CANADA
DEPARTMENT OF MINES
MINES BRANCH
HON W. TEMPLEMAN, MINISTER; A. P. LOW, LL.D., DEPUTY MINISTER;
EUGENE HAANEL, PH.D., DIRECTOR.

REPORT

ON THE

IRON ORE DEPOSITS

ALONG THE

OTTAWA (QUEBEC SIDE) AND GATINEAU RIVERS

BY
FRITZ CIRKEL, M.E.

OTTAWA
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To

Dr. Eugene Haanel,

Director of Mines,

Department of Mines,

Ottawa.

Sir,—

I beg to submit herewith, a report on the iron ore deposits along the Ottawa (Quebec side) and Gatineau rivers, accompanied by an appendix containing valuable data on the water-powers of the district described, furnished by C. E. Gauvin, C.E., of Quebec, and by J. P. Brophy, C.E., and C. Keefer, C.E.—both of the city of Ottawa.

For much valuable information and many courtesies received, the writer is indebted to the owners of the various iron ore properties; also to you, Sir, and to Dr. I. T. Donald, of Montreal, for suggestions and kindly criticism in the preparation of the report.

Two maps, Nos. 53 and 54, indicating the iron ore occurrences of Ottawa and Pontiac counties, and Argenteuil county, Que., 1908, respectively, are to accompany the report.

I have the honour to be, Sir,

your obedient servant,

Montreal, March 12, 1907. (Signed) Fritz Cirkel.

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REPORT

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INTRODUCTION.

The following report is intended to summarize the results of an investigation of the iron ore deposits along the Ottawa river (north side), Pontiac county, and along the Gatineau river.

The basis of iron manufacture is, of course, the raw material from which the metal is produced. A study of the economic features of the ore deposits; their geological occurrence, their manner of development, as well as their most profitable exploitation, will serve to furnish the practical manufacturer with the necessary data for laying the foundation of a new industry.

It must be pointed out, however, that most of the iron ore deposits in the district under consideration have been known for a long period: some of them for over sixty years; and that the establishment of an iron industry has been attempted more than once. The question naturally arises, why have these attempts failed? What are the principal causes that led to the abandonment of the economic exploitation of these resources? An answer to these questions will be found in the present report: in which an attempt has been made to bring to light all the facts, with a view of enabling those interested, to judge impartially the true economic bearings of this very important subject. The facts presented afford a comprehensive view of the possibilities for the establishment of an iron industry in at least two places where iron ore of good quality, and in large quantities, is known to occur. That the earlier attempts at Hull and Bristol failed, due to adverse circumstances, is no reason why, under existing conditions, the industry cannot now be made a complete success.

In this respect, mention must be made of the success recently achieved in the smelting of iron ores by electricity. Many undeveloped water powers are found in the district under consideration—offering facilities for the generation of comparatively cheap electrical energy; and since a number of these are near the iron ore deposits, it is only a question of time when a great part of this "white coal" will be used, not only for the exploitation and concentration of the ores, but for the electro-thermic production of pig iron.

To establish successfully an iron industry a great many factors require to be considered. To produce pig iron—the basis of all subsequent stages of the industry—a very heavy initial expenditure has to be made: in prospecting, securing and developing mines, timber lands, limestone quarries, railways, shipping docks, etc., necessary to secure a constant supply of the raw material. Further, the establishment of the plant itself demands a very heavy outlay, much heavier in proportion to the output than is required for the production of any other article of commerce. The initial stage of iron making—as every iron manufacturer of experience knows—is of an experimental character, and since it must be conducted on a large scale, in order to make it profitable, the risk involved is manifestly great. It is believed the present report will be of some assistance and value to those who may think seriously of undertaking the exploitation of the iron ore resources in the district investigated, with a view to the establishment of a permanent industry. Interested parties are furnished with a plain statement of facts, as to the character, extent, and location of the deposits.

In comparing an examination of iron ore deposits with that of other metalliferous deposits, we find that there is a great difference; and this difference is based upon fundamental diversities between the products treated. In dealing with iron ores, we encounter minerals of low intrinsic value, widely distributed over the country, and frequently occurring in large bodies, the industrial value of which depends chiefly on factors not directly connected with the geology of the deposits; but on their chemical composition, and on transportation facilities, fuel, etc.

In the district investigated several deposits were found to be of such a promising character, that a detailed examination of their extent will be necessary by means of magnetometric surveys*; since in most cases, the overlying humus makes it almost impossible, by ordinary means, to determine their nature and extent.

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* See Report on the Location and Examination of Magnetic Ore Deposits by Magnetometric Measurements. By Eugene Haanel, Ph.D., Ottawa, 1904.

CHAPTER I.

HISTORY, LITERATURE, GEOGRAPHY, AND TOPOGRAPHY OF THE DISTRICT INVESTIGATED.

History and Literature.

The district covered by the present report extends from the city of Ottawa, along the Ottawa river, on the Quebec side, for a distance of over 100 miles, and from Ottawa, along both sides of the Gatineau river, to the town of Maniwaki, a distance of 83 miles, comprising a total area of approximately 900 square miles. In addition, several deposits have been examined near Buckingham, on the Lièvre river, and north of Grenville on the Ottawa river, half-way between Ottawa and Montreal.

The first recorded occurrence of magnetic ore north of Ottawa is probably a brief note on the Hull deposit, in a paper read by Lieut. Baddeley, R.E., before the Literary and Historical Society of Quebec, in the year 1830. The writer states that the deposit forms a vein, or bed, from 10″ to 12″ thick, and appears to traverse the mountain in a southwest course, having a vertical position as regards the walls of the vein. On the opposite side of the mountain, at a distance of nearly a mile, and in the direction of the vein, ore was again found in great abundance.

In the Geological Survey report for 1845, pp. 46-7, is a description of the Hull ore bed, in which the opinion is expressed that, "according to present indications the Hull ore bed must be considerable." In the same report, pp. 77-8, reference is also made to a deposit of iron ore on lot 2, concession i, township of Bristol. It is said there that "it consists of iron in the micaceous form, at the junction of a bed of white granular limestone, holding mica and pyrites, with overlying gneiss."

In the Geological Survey report for 1853, p. 38, Sir William Logan refers to an occurrence of iron ore in Grenville, on the north half of lot 3, range v. It was estimated that the breadth of the vein ranged from 6 to 8 yards. It was traced for 150 yards, in a westerly and southeasterly direction, the country rock being a micaceous gneiss, interstratified with many beds of quartzite.

In the Geological Survey Report of Progress for 1866, Sir William Logan describes the iron ore occurrences on lot 28, range vi, Templeton, which are now known under the name of the Haycock mines. He writes: "On a low ridge, about mid length of the lot, or rather south of it, there occur several isolated exposures of hematite iron ore. Five of these exposures are included in a square of 400 paces, in the northeast corner of the south half of the lot. In the whole of these the ore is very pure, being unmixed with any spar, and it often displays large striated faces, while in fracture it is fine grained, and of a steel grey colour." Sir William Logan also refers to other surface outcrops of iron ore on this property, as on lot 1, range xi, of Hull.

