprising capitalists by the advice and under the superintendence of Mr. Gisborne.

Glasgow and Cape Breton railway.

The construction of this railway and of the fine wharf in connection with it at the terminus on Sydney Harbor is calculated to accommodate those mines which lie at some distance from a port of shipment, or which from various causes would otherwise be debarred from a safe and convenient outlet for their produce, at or near the points where they are situated. With the exception of those on Sydney Harbor all the shipping ports in this coal region are more or less precarious in point of safety, and limited in extent and capacity; and moreover involve a constant and very considerable expenditure in their maintenance. The advantages resulting, therefore, from the construction of the Glasgow and Cape Breton and International railways are of vital importance, not only to the ultimate success of the mines more directly interested, but to the general prosperity of the entire district; a large proportion of which, furthermore, would remain undeveloped but for the facilities thus afforded. The proposed extension of the Glasgow and Cape Breton railway to Louisbourg will add most materially to the value of this coal field, by furnishing an outlet for its produce throughout the whole year at a point which seems destined at no distant day to be one of the most important coaling stations on the Atlantic seaboard.

Commenced in June, 1871.

The Glasgow and Cape Breton railway which was only commenced in June, 1871, is now completed and in operation from the town of Sydney to Schooner Pond colliery, a distance of eighteen miles, passing through or connecting by short branches with the Lorway, Emery, Reserve, Haven, Lake, Balmoral and Schooner Pond mining areas. In addition to the main line there are already about three miles of sidings and branches. The road is very substantially built, and is ballasted with rubble and *slack* coal; it is single track, 3 feet gauge, with maximum grades of 1 in 100 against, and 1 in 75 with the traffic. It is laid with T rails, weighing 50 pounds to the yard, with fished joints; and is equipped with three Fairlie-patent double-truck locomotive engines 25 tons loaded weight with 11-inch cylinders, 19-inch stroke, and 3 feet 3 inches wheels coupled; also an ordinary locomotive used for construction. At the time of my visit 200 English made waggons were employed, each containing four tons, and 37 or 38 of these constituted a train; they are fitted with doors opening at the side and with sloping floors to shoot the coals laterally. At the terminus at Sydney commodious and substantial brick station buildings have been erected; also engine houses and work shops fully stocked with tools and machinery for every description of repair and construction which may be required. The cost of the railway thus equipped is about $20,000 per mile.

Cost of the railway.

Wharf.

The wharf at the terminus of the railway in the town of Sydney is a handsome and substantial structure 620 feet in length and 40 feet wide, with 36 feet depth of water at high tide at the outer extremity, and standing 24 feet above high tide level on the upper or railway floor, which is furnished with four tracks, seven loading berths with shutes, &c., and four traversing tables for transferring the cars from one track to the other; all of the most improved modern construction, and specially adapted for the speedy and effectual transhipment of the coal. The wharf is built upon very long and stout piles of Baltic timber, creosoted, and suitably strengthened by caps, ties and braces; the superstructure is of Canadian timber of the best quality, strongly framed together and protected by painting. This wharf was built at a cost of about $20,000.

Cost of the Wharf.

PRACTICAL TRIALS OF THE COAL.

Steam colliers.

In connection with the business of these new mines and of the Glasgow and Cape Breton Railway two steam colliers were employed during a part of last season. As having an important bearing upon the economical questions now under consideration, I desire to place upon record the observations, limited and imperfect though they may be, which I had the opportunity of making in regard to the consumption of coal in proportion to the work done both on the railway and on one of the steamers, premising that as they had not yet been brought into systematic operation, little attention had been directed to the economy of fuel.

The Fairlie locomotive engine consumed three tons of coal from the Reserve Mine per day, running sixty miles or three trips to and from the Reserve mine, besides shunting, &c., which might occupy two-thirds of the whole time; drawing thirty-eight cars, each containing four tons of coal. This engine is capable of drawing the load specified up a grade of in 100 at the rate of ten miles per hour, with the regulator valve half open.

The "Joseph Dodds" steam collier, an iron built screw propeller, chartered by the Glasgow and Cape Breton Railway Company, 1,048 tons gross register, drawing from 18 to 19 feet of water when loaded, and with screw propeller 12 feet 6 inches in diameter, carried 1,200 tons of coal from the Reserve mine besides 200 tons for the use of the vessel which steamed at an average speed of eight knots an hour. The engines are of the compound or double cylinder variety, with 30-inch high pressure and 42-inch low pressure cylinders and 3 feet stroke; 65 to 70 revolutions per minute, 75 pounds pressure of steam on the boilers, and surface condensation. This vessel consumed in twenty-four hours eleven and a-half tons of the Cape Breton coal, which was considered equivalent to nine tons of Welsh coal. The "Joseph Dodds."

IX. Gardiner Mine.

This mine which has been recently opened upon a property belonging to a Montreal company, is situated eight and a-half miles from the town of Sydney and on the south side of Bridgeport or Lingan Basin. The property is two square miles in extent, about half of which is land and half sea area; it is traversed at the distance of little over half a mile from the shore by the line of the International railway, close to which, and at a distance of 132 yards from the east side line of the area, a shaft, 12 feet by 9 feet, has been sunk, intersecting a fine seam of coal, called the Gardiner seam, which crops out towards the western boundary, running parallel with the side lines and thus underlying (provided no faults occur) 510 acres of the land, and 450 acres of the sea area. The seam is four feet nine inches thick of uniformly good coal, and the aggregate amount contained in this seam within the area may be stated at 6,680,000 tons. Other underlying seams probably of workable thickness and at no very great depth are known to exist on this area, but their precise conditions have not Gardiner mine. Area. Four feet nine-inch seam.

Three to four feet seam.

been ascertained. One which appears at the out-crop to be at least three or four feet thick and of good quality is only thirty-five feet of vertical thickness beneath the Gardiner seam. Another called the Carroll seam, which crops out about two miles from this colliery, will in all probability, from the structure of the field, be found at the depth of about 600 feet; this seam shows at the out-crop six feet of good coal, divided, however, into two benches by a band of shale. Between these two there is every reason to believe that other coal seams will be found. An analysis of coal from the Carroll seam, made by Dr. Dawson, gives:

Six feet seam.

Volatile matter	32.8
Fixed carbon	61.4
Ash (red)	5.8
	100.0

The Gardiner seam has been proved by trial pits and borings at the crop for a distance of one mile from the shore of Bridgeport Basin; bearing N. 38° E., with dip S. 52° E. $< 5^\circ\ 12'$ or 1 in 11. The shaft is sunk about 660 yards (horizontal measurement) to the dip, and cuts the seam at about 162 feet from the surface. It is situated 100 yards south of the railway, and is calculated to serve for a winning of 900 acres.

From the position of this seam in relation to the others in the series, it is obvious that it is one of the lowest in the productive coal measures of this basin; and the developments which have been quite recently, and are now in process of being made with regard to it, are of much interest, and will also tend to enhance the mineral wealth of the district by proving the existence of a valuable seam in addition to and underlying at a moderate depth those previously known. The vertical depth of the Gardiner below the Ross seam, the lowest which had previously been recognized in this part of the field, is from 500 to 600 feet.

Valuable seam beneath those previously known.

This coal seam having been struck at some considerable depth only very recently, and no opportunity having been afforded for more exact personal examination, I append the following extract from a letter lately received from the superintendent, Mr. William Routledge, an experienced and trustworthy authority:—

BRIDGEPORT, C.B., 1st March, 1873.

Letter from Mr. William Routledge.

. . . . . . We have had our coal fairly tried for steam purposes, and with, I think, very satisfactory results. At present our boiler-power consists of two boilers, each about 3 feet in diameter, one 20 feet and the other 32 feet long, supplying steam to a 12-inch cylinder steam pump with one foot stroke and 70 strokes per minute, and to a hoisting and pumping engine with 10-inch cylinder, 20-inch stroke and 60 strokes per minute. The steam for the steam pump is carried a distance of 200 feet from the boiler, 116 feet of which is down a damp cold shaft, causing a loss of pressure of say 10 per cent. before reaching the pump. The pressure on the boilers is about an average of 40 pounds to the square inch, and the consumption of coal necessary to keep up this pressure for the past week, during very cold weather and with the boilers exposed, was ¼-ton per hour or 6 tons in 24 hours. Considering the weather, and that the coals were not cleaned or dressed, I think this a very moderate consumption for the work done, and during summer it will be little over half this. I have to inform you that the top portion of the seam for fourteen inches down is a rich gas coal, below which is about half an inch of splent band, then three feet six inches of what I consider a good steam coal, having about three inches of splent at the bottom. The whole seam used for steam purposes makes a bright lively fire, free from sulphur, with very little clinker, and that of such a character as not to stick to the fire-bars. The splent when broken up to about egg size burns freely and does not at all affect the quality of the coal for steam purposes; in fact for our own use, I prefer it mixed among the other coal, as, from the amount of lime in its composition, it will preserve the fire-bars. For gas purposes I have no doubt the whole seam will prove very satisfactory; certainly, for coke making, from samples taken from an open grate, I believe it will be second to none. . . . . . .

(Signed,) WILLIAM ROUTLEDGE.

The works at this colliery have been skilfully planned and carried out with a view to efficiency and economy. The winding machinery now in process of erection consists of a pair of horizontal high-pressure engines of English manufacture, with 20-inch cylinders and 4 feet stroke, with link motion and all modern improvements applicable to colliery engines. The winding drums, two in number, are 8 feet diameter and 3 feet wide, with a smaller drum for hoisting the bank coal; the pulleys are 7 feet diameter and 3½inch tread, for round wire rope. The steam will be supplied by four boilers, 3 feet in diameter and 30 feet long. The dimensions of the small pumping and winding engine used in sinking the shaft are given in the superintendent's letter quoted above; and as in this operation an unusual amount of water has been encountered, an additional pump (Cameron's Special) of large capacity, intended for the permanent drainage of the mine, has also been put in operation. Works and machinery.

The connection with the International Railway will be effected by a short branch into the colliery, with 460 yards of track, and a switch at either end; and the railway company have contracted to deliver the coal from this mine on board the vessels at their wharf at the rate of 30-32 cents per ton. The colliery buildings consist of eighteen double houses for miners, blacksmith's shop, office and store, manager's and foreman's houses, barn and stable for thirty horses, &c.; and the machinery and other arrangements at the pit head are adequate to a production of 80,000 to 100,000 tons annually. From the comparative thinness of the Gardiner and the Lorway seams they will probably be found to be most advantageously worked on the long wall system, by which all the coal is extracted at the first operation.

X. Clyde or Ontario Mine.

This mine is opened upon an area owned by associations which have been variously denominated the Ontario and Clyde Companies. It comprises 880 acres of land situated on the coast between Glace Bay and Schooner Pond, and is underlaid throughout its entire length—two and a quarter miles—and at a very moderate depth by two of the most valuable seams Clyde or Ontario Mine.

of the series, the Phelan and Ross, as well as by others of importance, both above and below these. The situation of this property, both with reference to the quality and direction of the coal seams (which run longitudinally throughout the whole area) and its proximity to a good harbor, combine to render it an extremely valuable one. The development of this colliery has, however, been retarded by want of adequate markets, by litigation and by other causes apart from its merits, and which it is unnecessary here to detail.

Commencement of operations.

Mining operations were commenced in 1864, but owing to the causes referred to have been prosecuted irregularly and to a very limited extent. The only seam which has been opened is the Phelan, about eight feet thick, of which, however, eighteen inches of the top coal is left in to support the soft shaly roof. After deducting the area of ground worked over, the quantity of coal still available in this seam within the Clyde area is 7,630,000 tons. The coal hitherto raised from it at the Clyde is of the same quality as that at the Caledonia Mine, and has been chiefly used for the manufacture of gas. Dr. Harrington remarks that this is a "bright coal, somewhat brittle and breaking with sharp irregular fracture. A good deal of interposed mineral charcoal. No pyrites could be detected with a magnifying glass, although analysis showed the coal to contain over two per cent. of sulphur. Free burning and with reddish-grey ash."

Quality of the coal.

Works and machinery.

The seam is opened by a slope from the crop about 100 yards from the shore of Little Glace Bay and three quarters of a mile from Port Caledonia. The dip of the seam is N. 21° E., at angles varying from 10° at the surface to 5° at lower levels. The slope, which is 14 feet wide, for two tracks, 2 feet gauge, has been driven 160 yards; and levels, 6 feet wide, have been extended on each side, S. 69° E. for a total length of 400 yards, from which the coal has been worked fifty yards towards the crop. The working rooms are turned S. 7° E. with very regular cleat square to the bord direction; both bords and pillars being of equal width, 14 feet; the total breadth of the workings may be about 100 yards. The weight of underground rails is 22 pounds per yard. The slope is worked by a steam engine of 8 horse-power, which also drains the lower level by means of a water car discharging into the upper level and thence into the sea. The workings being on such a limited scale, and so near the surface, no special appliances for ventilation have hitherto been required, and the slope and water level become in turn the intake for air according to the direction of the external currents.

The quantity of coal yielded by this mine hitherto is inconsiderable, but it is capable of a large production on short notice, should circumstances arise to justify it. There is a small wharf on the property near the slopes, but so exposed as to be practically of little value. A short and light railway has quite recently been constructed—for a great part of the dis-

Wharf and railway.

tance on trestles—to connect the colliery with Port Caledonia. The coal sold from this mine has been chiefly sent to Halifax and Boston for gas making. The price hitherto has been about $1.75 per ton.

XI. Schooner Pond Mines.

The mining property on which this colliery is situated is now owned by a London company bearing the above designation, and the operations are conducted under the superintendence of F. N. Gisborne, Esq., of Sydney. It consists of land and sea area in equal proportions, namely, one square mile each, the former adjoining to the south-east, the property of the Clyde Company, and the latter constituting the sea-frontage of that property, and underlaid by all the valuable coal seams known to exist upon it. These run longitudinally through both properties, which are of great length in proportion to their breadth, thus affording an important advantage in rendering the seams accessible over a large area at the least possible depth.

Schooner Pond mines.

The only coal seam which crops out upon the land area owned by this company, and which has formed the object of mining operations, is the Ross seam, containing here at least six feet in thickness of workable coal, and underlying 105 acres on land and 640 acres under the sea, representing respectively 945,000 and 5,850,000 tons of coal. It will thus be seen that in so far as this seam is concerned, the sea area is by far the most important, and under the circumstances affords promise of very favorable results. In addition to this, however, the whole of the submarine area is underlaid, probably under workable conditions, by the great Phelan seam; and both land and sea areas by the Lorway, Gardiner, and other less developed seams, all of which have already been described.

Quantity of coal available.

As the thick and fine seam of coal now designated the Ross seam crops out in the sea cliffs on this property, it has attracted attention from a very early period, and has been worked in a rude and imperfect way by various parties. A lease of the land area was obtained from Government in 1862 by Mr. Hugh Ross, and mining operations were commenced in a somewhat more systematic manner under the name of the Acadia Colliery; but owing to the difficulty of shipment they were only conducted on a limited scale and discontinued in 1866, having produced during the three years operations an average of 2,900 tons annually.

Annual production.

The present company having acquired the very important sea area in addition to that referred to, commenced operations early in last year, mainly with a view to winning the coal contained in it; and with highly creditable energy have succeeded in the short interval, not only in developing the coal seam in a most satisfactory manner, but in estab-

Railway to Sydney Harbor. lishing a permanent and effective outlet for its produce by the construction of a railway connecting the mine with Sydney Harbor.

Quality of the coal. The quality of the coal from this seam, analyses of which are given in Table II, compares very favorably with that of any other in the district, and especially for steam and household purposes. As compared with that of the next important overlying seam, it is denser and less tender, and contains a much smaller proportion of ash. Dr. Harrington describes it as: "A compact coal with strongly marked planes of cleat. Lustre not so bright as numbers 1 and 2 (Lingan and Blockhouse). A little mineral charcoal, but no visible pyrites. Ash light reddish-grey. A free burning coal."

Old and new workings. The dip of the Ross seam here is N. 23° E. $<7°$ or 1 in 8. The old workings which are quite near the shore have not extended to a greater depth than the water level, and are so inconsiderable in amount as to require no detailed description. The new works consist of a slope from the crop, 300 yards west from the point where it comes out in the sea cliffs. Owing to the peculiar conformation of the coast, this slope is driven in a direction somewhat west from the full dip, or N. 2° W., so as to hug the shore as closely as possible to the deep, and thus obtain a better cover for the submarine workings. The slope, which is 11 feet wide, had at the time of my visit reached a depth of 310 feet measured on the angle of dip. At 184 feet, levels had been driven connecting on the one hand with the water level of the old works, and on the other for a distance of fifty yards on a course N. 55° W., this being also the direction of the cleat. A temporary suspension of the work of driving the slope had then occurred from inadequacy of the means of draining the water which flowed from the old works, but this has been overcome by the introduction of a good pump, and I am informed that the slope is now down to a deph of 600 feet. Although the work had been so recently commenced, much progress had been made in the erection of the **Buildings and machinery.** buildings and machinery requisite for carrying on an extensive business, the details of which, however, beyond such as are given in the Table, I am unable to specify.

The Glasgow and Cape Breton railway has been extended to this colliery distant, by the railway, eighteen miles from Sydney Harbor. Should no unforseen contingency occur there seems no reason to doubt that the expectations entertained by the company, of an output of at least 50,000 tons of coal during the present season, will be realized.

XII. Block House Mine.

Block House mine This mine has for many years been justly regarded, from the size and quality of the coal seam and advantageous situation, as one of the most important and valuable in the district, and next to the Sydney mine it has hitherto proved the most productive. It is situated on the shore of Cow Bay, seventeen miles from the town of Sydney. From a very early period in the history of the Province, coals have been extracted from the Block House seam, where it crops out at the sea shore; but extensive and systematic workings were not commenced till the year 1863, when the mining right to the area on which it occurs was sold by the original lessee, Mr. Marshall Bourinot, to a New York company, by whom the works have been subsequently conducted with little intermission under the superintendence of Mr. Robert Belloni. The property controlled by the company comprises three square miles, 1,280 acres of which are land, and the rest sea area.

Property controlled by the company.

The Block House seam, the highest and by far the thickest in the Cow Bay basin, and that on which the operations of the company have hitherto been concentrated, is entirely contained within the limits of this area, occupying a long, narrow and comparatively shallow trough extending east and west, and cut off towards the east by the sea. At the southern out-crop where the works are situated, the dip is N. 20° E. $< 6° 39'$ or about 1 in 9; at the opposite side of the basin it dips due S. $< 30°$ It has an average thickness of eight feet ten inches, of which one foot is left in to support the roof, and underlies 240 acres of the land area which (taking into account the steep dip on the north side) may be estimated to have contained originally 2,890,000 tons of coal, which, as the seam has been worked to a considerable extent, may now be reduced to 2,120,000 tons including that contained in the pillars. So far as the sea area is concerned it is doubtful if this seam can be relied on for a further supply, but the property is underlaid at a moderate depth by other mos important seams hitherto untouched, and which will probably be workable under the sea, as well as under the land area.

Position and thickness of the Block House seam.

Other seams at a moderate depth.

The Block House seam yields a remarkably fine solid homogeneous coal, free from partings or impurities of any kind, and containing a very moderate proportion of ash. The remarks appended to Dr. Harrington's analysis are as follows :—" A rather bright and compact coal containing a little mineral charcoal and minute veins of sulphuret of iron. A free burning coal. Ash purplish-red." It is almost exclusively used for the manufacture of gas in New York and Boston, and is said to yield 10,500 cubic feet per ton. It constitutes also an excellent steam coal, as may be inferred from the analyses of it in Table II., which is corroborated by practical tests. This seam although undisturbed by faults is characterized by the occurrence of peculiar irregular wedge-shaped masses of shale interrupting its continuity and causing considerable trouble and expense in their removal.*

Quality of the coal.