In the Report of Progress for 1866–9, page 255, Dr. Sterry Hunt has an account of the iron ore occurrences in Canada, in which he refers at length to the Hull mines, giving an exhaustive description of the smelting operations at that time carried on in the vicinity of Ironsides.

In the report for 1870–1, Mr. James Richardson gives a description of the country along the upper Gatineau, from its source to the mouth of Désert river.

In the Geological Survey report for 1873–4, Dr. Harrington made several references to the Hull ore bed, and the Bristol iron mines, on lots 21 and 22, range ii, township of Bristol. Of the latter mines he says: "The ore here forms a series of beds, with reddish syenitic gneiss, and glistening micaceous and hornblendic schists. Judging from the quantity of ore taken out, the thickness must be considerable. Besides this bed three others have been exposed by stripping; one of them was 2 feet thick, another only a few inches, but underlaid by occasional small lenticular patches of ore, while the fourth appeared to be about 9 or 10 feet thick, so far as the small amount of work done enabled one to judge."

In the reports for 1873–4, and 1876–7, Mr. H. G. Vennor enumerates the results of his investigations into the geology of the county of Pontiac: a part of the country drained by the Gatineau and Lièvre rivers, making special reference to the structural relations of the several divisions of the crystalline rocks. His labours included a study of the rock formations in the townships of Templeton, Hull, Lochaber, and Portland. Mr. J. F. Torrance gave a synopsis of the structural relations of the apatite-bearing members of the Laurentian, in the reports for 1882–83, and 84; finally, Messrs. E. D. Ingall and James White made an accurate survey of the important mining areas in the Buckingham district, in 1888 and 1889.

In the Report on the Mineral Resources of the Province of Quebec, by Dr. R. W. Ells, issued as part of the Annual Report of the Geological Survey, in 1890, the author gives a full synopsis of all that was known at that time, regarding the iron ores of the district north of Ottawa; he outlines the history of the mining industry from its inception up to that time.

Additional information, as to the geological formations in the region under consideration, will be found scattered through the reports of the Geological Survey, for 1892–93, 1899, 1895, 1896, and 1898. A report on the geology of a part of Pontiac and Ottawa counties, by Dr. R. W. Ells, appears in the Annual Report for 1899. A part of this report is devoted to the formations met with in the Hull, Buckingham, and Wakefield districts, also in the area between the Lièvre and Gatineau rivers.

Geography and Topography of the District.

The main streams which traverse the area under consideration are the Ottawa, with its three tributaries, the Black river, the Coulonge river, and the Gatineau river. Most of these, although having at places a succession of falls, are navigable for considerable distances—some of them for over 100 miles—while a great number of lakes situated in the immediate vicinity of these streams, can be reached by short portages. Nearly the whole country is easy of access, by good wagon roads, running mostly along the concession or township lines. The area tributary to the Gatineau is opened up by two roads, running on both sides along the river, as far as 200 miles from Ottawa. Numerous cross-roads, from these main arteries, tap the country farther back from the river; thus a cross-road was constructed several years ago from the settlements north of Maniwaki to the settlements on the upper Rouge river. A number of good colonization roads have been constructed of late into places which were previously unknown to civilization. These, in conjunction with the navigable small lakes with which the country is dotted, make the whole of the Gatineau country very easy of access. In addition to this, the Canadian Pacific railway runs along the western shore of the river, as far as Maniwaki. It is proposed to extend this line of railway, from its present terminus at Maniwaki, to Labelle, on the upper Rouge river. This extension will open up a very large portion of hitherto inaccessible country, which promises to render available a stretch of excellent farming land. The opening of these connecting links has made available a large number of areas in the Laurentian hills, which are underlain by the limestones of the Grenville series. Bands of the latter, some of them of considerable extent, can be found throughout the greater portion of the northern country, on the Gatineau river; and the excellence of much of the soil throughout this district is doubtless due to the decomposition of the calcareous members of the crystalline rocks. A great development of these crystalline limestones can be noticed on the east side of the river, in the townships of Low, Aylwin, Wright, Bouchette, and Maniwaki; while very extensive limestone bands, producing good agricultural soil, can be noticed on the west side, from the confluence of the Kazabazua, up between Thirty-one-mile lake and the river, as far as Kensington township. The agricultural character of the country west of the Gatineau is, to a great extent, due to the presence, in a number of places, of deposits of sand and clay, out of which the hills of granite or gneiss rise abruptly, sometimes in long chains of hills, sometimes in isolated masses.

As to the physical features of the country tributary to the Gatineau river, it must be said that the country north of the city of Ottawa is generally of a rugged character. Hills, and even mountains, of granite and gneiss, form a conspicuous part of the landscape, and some of them are very frequently of a steep and abrupt character. From North Wakefield, up to and beyond Low, a long chain of gneiss hills, some of them well wooded, form the border of the river, on both sides. They generally have a gentle slope towards the interior, while towards the river their aspect is abrupt and steep, the erratic courses of the roads and railway evidencing the difficulties arising from this cause. Tonguelike eminences, stretching out from the river and mountains, form intervening valleys, with good soil. Although the country has, at different times, been visited by large bush fires, and been otherwise denuded of its abundant vegetation, the mountains and hills appear to be all well wooded, for the most part with a second growth of timber. The country is traversed by a great number of small streams, emptying directly into the river, or into numerous small lakes. Farther to the northward of Low, on the west side of the Gatineau, the usually rugged character disappears somewhat, and the general aspect of the country—although there is a general increase in elevation—is that of a fairly level country, interrupted at intervals by gently rising hills.

The eastern border of the Gatineau, however, retains its general hilly character, as observed in the lower part of the Gatineau country; large stretches of agricultural land are a rare occurrence, but, instead of these, the intervening valleys are occupied largely by lakes. Two of these—Thirty-one-mile lake and Whitefish lake—form large, elongated stretches of water, over 20 and 30 miles long, with a northeast and southwestern course, approximately parallel to the Gatineau river. The lakes are fed by numerous small streams, and are bordered by high, well wooded hills. On account of their highly picturesque aspect, and being well stocked with trout, they are in great favour with sportsmen. Thirty-one-mile lake empties through several small lakes, and through Post creek, into the Gatineau, while Whitefish lake is drained by the Lièvre river.

The sand plains of Kazabazua form a prominent part of the generally level country, to the west of the Gatineau. The drift of these plains is mostly composed of a pure siliceous sand, and is often found to overlie a stiff blue clay. Rock exposures are seldom seen. Farther to the north these sandy plains disappear, and well wooded level plateaus take their place, interrupted by large stretches of agricultural land, and lakes, of which Blue Sea lake, with its many smaller tributary lakes, is the most important. Near the confluence of the river Desert with the Gatineau, the general aspect of the country is that of a rolling bench land, mostly representing good pasture and farming land, while here and there well wooded plateaus add considerably to the beauty of the landscape.