Peculiar masses of shale.

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* A detailed account of these remarkable masses, the occurrence of which may have an important bearing on the identification of the seams, will be found in Mr. Rutherford's Essay " On the Coal Fields of Nova Scotia," page.36. See also page 256, of this Report.

SURFACE WORKS.—The mine is worked in summer by two slopes, called respectively the Belloni and Ingraham slopes, converging to a point at the out-crop of the seam on the sea shore, where a wharf has been constructed which affords very great facilities and advantages for shipment, as the tubs can be emptied directly into the vessels. For operations during the winter a vertical shaft, 80 feet in depth, called the Dawson pit, has been sunk, and at the distance of 600 yards from the wharf, to connect with the Ingraham slope. The so-called Ingraham and Belloni slopes (the former being more properly a level and driven on the water level), are each 10 feet in width for double-track railway, 2 feet 2 inches gauge. The Belloni slope is driven 650 yards in the direction N. 35° W., or about half the angle of dip, from the crop at the wharf to the apex of the basin. They are both worked by the same engine, situated where they meet at the wharf. The engine, which may be rated at 40 horse-power, has a single horizontal high-pressure 15-inch cylinder and 3 feet 8 inches stroke. The winding drums, 5 feet in diameter, are fitted to run loose on the crank shaft, and are set in action as required, each independently of the other, by friction clutches. The tractive power is communicated to the tubs by means of a steel-wire rope, half an inch in diameter, working over a sheave near the bottom of the Dawson pit to draw the tubs inwards. The Belloni slope is worked by similar mechanism connected with the crank-shaft by bevelled gear at the proper angle. The whole arrangements here are exceedingly ingenious and complete; the engine moving continuously, and all the several parts being brought readily into action as required. The engine is supplied with steam from two plain cylindrical boilers 30 inches in diameter and 40 feet long.

Works and machinery.

Engine.

The Dawson pit, which serves chiefly for banking the coal in winter, is worked as a cage-pit, bringing up one tub or half a ton of coal at a time by an iron wire rope one and a half inches in diameter; it is also used by means of a steel-wire rope, three-quarters of an inch in diameter, passing down the pit, for conveying the motive power to an engine-plane, on the full dip from the bottom of the pit to the lowest part of the basin near to which it crosses the Belloni slope. The engine employed at the pit is of 50 horse-power, having a 16-inch cylinder and 4 feet stroke, with 45 strokes per minute, and 60 pounds pressure on the boilers which are three in number, and of the same dimensions as those at the slopes. This machinery is capable of raising to the bank 500 tons of coal per day, and is also employed for working by means of an endless chain, the trains of tubs which carry the bank coal to the wharf.

Capacity of the machinery.

The arrangement here referred to, which was originated and put into operation by Mr. H. J. Crandall, now manager of the Victoria Mine, is, like that at the slopes, most ingenious and well worthy of adoption under similar conditions and circumstances. It consists of a common iron chain with links five-eighths of an inch in diameter, wound round a cylinder or drum set in motion by the engine at the Dawson pit, which is connected with the wharf by a single track incline railway, 570 yards in length with slope of about 1 in 22 and gauge 2 feet 2 inches, the same as the railway under ground. The chain extends to the foot of the slope, and passing over a sheave or pulley fixed there, returns to the winding drum at the top. This endless chain is set parallel to the railway; and its position is so adjusted that the links form a series of couplings by which, in connection with strong catches fixed in the sides of the coal cars, these are taken up or down the slope in obedience to the motion of the chain. The cars, containing about half a ton each, are the ordinary tubs used in the mine with the addition of the catches; they become engaged by simply pushing them under the chain when in motion; and then disengage themselves at the top and bottom, by the simple action of the chain freeing itself from the clutches. This mechanism is capable of delivering four tubs per minute or 120 tons an hour from the bank to the wharf; and the machinery at the Dawson pit, 500 tons per day. The up-cast shaft for ventilation, 6 feet in diameter and 60 feet deep, is situated close to the endless chain railway and half-way between the wharf and the Dawson pit. In connection with the works at this colliery there is a good machine and repair-shop containing two lathes, a planing machine and other tools suitable for both heavy and light work. In the blacksmith's shop are six hearths and a large punching and shearing machine driven by a donkey engine.

As formerly observed, this colliery enjoys the peculiar advantage of shipping direct from the mine tubs into the vessels. This is due both to its situation admitting of the works being placed immediately at the shore, and to the circumstance that the coal is so remarkably free from impurities as to require no sorting or handling after being extracted from the mine. The wharf to which both slopes and pit deliver their produce is now 600 Wharf. feet in length and somewhat irregular in shape, being in some places 125 feet wide, this great breadth being required in order to give sufficient strength and weight to resist the action of the waves. It is capable of loading four vessels at a time. The depth of water at the extremity of the wharf is 24 feet at high tide, the tide rising and falling here to the extent of four and a-half feet. It is designed to extend the wharf to a length of 1,000 feet from the shore, thereby giving a depth of 30 feet; and additional shipping accommodation for light vessels was in progress at the time of my visit. The wharf is of sufficient width to accommodate several tracks and a very large platform scale, to carry and weigh eight tubs of coal at a time.

With certain winds, and at certain seasons of the year, this part of the coast is so exposed and dangerous as to occasion much trouble, inconvenience and loss; and as the wharf is unprotected by a breakwater, it has frequently been seriously damaged and endangered.

Underground works.

UNDERGROUND WORKS.—The general arrangement of shafts, slopes and levels having been already indicated, I shall describe briefly the details of the workings under ground, which are constructed on the usual pillar and bord system. In the present instance a peculiar interest is attached to the workings in this mine, which have been chiefly confined to the southern dip, from the circumstance that they have reached the bottom and end of the trough or basin in which the coal seam is deposited.

Levels.

The Ingraham slope has been extended a total length of 1,320 yards from the outlet at the wharf, or 720 yards westward from the bottom of the Dawson pit, which is 80 feet from the surface. The Belloni slope is driven from the same point on half the angle of dip 660 yards, nearly to the axis of the trough, where it meets the engine-slope from the bottom of the Dawson pit, 370 yards in length on the full angle of dip. From this latter slope, in addition to the Ingraham, four other levels are extended east and west 100 yards apart, and from these the bords are worked up to the full rise and nearly to the crop on the south side of the basin. At the distance of about 400 yards from the entrance of the Belloni slope, another called the Henrietta slope is driven on or about the full dip nearly to the bottom of the trough. In the earlier workings the proportions of pillars and bords were somewhat irregular; in those of more recent date the bords are 5½ yards wide, and pillars 20 yards long by 5½ yards wide. The lower levels westward intersect at a very acute angle the axis of the trough, and their extension in a straight line is on the rise of its western end; they will be worked as self-acting inclines, the bords being broken off north and south. There are from five to six miles of railway underground, 2 feet 2 inches gauge, laid with bridge rails weighing from 18 to 24 pounds per yard. The number of tubs used in the mine is 300; capacity 1,000 pounds each.

Underground railway.

Extent of the workings.

The workings extend over an area of about fifty acres, but no pillar workings had been instituted until last year, since which time a few have been successfully removed, and this kind of working will doubtless henceforth be followed up with advantage, provided proper attention is paid to ventilation.

Ventilation.

Ventilation.—Little or no gas is developed in this mine, and no special arrangement of lamps, or apparatus for extinguishing fire is requisite. The ventilation is effected by means of a furnace with 42 square feet of grate surface, in connection with the up-cast shaft. The average quantity of air set in motion is about 35,000 cubic feet per minute.

Drainage.—The drainage is effected by two direct-acting steam pumps placed underground, supplied with steam by the boilers at the surface, which raise the water to the Ingraham slope, by which it is discharged into the sea. The quantity of water thus drained from the lower levels is about 250 gallons per minute. The mine water having a powerfully corrosive action upon the pumps, it is found necessary to line the working barrels with lignum-vitæ.

The following is an analysis of this water, made by Mr. C. Hoffmann, of the Geological Survey Laboratory:

The water when received had a sediment of a yellowish-red color: the supernatant liquid had a brownish-yellow color, an acid reaction and a slightly acid and styptic taste. The sediment when treated with hydrochloric acid is for the most part taken up, the residue consisting of a dirty white coagulum or slime.

The water was filtered and gradually heated: at about 71° C. it became turbid, and as the temperature rose a dense precipitate of a yellowish-red color ensued. After protracted boiling the precipitate was filtered off and washed with boiling water, until the washings gave no reaction with barium chloride: upon treatment with hydrochloric acid it left a dirty white coagulum: the filtrate from the latter gave with barium chloride an immediate precipitate. The filtrate from the precipitate produced by boiling was colorless, and possessed a strong acid reaction, and was found to contain but little more than a trace of iron.

CONSTITUENTS IN 1000 PARTS OF THE WATER.

Suspended matter	.1510	consisting of
Ferric oxide	.1052	and
Sulphuric acid and organic matter	.0458	

The former combined with the ferric oxide as a basic sulphate of iron.

In Solution.	
Iron (as persalt)	.2426
Iron (as protosalt)	.1168
Manganese	.0078
Aluminium	.0420
Calcium	.1498
Magnesium	.0618
Potassium	.0134
Sodium	.1884
Silica	.0116
Sulphuric acid (So_4)	1.4808
Chlorine	.4100
Phosphoric acid	Traces
Organic matter	.2844
Total solid contents	3.0094
Total solid contents by direct estimation	2.9090
Specific gravity	1002.23

PRODUCTION—The productive capability of the mine, as at present opened, may be stated at 1,000 tons per day of twelve hours, which has, as I am informed, been reached on various occasions. At the time of my visit the average shipments amounted to 600 tons—400 direct from the mine and 200 from the bank—with sixty pairs of cutters. The *slack* coal amounts to about one-fourth of the whole; in summer such as is Production.

made in the mine is stowed there, but in winter it is brought to bank. The average annual quantity sold during the time in which this mine has been in operation, omitting those years in which work has been suspended or irregularly prosecuted, is 64,450 tons, which have been mostly exported to New York and Boston for the manufacture of gas. A large and powerful steam tug is employed in connection with this colliery.

Steam tug.

XIII. Gowrie Mines.

These mines, which from their first inception to the present date have been owned and controlled by a private firm,—Messrs. Archibald and Co. of North Sydney—furnish a remarkable example of a steady, continuous and regular production amidst all the fluctuations to which the business has been subjected during that time. The area on which the Gowrie mines are situated immediately adjoins to the south that owned by the Block House Company, and like it abuts upon the northern shore of Cow Bay, where a wharf and artificial harbor for the shipment of the coal have been constructed.

Gowrie Mines, area.

The mining area now referred to which was leased to Messrs. Archibald in 1861, is two square miles in extent, and altogether on land; it is underlaid at an easily accessible depth by several workable seams, only one of which, however,—the McAulay seam—has hitherto formed the object of mining operations. This seam underlies that called the Block-House at a vertical depth of about 450 feet; and its thickness varies from four feet eight inches to five feet two inches of good coal, with from two to six inches of coal of inferior quality, left in the mine to support the roof. The floor is of hard sandstone, without underclay, and the seam dips on the south side of the area N. 18° E. $<$ 8°, and on the northern out-crop S. $<$ 40°.

Workings.

The workings on this seam have been hitherto altogether on the southerly dip; and the boundary of the area in that direction has been established so as to include the entire crop of this seam; but it also embraces a large proportion of the coal contained in the northerly dip, and overlies an area of 760 acres, containing originally 5,700,000 tons of coal, of which, supposing 80 acres to have been worked over, about 5,220,000 tons besides that contained in the pillars will still be available.

Quantity of coal available.

After the requisite preliminary works to establish the continuity and quality of the seam, systematic mining operations were commenced here under the superintendence of Mr. Blowers Archibald in 1864, and have been continued ever since without intermission, and with admirable economy and efficiency, at a remarkably regular rate of production. The coal from this mine has a very general application and extensive distribution, having been sold in nearly equal proportions for home consumption, the British American Colonies, West India Islands and United

States, for domestic and steam purposes. The proportion of ash is somewhat objectionable for the latter purpose, but on the other hand its value in this respect is enhanced by the well established fact that it is not apt to form any clinkers. For the manufacture of gas its somewhat high proportion of sulphur is certainly deleterious, although it has been largely used for this purpose. The analysis of average samples from this colliery are given in Table II., and its quality may be further illustrated by the following extracts from letters referring to practical tests on a large scale. Quality of the coal.

Report of Mr. Sutherland, Chief Engineer of the S.S. "Sweden," on Gowrie coal.

"On the passage from Cow Bay to Liverpool (1869) I have given the Gowrie coal a fair trial, and found that when burning Gowrie coal alone our average steam was little under that obtained from Welsh coal, of average quality, but our consumption about 12 per cent. in excess of Welsh coal. I found on burning an equal mixture of Gowrie and Welsh coal, good steam with little over our usual consumption of Welsh. I believe a ship with proper furnace bars for Gowrie coal could use it with very good results. Reports on trials of Gowrie coal.

I may state that the Gowrie coal forms very little clinker, and consequently is easy on furnace bars; the amount of ash is even less than from Welsh coal, and the specific gravity much the same, being about 41 cubic feet to the ton."

"North Sydney, June 21st, 1869.

"We certify that the steamer 'Panther' has been using Gowrie Mines coal almost entirely for the past three years; and that it has been constantly improving in quality during that time.

"We consider it superior to Scotch and Sydney, and almost equal to Welsh for steam purposes; and find that it is particularly easy upon furnace bars.

"(Signed,) "ROBERT FORBES, Chief Engineer.
"JOHN BARTLETT, Master."

"*Office of the New York Gas Light Company,*
"New York, January 29th, 1864.

"F. H. Odiorne, Boston.

"Dear Sir,—The sample cargoes of Gowrie coal received at the works of the New York Gas Light Company yield about 9,000 feet per ton of 15 candle gas. The coke is of good quality and makes a strong heat. The coal was carbonized by us under very high heats.

"There is a considerable impurity in the coal (slate, &c.,) which may be separated in mining. It is my opinion that this coal, if properly selected before shipment, will yield gas in quantity and quality equal, if not superior, to any coal from Cape Breton.

"(Signed,) "JOHN H. ADAM, President."

Dr. Harrington's remarks appended to his analysis of the sample of coal from the Gowrie mine are as follows: "Very bright and firm, with marked planes of cleat. A little carbonate of lime, as in No. 3 (Sydney main seam) but in much smaller quantity. But little visible pyrites. Ash reddish-brown. Did not coke." Remarks by Dr. Harrington.

Surface Works.—Mining operations at the Gowrie mine, as at the Block House mine, date from a very early period in the history of the province when under French occupation. Passing over these and also the preliminary works of the present proprietors I shall proceed to describe the state of the colliery at the present time.

At the distance of 900 yards from the shore of the Bay and 450 yards from the crop of the seam a shaft called the Odiorne pit has been sunk to the depth of 205 feet, intersecting the McAulay seam; this is now the principal working pit. There is also another shaft (No. 2) which had been previously in use, situated 300 yards to the south of the former, and on the full rise of the seam from it. This latter shaft, designed exclusively for the crop workings, is connected with a slope to the crop, which served as a travelling way for the men and horses employed in the mines. Both

Machinery.

pits are provided with steam engines, the first of 30 horse-power for pumping and winding, and the second of 6 or 8 horse-power for winding only. The Odiorne pit, which is also used as an upcast shaft, is 15 feet by 5½ feet, divided into two compartments 9½ feet and 5½ feet by 6-inch bratticing, the larger division being mounted with slides, &c., as a cage-pit, and the smaller as a pumping shaft.

The engine at this pit has a single horizontal high-pressure 16-inch cylinder, and 3 feet 6 inches stroke, geared down 2½ to 1 on both pumping and winding shafts. The drums 8 feet in diameter and 5 feet long are furnished with flat wire rope, 4 inches by ½ an inch, and the cage is adapted to bring up only one tub at a time, containing 800 pounds of coal. This machinery is capable of hoisting two tubs per minute, and has frequently delivered at the pit-mouth at the rate of 300 tons per day. At the time of my visit the average production at this pit was 250 tons per day, round and *slack*. The pumps, two in number, 10 inches in diameter and 4 feet stroke, lifting a height of 200 feet, and at the rate of 250 gallons per minute, are worked by the same engine by means of the ordinary spear connections, and

Drainage.

drain the mine in eight hours pumping, viz., from 6 P.M. till 2 A.M. The steam is supplied to this engine by two cylindrical boilers 5 feet 6 inches in diameter and 26 feet long, with two internal flues, 22 inches diameter, in each.

The arrangements at the bank are very complete and commodious. There are two sets of shutes and screens, those for the pit being distinct from those for the bank coal which is drawn up to the platform by a small steam engine. At the time of my visit the bank might contain about 8,000 tons. Most of the *slack* (which amounts to between one-third and one-fourth of all the coal extracted) is left in the mine; that which is brought to or made at the bank finds a ready sale. About four tons per day of splent and sulphurous coal is picked out and sold to the miners, &c.

Railway.

This colliery is connected with the wharf by a short but substantially built railway 1,100 yards in length with a down grade averaging about 1 in

100 from the pit head, and an incline of about 1 in 15 for 180 yards as it approaches the wharf, enabling the cars to descend by their own gravity and with sufficient impetus to carry them to the end of the wharf without the application of further motive power. The empty cars are drawn back to the pit by horses. The guage of the railway, which is laid with T rails, 35 pounds to the yard, is 3 feet 7 inches; it is equipped with 84 waggons built at the colliery) each capable of carrying two tons. During last year a new engine shaft (No. 4) 12 feet in diameter was commenced 1512 yards north-west from the Odiorne pit, to cut the seam at the depth of 250 feet from the surface, on the extension of the levels from that pit. The new shaft at the time of my visit had been sunk 86 feet, and the railway graded to connect with that at the present colliery; when these works are completed a locomotive engine will be employed for the haulage of the coal from both pits.

Wharf and Breakwater.—The wharf, which is strongly built of timber on a foundation of crib-work ballasted with stones, is 1,156 feet in length and 24 feet wide, with T piece 230 feet from the water extremity, 175 feet long and 24 feet wide for the protection of vessels lying within that distance from the shore. The wharf is capable of accommodating eight vessels at once, drawing from 10 up to 18 feet of water; it is provided with eight shutes for smaller and two drops with turntables, &c., for larger vessels. As the bay is exposed and dangerous (especially in autumn which is the busiest time for the shipment of coals, and when easterly gales prevail) it has been found necessary to construct a very massive and substantial breakwater for the protection of the wharf and shipping. Wharf. Break-water.

This breakwater or pier is about 1,500 feet in length and 48 feet wide, built entirely of strong crib-work very heavily loaded with stone, and has 20 feet depth of water at low tide at its outer extremity. It is situated about 250 yards to the north-east (or seaward) from the wharf; and is made slightly arched or convex outwards, with the deck or upper surface sloping in the same direction at an angle of five degrees. It affords shelter and protection to a large number of vessels, which for such accommodation are required to contribute to its maintenance by small dues or tolls regulated according to the tonnage and time so occupied. Independently of the wharf, the cost of constructing this pier and repairing it, is stated to have been $60,000. Construction.