The Gatineau River.

The Gatineau river—the largest tributary of the Ottawa—is, according to the best authorities, about 260 miles in length; and drains, according to survey made by Hibbard and Carre, an area of approximately 9,000 square miles. This river—flowing through a valley bordered by hills of the Laurentian formation—with its many tributaries, large and numerous lakes, well wooded shores, swamps forming natural reservoirs, and storage grounds for its waters, is most admirably adapted for ensuring a constant volume of water. The impermeable rock which underlies the surface, the sand, the gravel and the clays of the drift, all favour the formation of springs, which, together with the numerous lakes and storage reservoirs, render the various minor streams, and in consequence the main stream, steady, and but little affected by droughts. The general course of the river, from the confluence with the Désert river, is south, although some deviations from this trend may be noticed; due to the erratic course of the mountain ridges. The elevation of the river bed, 38 miles from Hull, over sea level, is 134 feet; while at the confluence of the Pickanock river, about 50 miles distant, it is 480 feet, and at Maniwaki 561 feet, being a difference of elevation, between Hull and Maniwaki, of 372 feet.

Above the confluence with the Désert river, the Eagle river is the largest sub-tributary, running with its narrow, swift course, through a number of sandy and marshy plains. It flows in a general northeast direction, draining several lakes, in the township of Church, and adjacent township of Pontiac, and empties into the Désert river, about 15 miles from the junction with the Gatineau, in the township of Egan. Before the junction with the Eagle river, the Désert river drains Round lake, in the north, flows thence in a northeasterly direction, over Laurentian gneiss, untill it takes its long course, in a southern direction, to its junction with the Gatineau.

Amongst the other tributaries of the Gatineau may be mentioned the Gens-de-Terre, which drains a chain of lakes, in the township of Baskatong; also Baskatong creek, which drains Baskatong lake.

The course of the Gatineau, below the town of Maniwaki, is due south, until it reaches a point 20 miles distant, north of Bittobi lake, between the townships of Northfield and Wright. The most important drainage area lies to the east of the river, where the large Thirty-one-mile lake empties through a chain of small lakes, and finally through Post creek, into the Gatineau river, about ten miles below Maniwaki. To the west of the river a number of small lakes, the largest of which is Blue Sea lake, serve as drainage areas in that part of the country, and empty through a small creek into the Gatineau.

The river below Maniwaki is characterized by its nearly straight southern course, its even flow, and comparative narrowness. With the exception of the Six rapids, about 6 miles above the village of Gabriel, there are no falls, or water powers. A part of the Six Rapids "white coal" has been developed, and furnishes light and power to the villages of Maniwaki and Désert.

From Bittobi creek the river flows due west for 5 miles, when it turns again to the south, and continues in a tortuous course. The first principal tributary is the Pickanock river. This river drains a number of lakes, in the townships of Alleyn and Aylwin, has a general northeast course, and empties into the Gatineau near the town of Gracefield. Another stream which empties into the river is the Kazabazua, which drains the mountainous territory in the south of Aylwin, and the northern part of Low. Below the confluence with the Kazabazua the river follows a tortuous course, occasioned by the high bordering hills on the east side of the river. Below

Aylwin the Gatineau river is very rough for several miles, being broken by a number of rapids and falls. In the township of Low, near Low station, the Paugan falls form the most conspicuous part of the beautiful landscape. These falls have a height of 60 feet, and, on account of their splendid natural location, present great facilities for water power development. From this point to beyond the village of Wakefield the current is smooth and the passage easy. About half way between this village and Kirks Ferry the Cascade rapids, with a total head of 12 feet, are capable of developing great water power for industrial purposes.

Farther down the river, the falls between Kirks Ferry and Ironsides village are worthy of note. In a distance of only 6·63 miles, between Eaton chutes and below Kirks Ferry, they represent a difference in elevation of the water levels of 160·87 feet. This makes a fall per mile of 24·26 feet. From Wright Bridge, above the village of Ironsides, to Eaton chutes, the distance is 5·49 miles, and the difference of elevation in this distance being 154·46 feet, the total fall per mile would be 28·13 feet. This very rapid rate of fall, of over 28 feet per mile, indicates the great possibilities of the river for power development.

In summarizing the results of an investigation into the possibilities of power development on the Ottawa river for industrial, and especially mining purposes, one cannot fail to be impressed with its general topographic and geologic characteristics, its favourable climatic conditions, the low temperature, large rainfall, and small evaporation, the immense facilities for storage, the extensive forests, and an absence of destructive freshets. All these combine to place the Gatineau river in the front rank as a water power stream. This is further evidenced by the difference in elevation of the river level between Hull and Maniwaki. About 3·8 miles from Hull the elevation over sea level is about 134 feet, at Pickanock river, 55·9 miles from Hull, it is 480 feet, and at Maniwaki, a distance of 82 miles from Hull, it is 561 feet; the fall of the river between these two towns being, therefore, 427 feet. On account of the importance of the available waterfalls for power development, the details regarding the larger ones are laid down in a special report, which will be found in the appendix.

In addition to these data, a number of elevations are given in the following list, which have been taken from Mr. James White's book, entitled: "Altitudes in Canada."

Ottawa and Gatineau Railway.

Miles from Hull—

0·0	Hull, junction with Canadian Pacific Railway main line, 118·3 miles from Montreal	189	feet.
3·1	Ironside station	182	"
3·8	Stream, bed 134; rail	194	"
6·5	Chelsea station	365	"
7·0	Summit, rail	395	"

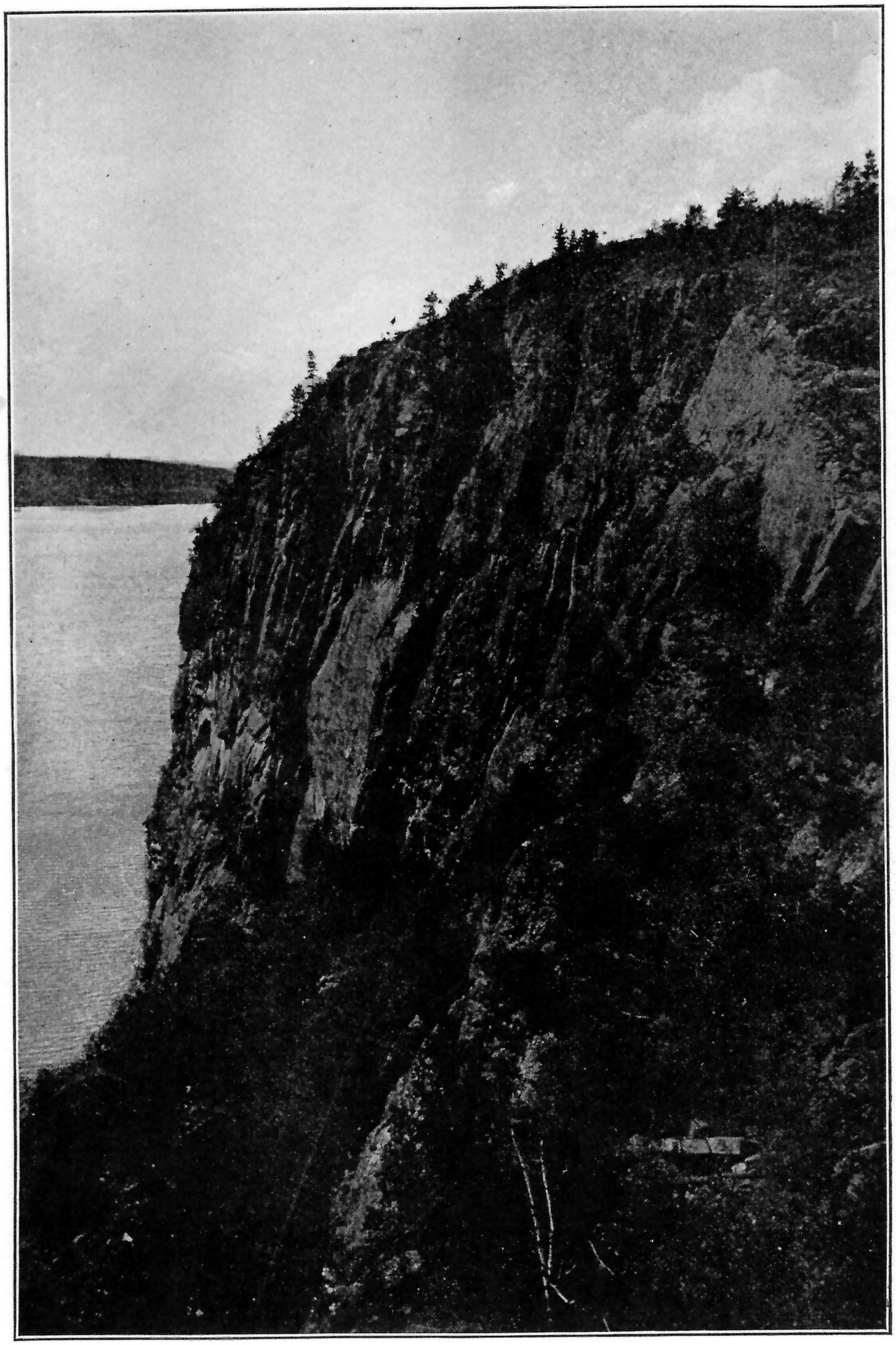
8·7	Depression, rail	288 feet.
10·3	Kirks Ferry station	294 "
10·7	Bay of Gatineau river, water, 286; rail	296 "
12·8	Summit, ground, 365; rail	363 "
14·0	Cascades station	304 "
15·8	Patterson creek, water, 305; rail	317 "
19·0	Rockhurst station	327 "
19·5	Peche river, water, 306; rail	328 "
19·8	Wakefield station	326 "
22·2	Indian creek, water, 318; rail	333 "
23·0	North Wakefield station	335 "
25·7	Bay of Gatineau river, water, 322; rail	341 "
28·1	Farrellton station	345 "
31·5	Brennan station	365 "
31·7	McGoey brook, water, 327; rail	360 "
32·6	Stag creek, bed, 320; rail	345 "
33·4	Low station	415 "
34·7	Brook, water, 407; rail	446 "
35·8	Summit, ground, 545; rail	530 "
37·2	Ryan creek, water, 443; rail	469 "
39·6	Venosta station	534 "
44·9	Kazabazua creek, bed, 517; rail	561 "
45·0	Kazabazua station	571 "
45·3	Summit, ground and rail	599 "
47·1	Aylwin station	493 "
51·5	Marks Cross station	595 "
53·6	Brook, water, 507; rail	515 "
55·9	Pickanock river, water 480, bed, 469; rail	509 "
57·6	Gracefield station	507 "
60·6	Summit, ground, 617; rail	612 "
63·1	Castor creek, bed, 571; rail	575 "
67·0	Blue Sea lake, high water, 537; water, (March, 1895), 533; rail	549 "
70·0	Station ground	571 "
71·3	Summit, ground, 644; rail	632 "
73·0	Brook, bed, 574; rail	582 "
74·3	Station ground	558 "
75·5	Brook, bed, 564; rail	585 "
80·6	Desert, station ground	561 "

Topography of the Southeastern Part of the County of Pontiac Along the Ottawa River.

Commencing with the township of Sheen, about 15 miles west of the town of Pembroke, on the Ontario side, the country north of the Ottawa river, which is nearly all taken up by the Laurentian formation, presents an aspect of alternating character. While at some places sandy beaches, and flat land, extend from the river, for a number of miles into the interior country, at others the shores of the river are rocky and precipitous, and give a clear indication of the geological nature of the various rock formations, throughout the greater part of the country. In the township of Sheen, a high precipitous mountain range may be seen, striking through the country in an easterly direction, and having its western terminus at Oiseau rock, on the Ottawa river, about 16 miles west of Pembroke. This mountain range, with a few interruptions, can be followed through nearly all the townships bordering on the Ottawa river, and has its last outlyers in the townships of Eardley and Hull.

In the aspects of its relief this whole Laurentian country is a somewhat uneven plateau, bordered to the south by the Ottawa river, and rising gently to the chain of mountains above referred to. Its landscape, except that of the lower lands near the Ottawa river, is of a pronounced type, which, while lacking the beauties of high mountain regions, and the reposeful tranquility of well cultivated lowlands, has a certain rugged character of its own, and may readily be distinguished as such, especially when covered with the bright, autumn foliage. The depressions in its surface are generally filled with drift forming flats, in which can be found many picturesque lakes of clear water. Drainage is provided for by a great many creeks, and several rivers, all emptying into the Ottawa river, the largest being the Coulonge, and Black river, in the townships of Waltham and Mansfield. Much of the country in these townships, and farther west in Sheen and Chichester, is taken up by well wooded, hilly, and to some extent mountainous land, and contains only intermediate strips and flats of land for agricultural purposes; but the country farther east of Mansfield, as far as Eardley and Hull, although occasionally interrupted by chains of hilly ridges, presents a more even plateau, in which large stretches of agricultural soil, dotted with numerous settlements, alternate with rocky, tongue-like eminences, for the most part covered with good timber. A great number of sandy plains extend along the Ottawa river, especially in the townships of Clarendon, Bristol, and Onslow. Some of them, particularly in Bristol, are covered with good timber, especially cedar.