UNDERGROUND WORKS.—These, which are on the pillar and bord system, have hitherto been altogether confined to the rise of the levels from the bottom of the shafts. At the old shaft (No. II) the breadth of the winning is 150 yards and at the Odiorne pit 300 yards, these works being separated by a barrier of coal. At the old workings, which, as before remarked, are very near the crop, the levels have been driven from the shaft north-east to the shore, 815 yards, and south-west upwards of 600 yards. Here the bords Old workings.

were 18 feet wide, and the pillars 18 feet by 9 feet, and several of the pillars have been removed. These works were discontinued in 1867, and operations since that date have been limited to that part of the mine commanded by the Odiorne pit.

New workings.

The two main levels, 150 yards apart, have been extended 1,000 yards towards the sea and 1,450 yards in the opposite direction, and are connected by self-acting incline gate-roads cut about half across the angle of dip, and coming out in the upper level 500 yards from the shaft. These main roads which are 7 feet wide and 5½ feet high, are laid with rail tracks, two feet gauge, and with T rails, 22 pounds to the yard. The incline roads are worked by a friction-strap and five-eighth inch steel-wire rope; the level roads by horses, of which at the time of my visit twenty were employed in the mine. The direction of the levels is N. 67½ W., and the cleat of the coal being E. and W., the bords or working places are turned due south from the levels, and are driven up 16 yards by 6 yards wide, the pillars being left 16 yards by 7 yards. The coal is holed at or near the bottom of the seam 2 feet in and 9 inches high, and is all wedged down, no blasting being required in this mine owing to the presence of a peculiar cross fracture in the coal in addition to the usual cleat; thus rendering it very easy to work although more liable than is desirable, to break into small pieces. For the bords the rails are of flat iron, 2½ inches by ⅝ inch. There are altogether about four miles of railroad under ground and 150 tubs, each of the capacity of one-third of a ton.

Ventilation.

Ventilation.—No explosive gas being generated in the mine no safety lamps are required, and the ventilation hitherto has been attended with no difficulty and requires no special appliances. To assist, however, in promoting the circulation of air, a small furnace, with 18 square feet of grate surface, has been placed 30 feet from the bottom of the cage-pit which acts as an upcast, the pumping compartment being the downcast.

Drainage.

Drainage.—The arrangements for pumping have already been described. Like that at the Block House mine the water is of a highly corrosive character, owing probably to sulphate of iron in solution, rendering it necessary to apply a lining of lignum-vitæ to the pipes and to make the buckets and the working barrels of a mixture of six parts of lead and one of antimony; this alloy although still far from perfect, being found best adapted to resist the corrosive action of the mine water. When made of iron and unprotected, a set of pipes and pumps were rendered useless in four or five days, but when fitted as above described will last three months.

Production and price.

PRODUCTION.—The average annual quantity of coal of both kinds sold at the Gowrie mines during the last nine years in which they have been in regular operation is 42,090 tons; and the greatest deviation from that average during any one year has not exceeded 13,000. For several years the selling price, loaded on the vessels, has been, for round coal, $1.75, and for *slack* 90 cents per ton.

General Remarks.

One of the most important points connected with the economical working of coal mines, as of all industrial undertakings, is, of course, the cost of production ; and especially the value of the requisite materials and labor. I am not prepared on the present occasion, more especially as there is considerable diversity in the different mines, to give full information upon all the items included under this head. The method of regulating the pay of the miners is very various ; in all cases, however, it depends upon the amount of work done. The following different systems of payment are adopted in different mines, and sometimes a combination of two or more of these in the same mine : by the cubic yard ; by the ton ; and by the lineal yard advance. At the Sydney mines the price paid is 46 cents per ton in whole, and 40 cents in broken coal, filled into the tubs, the *slack* riddled in the mine, and all weighed at the surface. The miners find their own powder and lights. For driving levels, &c., 80 cents per lineal yard is allowed over and above the rate paid for the coal thus extracted. The average daily work of each miner is three and a half to four tons, and in drifting, two men will advance four and a half feet per day. I am informed that it is not unusual for the men to earn from $60 to $80 per month. Ordinary laborers and surface hands are paid, on an average, at the rate of 85 cents per day. The rates at the other mines are regulated in the same proportion, allowing for the different methods of computation, and modifications according to local circumstances. At the smaller establishments, however, the rate of wages is usually from five to ten cents higher than at the Sydney mines, and it has been found necessary of late years, in order to secure the requisite amount of labor, to pay higher prices than had previously ruled ; and with the increased demand this year it is probable that these will require to be still further augmented. During the three or four months of winter, when there is no shipment of coal, it is usual either to reduce the rate of wages or the amount of work done.

Different systems of payment.

Average earnings of the miners.

Reduction of wages or work during winter.

The following estimate of the cost of raising and shipping one ton of coal, including various items of expense in addition to that of the actual mining, is submitted as an approximate average :

Mining expenses, averaging say	50 cents per ton.
Wages of putters	6 " "
Underground haulage (one horse for every 2,260 tons raised annually)	5 " "
Timbering	4 " "
Engine power, winding	2 " "
Firemen to upcast, watchmen, and road cleaners	2 " "
Overseer and assistants, engineers and firemen at pit mouth	3 " "

Expenses of screening and loading coal	6	cents per ton.
Expenses of loading bank coal	12	" "
Salaries and incidental expenses	10	" "
Railway transportation, say 5 miles at 3 cents	15	" "
Loading at wharf	3	" "
Government Royalty and taxes	11	" "
	1.29	
Interest on capital, insurance, wear and tear, agencies, discounts and contingencies, say	25	" "
Total cost per ton free on board	1.54	

Cost of coal per ton.

The above estimate, from the most reliable data available, is based on a production of 50,000 tons per annum, and must be regarded simply as applicable to the average condition of affairs at the present time, which may be materially modified by various local and incidental causes. Pumping and ventilation are merely questions of increased consumption of coal, and have consequently been omitted in the above statement.

Miners.

It may be estimated that two-thirds of all the mining population of Cape Breton at the present time are Scotch Highlanders or their descendants, who are a very frugal, industrious and deserving race, and make excellent miners. As regards their social condition, every encouragement and facility for its improvement is afforded by the various colliery proprietors, by providing comfortable dwellings, schools, churches, medical attendance, &c., probably on a more liberal and enlightened scale than is usual in most other countries. An increase of this class of population, or of such others as may have been accustomed to work in mines, is greatly to be desired, and for this purpose every encouragement for their immigration should be extended. Owing, to the scarcity and enhanced price of coal in England, and consequent anticipation of increased demand, the past season has been characterized by great activity in developing and rendering available the vast resources of this coal field. But for several years back the coal-mining industry in Cape Breton has been in a languishing condition in consequence of deficient markets, and in fact the mines have been in many instances worked either with little or no profit or at an actual loss, the proprietors merely keeping them in operation in hope of better times. Under these circumstances, and as tending to promote the interests of this most important industry, the following suggestions are offered, referring chiefly to certain objects which it is considered desirable to attain, and which I shall merely indicate without attempting at present to elaborate them.

Condition of the coal trade in Cape Breton.

Utilization of *slack* coal.

1. Utilization of *Slack* or Small Coal.—This I conceive to be one of the most important objects which can engage the attention of persons interested in coal mines. At least one-fourth of all the coals mined in this district assumes the form of *slack*, and only a small proportion of

it is saleable even at a less price than it costs to produce it; and in many instances its removal to waste is a source of additional expense. Under these circumstances it seems at all events most desirable that whatever fuel is required on the works or railways, &c., connected with them, which may amount to one-fifteenth of the whole, should be used in this form; and further, that the rest of the *slack* should be either converted into coke, or into a solid fuel by admixture with some other ingredient. It appears to me probable that both these objects could be successfully and economically attained.

2. LONG WALL WORKING.—This system should be adopted for all seams under four feet or four and a half feet in thickness. Many such seams exist in this field, and might be profitably mined, although not perhaps on the pillar and bord system. The long-wall system admits of the introduction of coal-cutting machinery and of the extraction by one operation, of the largest quantity of coal, with the least injury to its quality, and also simplifies the mode of ventilation. System of working.

3. THE EMPLOYMENT OF STEAM COLLIERS ON AN EXTENSIVE SCALE. Steam colliers. —This would ensure a greater regularity in the delivery, and a longer continuance of shipment at the time when it is most desirable.

4. COLLECTION OF STATISTICS.—The systematic collection and recording of accurate statistics of all matters connected with the business of coal-mining, including accurate plans and descriptions of underground Mining records workings, authentic statements of the results of actual trials on a large scale on railways and steamboats, and in furnaces, gas-works, &c. Such records, which should be accessible in the proper quarter to all persons interested, would prove of incalculable value in connection with the future working of our coal fields. Not only would they be the means of saving an immense amount of useless labor, but they would also prevent the occurrence of many serious accidents involving the sacrifice of life and the loss of much valuable property. In this connection, and respecting the general management and regulation of the coal mines of Nova Scotia, the following remarks by Mr. Rutherford, late Government Inspector of mines for that Province, in his Report for 1866, pp. 69–72, are well worthy of reproduction, and are accordingly appended.

I have the honor to be, Sir,

Your most obedient servant,

CHARLES ROBB.

TABLE I.

LIST OF COLLIERIES IN OPERATION.

WITH STATISTICS OF LABOUR, MACHINERY, PRODUCTION AND EXPENDITURE.