As a result of the natural physical conditions, the region under consideration is easy of access. A great many colonization roads have been constructed, and by these means, large areas, formerly difficult to reach, can now be traversed with ease. One of the oldest colonization roads in the country is the one which leads from Aylmer, past the village of Quio, through the lower sections of the townships of Bristol and Clarendon, to the town of Bryson, in Litchfield. In addition to this main road a great many cross roads have been constructed in recent times; hence it may be said that this part of the Pontiac region is one of the most accessible districts in the Province of Quebec. In addition to these arteries, the Pontiac Pacific railway, now a branch line of the Canadian Pacific railway, starting from Ottawa, affords accommodation in reaching quickly the principal villages and towns of the region.



Oiseau Rock, Ottawa River: 20 miles west of Pembroke.

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North of the great chains of hills, extending in an east and west direction, the country is undulating in character; though hills, and even mountains, not, however, exceeding 1,000 feet in height, are a more frequent occurrence. On account of its well wooded, rocky nature, the country in general is not easy of access; while the roads, through the intermediate valleys, have a very erratic course. The uplands of this region consist of rather level-topped elevations, or ridges, which separate the valleys; in fact the whole surface may be considered as an undulating, well wooded plain, which slopes to the north. Above the plain rise scattered mounds, and in it have been cut numerous valleys. The general features of this country may be seen from the tops of the mountain ranges, separating it from the southern, or river part.

The Ottawa River.

What has been said regarding the general physical aspects of the Gatineau, may also be applied, to some extent, to the Ottawa river. But the drainage area from the township of Sheen, down to the city of Ottawa, is comparatively much larger than that of the Gatineau, owing to the fact that there are two large tributaries—the Black river and Coulonge river—each of them over 100 miles in length, and these drain a large number of lakes in the interior, farther to the north.

Taken as a whole, the course of the Ottawa river is a very tortuous one, while the character of the shores is determined, in most cases, by the underlying rock formations. From Fort William, in the township of Sheen, down to Petawawa, on the Ontario side, the river represents a large lake, dotted with numerous small and rocky islands, mostly composed of syenite. At Petawawa the river splits up into two channels, a northern, called Culbute channel, and a southern, forming between them the triangular shaped island of Allumette. In the north, or Culbute channel, a heavy rapid is overcome by a lock, while in the south, or Pembroke channel, the navigation is interrupted by the Allumette rapids, about 3 miles below the town of Pembroke. This, however, can be traversed by steamboats, at certain seasons of the year.

Above the town of Pembroke the river is navigable, and in the summer a steamboat plies between Des Joachims rapids and Pembroke, a distance of about 40 miles. Below the Allumette rapids the southern channel commences its northern course, and joins the northern channel at a point below a chain of elongated shaped islands, which form between them a number of rapids, called Paquette rapids. Near the junction of the two channels, the Black river empties into the Culbute channel. This river has a very tortuous course, flowing, as it does, for a great part of the way through banks of sand, with a steady current of several miles per hour. Even when the water is low, rapids occur at frequent intervals, necessitating a number of portages, some of which are very difficult. The greatest of them is past the Long rapids, 60 miles from the mouth, where a portage of 3 miles is necessary, over the spur of a mountain.

With its many tributaries, its large lakes farther back in the interior, and its well timbered shores, forming great storage grounds for its water, Black river ranks amongst those streams which ensure a bountiful and constant supply of water. Near its junction with the Culbute channel, about one mile from the town of Waltham, there is a rapid change of level, giving rise to the formation of the beautiful Waltham falls. These falls are now being developed for the production of electrical energy, and the town of Pembroke will be supplied with power and electric light from this source. The country between the Black and Coulonge rivers, south of Forans creek, and its chain of lakes or streams, is, on the whole, rugged and very hilly.

After the junction of the two channels, the Ottawa river, for about 8 miles, takes again an eastern course. Many small, but well wooded islands, are a prominent feature of this part of the river. About two miles west of the village of Fort Coulonge the Coulonge river empties into the Ottawa. This river is over 100 miles long, runs from its source in a southeastern direction towards the Ottawa, and, owing to its numerous connexions with a great number of large lakes, has a very extensive drainage area. It is used principally as a means of transportation of timber, which is being cut, at the present time, in the numerous timber limits traversed by the river.

In the township of Mansfield, on range iv, the Coulonge River falls may be noted. These falls, which cut through narrow gorges of high and rough declivities, present a beautiful scene. Looking at the immense volume of water carried over these cliffs, one may wonder why they have not ere this been utilized for power development.

A part of these falls has been diverted into an immense timber slide, which forms the connecting link for the transportation of timber, between the upper Coulonge and the Ottawa river.

From the village of Fort Coulonge, the Ottawa river takes an approximate southeastern course, for about 20 miles, until it reaches a point about 3 miles below the village of Portage du Fort. Compared with that part of the river, and its channels above the junction of the latter, the entire stretch from Fort Coulonge, to the point above mentioned, affords a different aspect. The river becomes much narrower; the shores, for the most part, represent a rolling beach land, or well wooded hilly ranges, sometimes of mountainous character, and low plains, or sandy beaches, become rare. Numerous islands, most of them covered with a second growth of timber, impede the rapid course of the river, and form, at places, deep, narrow gorges, dangerous to navigate. Three miles below the village of Fort Coulonge the Ottawa divides into a southern—Roche Fendu, and a northern—Calumet, channel, forming the island of Calumet. Owing to the rugged and broken character of the country, rapids and falls are numerous, the more important being the Roche Fendu, in the southern, and the Calumet falls in the upper channel, below the village of Bryson; and also the falls near the village of Portage du Fort.

From this village the river takes a southeastern course for about 20 miles, until it reaches the islands in Chats lake. Below Portage du Fort the Cheneaux rapids may be mentioned. The river widens out, at some places for several miles, and its shores do not exhibit a hilly or mountainous character; they are for the greater part composed of well wooded, low plateaus, or sandy beaches, while the river itself has more of a straight course. From Chats lake the river takes a north-westerly course for about 10 miles. A number of islands divide its flow, below Chats lake, into several small channels, which give rise, in connexion with the rocky river bed, to the formation of Chats falls; between Pontiac village, on the Quebec side, and Fitzroy harbour, on the Ontario side, the largest and most powerful waterfall on the Ottawa river: a detailed description of which will be given in the appendix. From Chats falls to Britannia bay, on the Ontario side, the river does not present any noteworthy features. It is very wide—at some places several miles—and its shores are mostly composed of sandy beaches, or wood covered low-lands; no islands are met with, and for the whole length there is no serious difficulty to river navigation. Below Britannia the shores of the river approach each other, the flow of the river becomes swift, and at some places turbulent; rapids are met with at several places, and immediately west of the city of Ottawa the famous Chaudiere rapids are a conspicuous feature.

In the following table a number of elevations of the Ottawa river, and inland points, over sea level, are given. They have been compiled from Mr. James White's book, "Altitudes in Canada" :—

PONTIAC PACIFIC JUNCTION RAILWAY.

Miles from Ottawa.			
0.0	Ottawa, Central station	212	feet.
0.4	Ottawa river, highest water recorded (May, 1896) 149·5, high water (May 8, 1899) 145·5; lowest water recorded (Sept. 28, 1881) 124·6; average low water, 128·3; bottom of bridge, 181·4; base of rail	189·7	feet.
1·7	Hull station	163	feet.
7·2	Deschenes station	198	"
9·8	Aylmer	217	"
11·0	Brook, water, 216; rail	224	"
17·4	Breckenridge creek, water, 201; rail	214	"
17·5	Breckenridge station	215	"
19·2	Ferris creek, water, 201; rail	212	"
20·8	Tremblay creek, water, 204; rail	211	"
23·3	Eardley station	215	"
25·1	Parker crossing	232	"
28·8	Mohr creek, water, 214; rail	226	"
32·0	Mohr station	226	"
32·9	Quyon station	275	"
33·6	Quio river, high water, 242; low water, 239; bed, 234	282	"

35·9	Bristol Mines junction	393	feet.
40·1	Bristol mines, end of spur	314	"
36·0	Wyman station	394	"
39·4	Tank, bed of stream, 450; rail	468	"
40·1	Bristol station	477	"
42·8	McKee	521	"
46·6	Shawville	527	"
47·6	Summit, ground, 614; rail	610	"
50·9	Clark station	588	"
55·0	Clark creek, bed, 491; rail	503	"
57·0	Stevenson creek, high water (1878), 351; ordinary high water, 349; low water 339; rail	354	"
57·8	Campbell Bay station	361	"
61·5	Franktown creek, bed, 355; rail	363	"
62·3	Vinton station	367	"
64·3	Bernard creek, high water, 358; low water, 350; rail	371	"
69·1	Coulonge station	361	"
70·9	Coulonge river, extreme high water, 353·5; ordinary high water, 349·5; low water (October, 1886), 338·5; rail	366	"
76·6	Mellon station	365	"
80·4	Waltham	367	"
80·7	Ottawa river at Waltham, ordinary high water, 353; low water (Sept. 30, 1887)	340	"
104	Bay of Ottawa river near Pembroke	368	"

Forest Conditions.

In its primeval state, the southern part of the county of Pontiac, and the country tributary to the Gatineau river, was a vast forest of magnificent timber. The lumberman's labours were first directed to getting out the pine; both because of its high value, and because of the fact that it could be floated down stream to the market. But the amount of pine timber is limited, and its production, in the region under consideration, is waning every year. Its place is being taken, to a large extent, by hard wood timber: cedar posts and poles, hemlock lumber and bark. The changes which have been wrought annually by the lumberman's axe, and the succeeding forest fires, which swept over the country from time to time, destroying everything in their path, have been very considerable. The once popular belief that the whole country, especially along the Gatineau river, was worthless after the loss of its dimension timber, has given way to a general confidence in its agricultural and mining possibilities. This is amply evidenced by the rapidity with which these lands are being opened up by farmers, and to some extent by miners, and by their rapid rise in market value. It is only fair, however, to also call attention to the fact that, large areas of the original timber, consumed by forest fires, have been replaced by a second growth of both soft and hard timber, most of it in the form of dense thickets, which shade and protect the ground more effectually than the original forest.

As to the supply of fire wood, or timber, for mining and iron smelting purposes, in the region under consideration, it may be safely said that, owing to the peculiar physical character of the surface, conditioned by the occurrence of the various members of the great Laurentian formation, abundance of good timber is found nearly anywhere, where mining has a chance to take a foothold. Well cultivated plains, and sandy lowlands, alternate with hilly, or even mountainous ranges, and as they are almost everywhere densely covered with a second growth of timber, and as nearly all the mines have been discovered in just such hilly or mountainous parts of the country, it is safe to say that the supply of wood is abundant, at least for some time to come.

CHAPTER II.

GEOLOGY OF THE DISTRICT. DISTRIBUTION OF FORMATION.

The county of Pontiac, along the Ottawa river, and the country along the Gatineau, display principally the Laurentian formation, the great central nucleus around which the Silurian was subsequently deposited. A small area, extending about 4 miles north, and 12 miles west, from the city of Ottawa, is taken up by the lower Silurian rocks, which also occupy small stretches inland from the shores of the Ottawa river farther west.

In order to convey a better understanding of the character of the iron ore deposits, and their relation to the enclosing country rocks, it has been deemed advisable to deal first with the geology of the area under consideration. As the writer was commissioned only to investigate the iron ore deposits proper, it was necessary, in order to make this report as complete as possible, to take advantage of the results of the investigations made by H. G. Vennor, J. F. Torrance, and Dr. R. W. Ells, of the Geological Survey, covering a period from 1873 up to the year 1899, and published in the reports of the Survey. These are supplemented by a number of observations made by the writer, during the field work, in the year 1906.

For the sake of convenience, the writer has divided the district into several portions, which will be described in order, proceeding from the west. These portions will embrace:—

(1.) The western division, including the townships of Sheen, Chichester, and Waltham, to Coulonge river, and the island of Allumette.

(2.) The centre division, from the Coulonge river, along the Ottawa, to the boundary line between the counties of Pontiac and Ottawa.

(3.) The Gatineau division—that part of the country immediately tributary to the Gatineau river, from the town of Hull, to Maniwaki, a distance of about 85 miles.

The Western Division.

This division embraces—apart from a small portion of the lower Silurian on Allumette island—the great series of crystalline rocks, which are, at places, intricately contorted, interrupted, and dislocated by faults. These rocks consist of a great volume of granitic and hornblende gneisses, and schist, with important bands of quartzite and hornblende slate. In addition to these we find a large development of pale, and sometimes fleshy coloured syenites, which are conspicuous on account of their coarse character. In the western part of this division, in the townships of Sheen and Chichester, pegmatite and quartzose dikes are frequently encountered, while a fine grained diorite, sometimes highly mineralized, composes the main constituent of the eruptives.

On ranges ii, iii, and iv, Chichester, there is a great development of hornblende rocks, from pale coloured, coarse syenites up to nearly pure hornblende. The general strike of the formation, in that part of the country, is about N. 80° E. with occasional variations. On lot 49, range iii, there are indications of magnetic iron ore in a syenite. Thus far only small disseminations of the ore have been found, and no further development has been attempted.

Granitic gneiss, with a northwest course, and dikes of pegmatite, are also abundant; while quartz, and quartzose rocks, are frequent, cutting at places the formation at right angles.

Dikes of a fine grained mica diorite have been noticed on range ii, between lots 47 and 50, of the same township. These dikes are, as a rule, heavily impregnated with iron pyrites, and phlogopite mica. The country rock is granite. Impregnations of magnetic iron, but of no economic value, have been noticed, near the contact with the dioritic dikes.