No.	Commenced in Year.	Name of Mine.	Proprietors.	President.	Manager.	Area sq. Miles.	Miner's Houses.	Men and Boys.	Horses.		Engines.		Total sold.	Expenditure on Works.
									Mine.	Surface.	No.	H.P.	Tons.	$.
I.	1827	Sydney Mine	General Mining Association, London.	Col. Scovell	Richard H. Brown.	23	250	474	40	24	10	760	3,310,169	400,000
II.	1854	Lingan Mine	" " " "	Col. Scovell	Donald Lynk	24	35†	225	14	11	1	50	487,129	340,000
III.	1866	Victoria Mine	Victoria Mining Co., Halifax	Wm. J. Frazer	H. J. Crandall	4	35†	125	3	4	5	220	51,880	150,000
IV.	1858	International Mine	International Mining Co., N. Y.	Alfred McKay	R. Macdonald	4	12	137	14	16	3	90	191,506	450,000
V.	1862	Little Glace Bay Mine	Little Glace Bay Co., Halifax	Jas. A. Moren	Henry Mitchell	$2\frac{1}{2}$	50	100	12	4	5	100	514,783	253,000
VI.	1865	Caledonia Mine	Caledonia Co., Boston	J. H. Converse	Henry Poole	2	46	100	7	4	3	66	130,377	165,000
VII.	1871	Reserve Mine	Glasgow & Cape Breton Co., London	H. L. Micholls	F. N. Gisborne	1	24†	180	6	4	1	60	27,802	436,400
VIII.	1872	Lorway Mine	Lorway Mining Co., London	— Underhill	F. N. Gisborne	2	24†	65	......	6	1	30	1,478	80,000
IX.	1871	Gardiner Mine	Gardiner Mining Co., Montreal	Wm. Gunn	Wm. Routledge	2	20	33	......	3	3	160		45,000
X.	1862	Clyde [Ontario] Mine	Messrs. Campbell & Co., Halifax, &c.	....	....	$1\frac{1}{3}$	16	21	1	1	1	10	29,864	23,000
XI.	1862	Schooner Pond Mine	Schooner Pond Co., London	H. L. Micholls	F. N. Gisborne	2	12†	21	6	.....	1	30	10,393	44,800
XII.	1860	Block House Mine	Block House Co., Halifax	Henry Lawson	Robt. Belloni		90	300	20	10	4	120	564,802	130,000
XIII.	1862	Gowrie Mine	Archibald & Co., Sydney, C.B.	....	B. & C. Archibald	2	80	100	20	8	1	40	401,020	200,000
					Totals	$73\frac{1}{6}$	694	1881	148	95	39	1736	5,721,208	2,766,400

The miners' houses are for the most part double tenements. The "expenditures," which are for the most part taken from the Reports of the Commissioner of Mines, do not include the value of leases or of real estate. In the case of the Sydney Mines there is no record previous to 1863, since which time the expenditure amounts to about $200,000. The expenditure for the International and Reserve Mines includes the cost of International Railway and Wharf, and of the Glasgow and Cape Breton Railway and Wharf, with all equipments.

The total quantity of coal remaining in the seams enumerated and described in this Report may be estimated at 261,762,000 tons. It must, however, be understood that there are a number of other seams in the district, which have not yet been worked and are not included in this estimate, and that from these as well as from areas, partly on land and partly sub-marine, likewise omitted, but which are doubtless underlaid by some of the seams enumerated, a very large additional quantity of coal can be made available and the total quantity which this coal field is capable of yielding, exclusive of any that may be obtained from seams of a less thickness than four feet, is probably not less than *one thousand million tons*.

TABLE II.

DESCRIPTION AND ANALYSES OF SEAMS WORKED.

Name Mine	Description of Seam.	ft. ins.	Analysis	Sp. Gr.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur	Cubic ft. of Gas per ton.	Color of Ash.	Theoretical Evaporative Power.	Authority.	Depth in feet.	Extent in acres.	Direction and Angle of Dip.	Cleat of Coal.
				Analyses of Coal.									Workings.			
	Good coal	4 2	No. I.	1.338	26.94	67.57	5.49		6,500		9.29 8.49	Johnson	Shaft, 360			No regular cleat; works best in N. and S. direction.
	Parting		" II.		31.87	64.59	3.54			Reddish		How	Shaft, 630	867	N. 60° E. ∠ 5°	
Sydney Mines	Good coal	1 8	" III.	1. 30	34.18	61.50	4.32	1.24	8,200			How				
(Sydney Main Seam).	Total thickness	6 0	" IV.		32.74	61.54	5.72	3.37		Reddish Grey		Harrington.				
	Coal	3 0	" I.	1.282	30.03	66.91	3 06		9,600		9.19	How	Slope, 2,700	70	N. 37° E. ∠ 13°–16°.	S.E.
	Fireclay	0 6	" II.		35.16							Dawson	(Vertical Depth, 725).			
Lingan Mine	Coal	5 8	" III.		34.23	63.98	1.79	0.77		Reddish Grey		Harrington.				
	Total thickness	9 2														
	Top coal	0 7	" I.		38.70	58.40	2.96				8.02	Dawson	Slope, 1,000.	1¾	N. 3° W. ∠ 38°	E. and W.
Victoria Mine	Good coal	6 0											(Vertical Depth, 735).			
	Total thickness	6 7														
	Good coal	0 3	" I.		38.50	56.50	5.00		10,000	Reddish Grey	7.76	Manhattan Gas Co.			S. 84° E. ∠ 5°	N. 75° — 80° W.
	Parting		" II.		34.09	62.92	2.99	2.26		Reddish Brown		Harrington	Shaft, 96			
	Good coal	2 3											Slope, 550	7		
	Mineral charcoal	0 1														
International Mine	Good coal	3 3														
	Parting															
(Harbor Seam).	Good coal (holing)	0 3														
	Total thickness	6 1														
	Shaly coal	1 8	" I.		36.54	62.53	0.93		8,500		8.59	H. Poole.			N. 50° E ∠ 40°.	
	Good coal	5 0	" II.						10,000			Philadelphia Gas Co.	Shaft, 130	57		
	Shaly coal	0 1½	" III.				1.30					How	Slope, 400			
Little Glace Bay Mines.	Brown carbonaceous shale	0 0½	" IV.		28.62	65.85	3.24	2.29		Brown.		Harrington	(Vertical Depth, 100).			
	Good coal	2 6½														
(Hub Seam).	Total thickness	9 4½														
	Coarse coal	0 2½	" I.		30.21	67.78	2.01	0.90		Light Grey	9.31	Harrington.	Shaft, 40	28	N. 27° E. ∠ 6°.	
	Parting		" II.				2.12					How				
	Good coal	1 5														
Little Glace Bay Mines.	Mineral charcoal	0 0¼														
	Good coal	3 4½														
(Harbor Seam).	Total thickness	5 0¼														
	Roof coal	1 3		1.329	33.00	57.37	9.63		9,700	White to Brown	7.88	Poole	Shaft, 188	30	N. 27° E. ∠ 5°	E. 10° S.
Caledonia Mine	Good coal	6 9														
(Phelan Seam).	Total thickness	8 0														
	Good coal	4 2	" I.		37.26	58.39	4.35		9,500		8.02	Royal School of Mines	Slope, 790.	1½	N. 58° E. ∠ 5°.	
Reserve Mine	Coarse coal	2 0	" II.		35.47	61.67	2.86	2.06		Reddish Grey		Harrington	(Vertical Depth, 70).			
(Phelan Seam).	Total thickness	6 2														
	Coal	1 7	" I.		24.47	55.98	13.28	6.27		Greyish Red		Harrington.	Shaft, 100.		N. 51° E. ∠ 5°.	
	Band	0 1											Shaft, 66.			
	Coal	1 10														
Lorway Mines	Clay parting	0 0¼														
	Coal	0 6														
(Lorway Seam).	Total thickness	4 0¼														
	Good gas coal	1 2	" I.		34.33	61.97	3.70		10,700	Reddish	8.51	Dawson	Shaft, 162		S. 50° E. ∠ 5°.	
	Splent	0 0½	" II.		31.96	65.22	2 82	1.18		Light Grey		Harrington				
Gardiner Mine	Good steam coal	3 3														
	Splent	0 3														
(Gardiner Seam).	Total thickness	4 8½														
	Top coal	1 6	" I.		33.00	57.37	9.63		9,700		7.88	Brown	Slope, 450.	4	N. 21° E. ∠ 5½	N. 83° E.
	Coal	6 0	" II.		32.82	64.33	2.85	2 17		Reddish Grey		Harrington	Slope, 270.			
Clyde Mine	Bottom coal	1 0											(Vertical Depth, 45).			
(Phelan Seam).	Total thickness	8 6														
	Coal with clay bands	1 4														
	Coal	0 4¾	" I.		38.10	58.45	3.45		9,500		8.03	Royal School of Mines	Slope, 400	1¼	N. 23° E ∠ 8°	N.W.
	Shale, hard	0 1	" II.		31.75	66.85	1.40	1.21		Light Reddish Grey		Harrington	(Vertical Depth, 57).			
	Coal	3 7½														
Schooner Pond Mine	Soft shaly band	0 3														
	Coal	1 3														
(Ross Seam).	Total thickness	6 11¼														
	Top coal left	1 0	" I.		38.80	55.80	5.40		10,500	Red	7.67	Brown	Shaft, 80.			
Block House Mine	Coal	7 10	" II.		31.94	62.79	5 27	3.76		Purplish Red		Harrington	Slope, 2,000 (Vertical Depth, 160).	75	N. 21° E. ∠ 6½°.	
(Block House Seam).	Total thickness	8 10														
	Coal	2 2	" I.	1. 33	36.15	58.01	5.70	2.34	9,000		7.97	Richard and Buist	Shaft, 205.			
	Shale	0 0½	" II.		32.07	64.43	3.50	2.86		Reddish Brown		Harrington	Shaft, 250	80	N. 18° E. ∠ 7°	E. and W.
Gowrie Mines	Coal	2 8½														
(McAuley Seam).	Total thickness	4 11														

The samples submitted to Dr. Harrington for analysis were taken without selection from the coal as it came to the bank, and may be assumed only in a general way to represent the average quality of the various seams. In all Dr. Harrington's analyses the amount of volatile matter has been determined by slow coking. By fast coking it is of course much greater, and a better coke is produced; and this is true of some of the South Staffordshire coals which, according to Dr. Percy, give a good coke with rapid and do not coke at all with slow heating. The average of all the above analyses gives Specific Gravity, 1.316; Volatile Matter, 33.441; Fixed Carbon, 61.873; Ash, 4.223; Sulphur, 2.37; Gas, 9340; Evaporative Power, 8.33.