On lot 12, range vi, township of Sheen, a dike of pegmatite cuts through clearly stratified granitoid gneiss, and contains small pockets and bunches of magnetic iron ore, with a fine grained intermixture of iron pyrites.

The district traversed by the Black and Coulonge rivers is largely occupied by flesh coloured granite, and gneiss. The latter is sometimes greyish and hornblendic, and occasionally garnetiferous. Bands of crystalline limestone are well exposed along the lower 40 miles of the Black river, and similar bands occur along the Coulonge, as far as the 70 mile post from its mouth. The general strike of the gneiss and limestone in this area is N. 30° W., but this is frequently deflected by other granitic intrusions. The upper parts of these streams flow through a comparatively level country, largely covered with sandy drift, which is, in places, underlain by clay. Isolated masses of reddish granite rise here and there, but this portion of the country is much less rugged than that nearer to the Ottawa. The country between the Black and Coulonge rivers, south of Forans creek, and its chain of lakes, is generally rough and hilly. No limestone has been discovered in any of these lakes or streams, or along the portages. The character of the country to the north is mostly undulating, with open valleys and sandy plains between. On Bryson lake, cliffs of greyish quartzose gneiss occur, but no limestone.

The most extensive crystalline limestone belt met with is that occurring about four miles north of the Ottawa river, on the Coulonge river, between ranges A and B, in the township of Pontefract. These limestones strike in a northwesterly direction, with a dip of 45° to the northeast. A section through the formation, in a southward direction from the Coulonge, and through Mansfield, shows that these limestones are underlain in succession by a belt of gneiss, composed of red granitoid gneiss, dark greenish hornblendic gneiss, and slates; also whitish gneisses, abounding in quartz and feldspar. This belt of gneisses is again underlain by flesh coloured quartzites, quartzose strata, with crystalline limestone, the latter carrying sometimes pyroxene, serpentine, graphite, and apatite.

The lowest part of the section is composed of red and grey, thin-bedded and clearly stratified, granite and hornblendic gneisses. The dip of this whole section is northeast, and lessens considerably as we descend, until in the lower gneiss the incline is seldom more than 10° or 15°. The quartzose strata, with the pyroxenic limestones, above alluded to, continue westward from the Coulonge river. On this course the strata run through into range B of Pontefract, and continue on the west side of the Coulonge river, which, coinciding with the general run of the formation, has a northwestward course. Samples of magnetic iron ore, in a matrix of a coarse crystalline limestone, were shown to me, when travelling through that part of the country; and in comparing the specimen with the limestone just described, I infer that, as the location from which the ore was taken was not known, the same must have come from this limestone belt. Strictly speaking, the formation above referred to is composed chiefly of coloured quartzites, and a variety of quartzose rocks, while the limestone forms only a small part of the whole series. The limestone is very coarsely crystalline, and large portions are of a flesh red colour. Metalliferous matter can be noticed, in parts lying nearest to the quartzites, and, upon closer examination, graphite, and magnetic iron, both of them in a finely disseminated form, are recognized.

Serpentine and pyroxene, also crystals of apatite, are frequent occurrences in the limestones, but so far the latter has only been found in very small quantities. Serpentine and pyroxene can be seen forming small rounded boulders, and, taking the whole aspect of this crystalline limestone into consideration, it appears that the geological structure of this portion closely resembles that encountered in the Templeton and Buckingham districts; where apatite, or phosphate of lime, has been mined extensively for years. Other characteristics of these crystalline limestones are, the occurrence of a conglomerate, or breccia, of silver white mica, and biotite, in minute scales, of bands of pyroxene of a greenish and faded colour, and of rust coloured quartzites. Some of the limestones are of the fine grained varieties, and are of magnesia, or dolomitic, character.

In the lower portion of the Coulonge river, between ranges ii and v, the shores exhibit a succession of gneissic and syenitic strata, which also make up the high mountain range striking through this country in a northwesterly direction through Waltham, Chichester, and Sheen, terminating at Oiseau rock, on the Ottawa river. The gneiss, for the greater part, is clearly bedded, and nearly everywhere dips at a low angle. In some places it is nearly horizontal. The mountainous character gives rise to several splendid water powers; for instance, the great falls on the Coulonge river, on lots 8 and 9, range iv, Mansfield, and those of the Black river, in the immediate vicinity of the village of Waltham, not far from the confluence with the Ottawa river. In the vicinity of Waltham the rocks are a belt of gneiss of varied colours and characters; dark greenish hornblendic gneisses; also the fine grained whitish varieties, abounding in feldspar and quartz, and red granitoid gneisses, sometimes with obscure stratification. Most of the gneisses are contorted and twisted, and this is principally due to the presence of pyroxenic dikes; small patches of crystalline limestone have been observed, but their extensions seem to be of local character only. Flesh coloured calcite is frequently met with, in conjunction with pyroxene, and the formation closely resembles, as already stated, that of the apatite bearing belt in Templeton and Buckingham. On the road towards the village of Chapeau the formation seems to change somewhat. Instead of dark greenish hornblende, and pyroxenic gneisses, flesh coloured granitoid, and syenitic rocks, constitute almost the entire shores of the Culbute channel of the Ottawa river, especially round the village of Chapeau, on Allumette island.

South of Chapeau the character of the rocks changes entirely. The Laurentian formation is overlaid, almost in the whole of Allumette island, by lower Silurian limestones, Chazy, Birdseye and Black River. The typical Black River occurs at Paquette rapids, many of the beds being filled with fossils of that formation, which are beautifully preserved. Much of the island is low, and large areas of sand and bog occur inland. The northwest portion is mostly composed of syenite.

Above Allumette island, opposite the mouth of the Petawawa river, a brick red syenite is very extensively developed, and the same rock forms also a number of islands in Allumette lake. This red syenite does not, as a general rule, form a hilly country, but rather extensive sandy plains, in which often no rock is seen for considerable areas. It continues to be displayed along both shores of the Ottawa river for some distance beyond the upper Allumette lake, still forming a low lying, flat country; while immediately along the northern shore come in the mountainous ranges of gneiss, apparently resting on the syenitic formation, dipping inwards, or to the northward, at low angles. Generally speaking, the course of the gneissic rocks along the north shore of the Ottawa, in the section under consideration, is, with the main Ottawa valley, approximately northwestward. However, they describe a number of undulations, the local strikes alternating from the northeastward to the northwestward. It is possible that some of these undulations have carried the gneissic rocks across the Ottawa river, and beyond Oiseau rock both shores are taken up by gneissic strata.

The Centre Division.