REMARKS

EXTRACTED FROM MR. RUTHERFORD'S REPORT FOR 1866.

With a few exceptions the remarks I am about to make will apply to nearly all the Collieries in the Province; and I have on this account avoided what would have been a mere repetition had I made them in each case. They have reference to pillar working, ventilation, drainage, storing of coal, and plans, under which classification I proceed to give them.

PILLAR WORKING.

The facility with which the coal has been reached in all the districts, as compared with other mining countries in which, from the exhaustion of the seams near the crop, expensive sinkings become necessary to reach the underlying coal, and consequent great skill and carefulness are required in properly opening out the mine; this freedom from an expensive preliminary outlay, instead of enabling an effective winning of a large tract of coal to be made before commencing the regular working thereof, seems to have engendered an indifference to future operations, and allowed the desire for an immediate profit to supersede the necessity of a judicious arrangement of the mode of working. To this cause I attribute the short distance from the crop, to which in most of the mines the workings are confined; and the adoption of a system by which as much of the seam as possible is taken away in the first working and the pillars are reduced to a minimum of strength for the purposes of support. The injudiciousness of this system cannot be too strongly urged. The introduction into the market of coal worked so close to the crop must have operated prejudiciously—and I have reason to believe that it has—to the interests of the mine owner; and the continuance of the scale of pillarage, which has, I think, from the preceding cause been too generally adopted, will be fraught with consequences of a more serious character. For, although with the present limited extent of workings and the absence of pressure in consequence of the proximity of the coal to the surface, the pillars may be sufficient to keep the mine open for ventilation or other purposes, yet if unaltered where the overlying strata are very much thicker and heavier, their inability to support will in no long time be exhibited to the serious detriment of all concerned. For this reason I have felt it my duty to recommend an increased size of pillars as the workings extend to the dip, with a view to their subsequent entire removal. I have also advised the working of the pillars at such a distance from the crop as the quality of the coal will warrant. I am glad to be able to report that this has been effected with success at the Lingan and Gowrie Collieries, and been attended with an additional advantage, to which I will hereafter refer.

This removal of the pillars should commend itself to the managers of mines not only on account of the importance of avoiding a waste of coal, but also because it has the further advantage of lessening the working area of the mine, and consequently reducing the amount of materials required to supply the otherwise rapid extension of roads, and the means of conveyance necessary in widely spread districts.

VENTILATION.

The limited extent of the workings of many of the collieries, and the adoption of the system on which they have been made, have not been without their effect so far as ventilation is concerned. The maintenance of travelling roads through the pillars, and the adoption of any artificial aid, appears to have been thought unnecessary in most cases,—a difference of level as respects the intake and outlet, and the difference of the internal and external temperature, being chiefly relied on to cause the circulation of a current of air.

The freedom from gas of an explosive character—carburetted hydrogen—and the absence of the equally noxious and dangerous non-explosive gas—carbonic acid—have produced an indifference as to the necessity of making provision for a more effective ventilation as the workings become extended. In most of the mines all that is attempted is the conduction of the air into the neighbourhood of the face, and thence allowing it to find its way to the nearest place of outlet. The parts of the mine standing in pillars—as well those immediately behind the working places as those more remote—are thus without any admixture of the air but that which the movements in the mine may occasionally cause to pass into it. A steady and constant current is not to be relied upon under such circumstances, and it therefore frequently happens that the circulation is reversed, and the intake becomes the outlet.

The mere fact of there being at present in most of the mines no deleterious gases requiring to be swept away or reduced to an innocuous mixture, should not be deemed sufficient to render unnecessary the provision of such a quantity of fresh air as is necessary to the healthy pursuit of the occupation of the miner. To effect this, no simpler agent can be employed than the furnace. This, properly constructed, and placed at the bottom of one of the ventilating shafts,—which should be used exclusively for that purpose,—would, with attention to the size of the air-courses and the position of the stoppings, suffice to maintain the steadiness of current and amount of fresh air which are too frequently wanting.

DRAINAGE.

In many instances the exposure of the coal on the faces of the cliffs has induced the opening of the seams to be made by driving an adit or level from the shore, which has answered the double purpose of being an outlet to the coal and the water made in the mine. The desire to obtain as much coal to the rise as possible, has, in many cases, led to this level being so placed that it is within the reach of the tide, which occasionally flows into the mine. These levels are in many collieries still used as the outlet for the water after being lifted from the dip workings. I am glad to be able to state, however, that in some of these collieries precaution has been taken, by fixing dams, to prevent any unusual rise of the tide extending so far as to overflow into the dip workings. In those mines in which the workings have not yet been made to the dip, I have recommended the adoption of simllar means to prevent such a casuality. The quantity of water made in the mines is not large, and, generally speaking, the provisions made for its removal appear to be adequate. One objection that has been made to the working of the pillars is the apprehension of the breakage of the strata setting free a larger quantity of water than could be removed by the present appliances. I have given some attention to this, and am inclined to the opinion that much of the water met with in the dip workings finds its way there from the surface, and that if it were tapped in the upper workings a considerable diminution would be the result. For this additional reason I have advised the removal of the pillars to the rise of the water levels; and it is to the benefit in this respect which has been experienced at Lingan and Gowrie, to which I before alluded.

STORAGE OF COAL.

It may perhaps seem premature to cry "waste" at so early a stage of mining as the very recent development of the mineral resources of this country implies; but, at a time when attention is being directed in England to the exhaustion of her coal supplies, and the consequent necessity of economising them by every available means, it cannot, I think, be considered inopportune to direct attention to a source of waste which may with care, to some extent, be lessened.

In many of the collieries the greater part of the slack made in working is separated from the large coal by riddling, and thrown aside in the mine. The proportion thus taken out varies from 5 to 20 per cent. This slack is seldom removed, and has therefore largely accumulated, It is reasonable to suppose that if it could be sold even at a very small profit, it would not be left in the mine: and it is thus treated to avoid expense of depositing it on the surface, and the combustion that would probably occur if a large quantity were heaped together. By attention to the peculiarity of each seam, and the manner in which the miner performs his work, the proportion of slack made in the ordinary course of working may be reduced, and the loss of merchantable coal from this cause be diminished.

But there is another source of loss to which, inasmuch as it affects the revenue to a much greater extent, I wish to draw attention. I allude to the large stores of coal that are formed during the winter months. The suspension of shipment for a period of from three to four months necessitates the adoption of one of two courses: either the colliery must be stopped, or be continued at work and the coal brought out and stored on the surface. It must be evident that in the former case both employers and workmen would be subject to much inconvenience and loss: the workmen would be obliged to seek other means of employment, and the mine owner would be unprepared to commence operations on an adequate scale when the shipping was resumed. For this reason the latter course is adopted, and the consequence is a deterioration of the coal from exposure and the production of a large proportion of slack both from this cause and from the breakage in putting down and re-lifting. To such an extent does this take place that I have reason to believe that in some instances the produce of large coal from the heap has not much exceeded 50 per cent. When it is remembered that a large percentage has already been taken out in the mine, and that the coal brought to the surface is with respect to size in nearly a merchantable state, the loss of revenue from this cause must be apparent. Impressed with the importance of obviating this as much as possible, I have endeavored to induce the adoption of some means by which this loss may be reduced to a minimum, and I am hopeful that as the interests of the mine owner are seriously affected by so small a yield of saleable coal, they will readily adopt any practicable scheme for realizing so desirable a result. This would, I conceive, be to a considerable extent accomplished by an extension of the power of production by a judicious laying out of the mine, and the formation during the winter of a number of working places, together with the opening of more shafts or other means of bringing the coal to the surface. With such a provision much of the coal might be stored under ground and be raised as required without interrupting the ordinary working of the colliery. The injury to that portion which would be sent out of the mine would also be very much less if suitable erections were made for protecting it from the weather. There are details of arrangement in carrying this out which it is unnecessary to state here; I make the suggestion with the hope of drawing the attention of owners and managers of mines to the importance of devising some means of lessening a loss by which the interests of all are affected.

PLANS.

It is much to be regretted that some system has not been earlier organized by which an accurate representation of the workings would be preserved. In many instances I regret to find no record, either by survey or written description, of the first operations. The coal has been worked on the principle to which I have alluded, with no intention of returning to those parts of the mine in which operations have ceased. Being thus abandoned, and no care exercised in keeping the workings open, they are closed in many instances by the falling of the roof, and cannot, therefore, be shown on the plans with that degree of accuracy which is desirable. The importance of a knowledge of the position of old workings has been so often and painfully illustrated by the numerous accidents that have occurred in England from the absence of it, that I cannot too earnestly direct the attention of mine owners to a neglect that may hereafter be attended with serious consequences. These workings are generally near the crop, and liable therefore to be filled with water; and as the subsequent operations are not in all cases connected with them, the risk incurred from the ignorance of their position must, I think, be evident.

Most of the collieries have now plans of the workings. Some improvement is desirable in many of them with respect to the mode of showing the workings in different seams; but more especially would I recommend the adoption of one uniform scale for the variety which prevails at present.

I have the honor to be,

Your obedient servant,

JOHN RUTHERFORD,

Inspector of Mines.

To P. S. HAMILTON, ESQ.

Chief Commissioner of Mines.

NOTES

ON SAMPLES OF BRICK-CLAY FROM FORT GARRY.

BY

BERNARD J. HARRINGTON, Ph. D.,

CHEMIST AND MINERALOGIST.

Clays, as is well known, differ very considerably in their composition, and consequently in their suitability for the manufacture of different kinds of bricks. If we are desirous of making a brick of a refractory nature (fire-brick), we must select a clay consisting mainly of silica and alumina, and as free as possible from lime, oxide of iron and other bases which would form fusible compounds with the silica. Clays, however, which are to be employed in the manufacture of building-brick, may, in addition to the silica and alumina, contain small quantities of lime, oxide of iron, magnesia, potash and other bases, and yet be considered of good quality; indeed, a small quantity of protoxide of iron is looked upon as favorable, inasmuch as it promotes the strength and hardness of the bricks. But beyond a certain point these oxides (lime, magnesia, oxide of iron, &c.), are objectionable for different reasons; thus lime, or protoxide of iron, might make the brick too readily fusible, or the lime, which in the clay was combined with carbonic acid and which would on burning be converted into caustic lime, might cause the bricks to disintegrate on exposure to moisture.

Fat clays.

Clays which are free or nearly free from admixed sand or carbonate of lime are spoken of as *fat* clays, and are liable to considerable contraction and cracking on drying. The best way of counteracting this is by a proper admixture of sand, and the want of attention to this point appears, in some cases, to have been the cause of failure in the attempts to make brick at Fort Garry.

Loams and marls.

Mechanical mixtures of clay and sand constitute what are known as loams, while mixtures of clay and carbonate of lime constitute the so-called marls. If a loam contains the clay and sand in proper proportion it may be directly used for brick-making; but, from what has already been stated, it is evident that marls or marly clays are unsuited for this purpose.

Characters of the clays from Fort Garry.

The samples of clay from Fort Garry are from different depths from the surface, and are numbered accordingly; No. I. being a surface clay; No. II., 3 feet below I.; No. III. generally about 7 feet below the surface; and No. IV., 20 or 25 feet below the surface. All the samples effervesce on treatment with hydrochloric acid, owing to the liberation of the carbonic acid combined with the lime. This, however, is especially marked in the case of Nos. I., II. and IV., No. III. apparently containing a very small proportion of carbonate of lime. No. III. is of a light grey color, and, when dry, hard and breaking with a conchoidal fracture; when mixed into a paste with water it is more plastic and tenacious than any of the others. No. IV. is also somewhat hard and compact, its color being light bluish-grey. Nos. I. and II., on the other hand, are soft and friable, being of a decidedly marly character; they are both of a light-grey color.

All the samples are what are known as "red-burning clays;" that is, they contain protoxide of iron, which on burning is converted into the red oxide or peroxide. It will be observed that some of the accompanying samples of brick have barely any reddish tint, while others are of a deep red color. This is due to the different degrees of heat to which they have been subjected (some parts of the furnace being much hotter than others) rather than to any great variation in the amount of oxide of iron; for the difference, in some cases, is most marked in different bricks made from the same clay.

No complete chemical analyses of the clays have been made, as a chemical analysis does not always indicate the best proportions of clay. sand, &c., to be used. According to Muspratt, "it is nearly impossible to ascertain the applicability of any kinds of clay without a direct trial. Although the mode of occurrence, the color, the plasticity, degree of purity, property of effervescing or not with acids, may all help in enabling the brickmaker to form a correct opinion as to the nature of the clay, yet it is always advisable to obtain complete certainty as to the suitableness of the clay for the purposes desired, by *burning a few bricks by way of trial.* The cases are naturally not frequent in which clay is obtained with all the requisite properties, and it requires a *long series* of experiments to ascertain what proportions of *fat* and poor clay, sand and other substances, should be mixed together in order to obtain a brick-earth of the proper quality. If the clay is too fat the bricks will be denser than they should be, with too little porosity, and subject to bend and crack in the fire; if the clay is not fat enough the bricks will be soft and easily fall to pieces." Practical trials necessary.

With such considerations in view, I have made a number of small bricks containing different proportions of clay and sand from Fort Garry. The results will, I trust, be instructive and serviceable to the Fort Garry brickmakers. The sand employed was that sent with the clays, and was from two localities—Sturgeon Creek and Point Douglas. The dry clay was first ground, and then, with or without sand, as the case might be, mixed into a paste with water and thoroughly pugged. The bricks were moulded in a small wooden mould, dried for several days at a temperature of 212° F., and finally burned in the muffle of a cupelling furnace.

Duplicates were, moreover, made, and half of them soaked in water after burning, and then slowly dried. This caused many of those made from the more calcareous clays to crack and fall to pieces owing to the slaking of the lime. It should, however, be observed that this disintegration in no case took place when the bricks were made of No. III. clay with a proper admixture of sand.

Proportions of clay and sand used.

The following are the proportions of clay and sand used in my experiments, the numbers corresponding with those upon the accompanying bricks:—

(1) No. I. clay, without sand. Made light red bricks which were compact and firm, but would be improved by the addition of sand, as they are too soft and would not be durable.

(2) Equal weights No. I. clay and Point Douglas sand. Made red bricks, which, however, after thorough burning and soaking in water, cracked badly. The proportion of sand should be very much reduced, the clay not being a *fat* one.

(3) Three Parts No. III. clay and one part Point Douglas sand. Produced very excellent red bricks, which at a very high temperature were slightly glazed upon the surface.

(4) No. II. clay, without sand. When not sufficiently burned the brick had a yellow color and soon cracked badly. A brick burned at a higher temperature showed no tendency to crack, but was too soft and calcareous. Color pale red.

(5.) 1 part No. III. clay, 1 part No. I. clay, and 2 parts Sturgeon Creek sand. Gave red bricks, one of which cracked slightly after soaking in water. When thoroughly burned did not crack even after soaking. The same proportions of clay with 1 part or less of sand would probably give fair bricks.

(6.) No. 3 clay, without sand. This being a *fat* clay, as might be expected, when used without sand shrinks and cracks on burning.

(7.) 1 part No. II. clay and 1 part Sturgeon Creek sand. Light red bricks, one of which cracked very badly after soaking in water. Not more than ¼ the amount of sand should be used, if No. II. clay is used at all.

(8.) 1 part No. IV. clay and 1 part Sturgeon Creek sand. Gave good red bricks, not exhibiting any tendency to crack, even after soaking in water. In the event of coarser sand being employed a smaller proportion would be necessary.

(9.) No. IV. clay without sand. Too *fat*. Bricks perfectly worthless from cracking.

(10.) 3 parts No. III. clay, and 1 part Sturgeon Creek sand. Gave excellent red bricks, although they perhaps would not be so good as No. 3 where Point Douglas sand was employed.

(11.) 1 part No. III. clay and 1 part Sturgeon Creek sand. Gave good red bricks.

(12.) 1 part No. II. clay, 2 parts No. III. clay, and $1\frac{2}{3}$ parts Point Douglas sand. One of the bricks, after soaking in water, cracked very slightly. There are two causes for this cracking, (1) the presence of the No. II. clay, and (2) too large a proportion of sand.

(13.) 1 part No. I. clay, 1 part No. II. clay, and 2 parts Sturgeon Creek sand. Too calcareous and too much sand. Cracked after soaking in water.

(14.) 3 parts No. I. clay and 1 part Douglas Point sand. In one case a slight tendency to crack; too calcareous.

In the manufacture of bricks at Fort Garry I should recommend the use of the *least calcareous* clay (No. III.), together with Point Douglas sand; the sand forming about $\frac{1}{6}$ to $\frac{1}{4}$ of the mixture (supposing the clay to be dry.) If No. III. cannot be obtained in sufficient quantity, and the more calcareous clays have to be resorted to, either I. or IV. is preferable to No. II. Point Douglas, or similar sand, also, should be used ($\frac{1}{5}$ of the mixture say in the case of IV., and $\frac{1}{10}$ to $\frac{1}{6}$ of the mixture in the case of No. I., supposing the clay to be dry.)

While I recommend these proportions for trial, I think it quite possible that they may have to be slightly altered. Trials on the large scale and time, will alone decide this.*

It is evident that in the attempts to make bricks at Fort Garry the burning has not been properly attended to; for while the clays are all "red-burning clays," the memorandum accompanying them speaks of the bricks obtained from them as being white, showing that the temperature had not in any case been high enough. **Insufficient burning.**

Bricks, to be of good quality, must be thoroughly burnt. Those made from precisely the same clays will vary very considerably in appearance, as well as in strength and durability, according to the heat to which they have been subjected.

BERNARD J. HARRINGTON.

MONTREAL, May, 1873.

ANALYSES OF SERPENTINE FROM ABBITIBBE

and Green Mineral from Carboniferous Conglomerate New Brunswick.

The serpentine from an island in Lake Abbitibbe, mentioned page 6 and partly described by Mr. McOuat on page 128 of the present report, has since been more fully examined. It has a hardness of a little over 4 and specific gravity of 2.77. When treated with a mixture of equal parts of sulphuric

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* The small bricks above described are exhibited in the Geological Survey Museum.

acid and water it is almost instantaneously decomposed. Little black grains were left with the silica and found to consist of chromic iron.

Analysis gave,

Silica	38.48
Alumina	4.15
Protoxide of iron	9.24
Magnesia	35.73
Oxide of nickel	.28
Chromic iron	.51
Loss on ignition	11.60
	99.99

An examination of the green mineral in the Lower Carboniferous conglomerate at Harvey, N.B., and mentioned on pages 6 and 184, has also been made. It has a hardness of about 3 and specific gravity of 2.75. The colour is leek-green and the lustre dull,—in places sub-resinous. Before the blowpipe it whitens and fuses on the edges to a glassy white enamel. Sulphuric acid decomposes it, but only partially.

Analysis gave,

Silica	66.84
Alumina	19.66
Peroxide of iron	2.12
Lime	.34
Magnesia	.60
Potash	3.54
Soda	.06
Loss on ignition	5.66
	98.82

From the above it will be seen that this mineral resembles pyrophyllite in some of its characters. It is, however, harder and contains a larger quantity of alkalies and less alumina. Judging from its appearance and hardness, it might readily be mistaken for serpentine.

* Calculated as protoxide.