The geological structure of this part of the country is somewhat different from that of the western division, in that crystalline limestone belts, some of them of large extent, both as to width and length, are more conspicuous. Thus, commencing with the country east of the Coulonge river, we have the great limestone belt, which strikes along the township line between Litchfield and Mansfield, on ranges i and ii of the latter, then taking a northeastern course over lots 4 and 5, range ix, and of lots 8, 9, and 10, range x, Litchfield, in proximity to Bernard creek, which in the last named lots runs parallel with the range line. Farther to the east this limestone belt apparently terminates, and drift covered lowlands, in the vicinity of the lake in range x, take its place. From lots 8, 9, and 10, in the last named range, the creek above referred to runs round a spur of mountains, composed of dark greenish, hornblendic gneisses, abounding in feldspar and quartz, and also of coarse grained pale and flesh coloured syenites. The dip of the gneiss, as observed in various places, is 50° to the westward, its strike N.W. 10°. It is on this gneissic syenitic range, just on the line between lots 4 and 5, on the slope of the mountain, where magnetic iron ore, in apparently large pockets, has been discovered. The hilly character of the country gives rise to quite appreciable water falls in Bernard creek, on lot 5; but up to this time they have not been utilized. Near these falls, the contact of the gneiss with the crystalline limestones can be noticed, and followed for quite a distance. From lot 5, range ix, Bernard creek takes a southwesterly direction. The limestones are entirely lost sight of beneath the great accumulation of sand, which here follows the creek. The drift sand extends not only past the mouth of the Coulonge river, but occupies nearly the whole front of Mansfield. It also turns upon itself, and runs along the shore of the Calumet channel, in a general southeasterly direction. It is likely that the Litchfield limestones, above referred to, follow this course of the sand drift also, because on a portion of the shore, in range iv of this township, they are again exposed, and overlie a belt of gneiss, of various colours and compositions. This gneiss strikes in a northwesterly direction through the country, dipping at an angle of 50 degrees to the southwestward. The character of this gneiss, its dip and strike, coincide exactly with that found near Bernard creek, on lot 5, range ix, Litchfield, and we may, therefore, conclude, that the strata in both localities belong to the same geological horizon. These same gneissic rocks set through to the banks of the Coulonge river; and the greater part of them may be said to occupy the country from range ii, in Mansfield, up to the township of Pontefract.

The centre, and eastern part of Litchfield, form continuations of the gneissic strata encountered on the banks of the Coulonge river; and along the upper course of Bernard creek. The great mountain ridge, which strikes through ranges viii and ix, in a northwesterly direction, seems to divide the townships into a southern and northern area. The southern area, along the Calumet channel, is occupied by sandy drifts and plains. Natural rock exposures are not frequent. Those in evidence, as well as small pits and crosscuts made in the course of mining operations, seem to point to the fact that, the rock formations, which underlie the long sand beaches, are mostly hornblendic, though frequently interstratified with grey gneissic strata. All of these rocks have nearly the same strike and dip as those observed in the western part of Litchfield. Magnetic iron ore, of excellent quality, but in apparently limited quantities, has been found in the northern parts of range v, in a coarse grained, pale coloured syenite. Impregnations and disseminations of magnetic iron through syenite are frequent, and though they have not as yet reached the importance generally attached to them, their frequent occurrence through this part of the country encourages further search and development work.

The great mountain range, above referred to, consists mostly of the typical gneiss and syenite series, the fundamental rocks, found in the western part of Litchfield. Coarse, pale coloured syenitic rocks seem, however, to be the more prominent constituents of the mountain range. In approaching the syenitic rocks the clearly stratified gneisses assume a slight incline and are often nearly horizontal; but there are exceptions to this rule, and localities were visited through which the dip of the strata was nearly or altogether vertical. In several places on this high mountain ridge magnetic iron ore was seen, associated with syenitic rock, fresh coloured feldspar, or a glassy translucent quartz. Its most northerly occurrence is near Otter lake, and here, near the shore of the latter, a highly crystalline magnetite was found, associated with a flesh coloured feldspar.

Beyond the mountain range above referred to, the country is of a rugged description. It is for the greater part inaccessible, being destitute of roads and densely wooded; and even on the canoe routes, many stretches, along lakes and streams, show no rock outcrops, owing to the heavy mantle of drift; and it is possible that limestone bands may occur, even though no trace is visible on the surface.

From the townline between Litchfield and Mansfield, down to the village of Bryson, in the southern portion of Litchfield, the Calumet channel shows but few rock outcrops. The banks of the river are composed of sand and clay, while the channel itself is often shallow, with numerous drifting sand bars.

Proceeding in a southeastern direction, in Litchfield, along the shores of the Calumet channel, the crystalline limestone is again in evidence, and forms a most prominent element in the geological structure of that part of the country. The first evidence of this we find on the shore of the Ottawa, in range iv. Here the limestone can be followed in a southwestward course, towards the township of Clarendon, into range ix, on lots 23 and 24, where its position is indicated by a long, low lying strip of meadow land, the centre of which is traversed by a creek, which runs northwestward into the Calumet channel. Following down the latter, we find that the greatest development of limestone is around the village of Bryson. Near this village a lime kiln is in operation, and the limestone obtained from a quarry nearby is of an exceptionally pure character. The strike of the rock is N. 10° E., and its dip 45° to the eastward. Before we cross the bridge to the island of Calumet on the western side of the road, near Bryson, an apparently large belt of crystalline limestone, with a northeasterly strike, can be noticed, in which magnetite iron ore has been found, in a disseminated form. This limestone belt extends southwestward along the shores of the Calumet channel, as far as Portage du Fort, some nine miles from Bryson, and it is probable that it crosses the river at that point, into the townships of Horton and Ross. At Portage du Fort village there is a great development of the crystalline rocks, the intrusions being particularly well marked, and their action upon the limestone being indicated by the alteration of this rock into marble. From certain beds of this locality the marble employed in the interior of the parliament buildings, at Ottawa, was obtained.

Near Bryson the limestone crosses the Calumet channel and enters the island of Calumet, and after describing a sharp V shaped turn, and traversing the southern extremity of that island, it probably recrosses the Ottawa, and enters Ross township, somewhere about 5 miles west of Portage du Fort. At a point about 9½ miles west from Portage du Fort another limestone belt can be noticed entering Calumet island, but whether this has any connexion with the one above referred to cannot be said with certainty.

The crystalline limestone belt above referred to as passing by the village of Portage du Fort, and along the Calumet channel, exhibits peculiar characteristics, not observed in any other limestone belts so far described. The limestone is rendered peculiar by the curious forms of serpentine which it contains. These weather out in relief, on the surface of the bands, and present the appearance of broken layers, cup and saucer shapes, circular concretions, and other forms difficult to describe. As a rule, the colour of the serpentine is grey and yellowish grey, opaque weathering and white; but where the limestone has been exposed to the action of the water, as at the great Calumet falls below Bryson, and also at a point a little below Portage du Fort, on the shore of the river, the enclosed fragments are of a brilliant red or orange colour on their surfaces, and where polished, by the action of the water, might easily be mistaken for layers and lumps of jasper and chert. The gneiss underlying these limestones exhibits a rusty, or a deep brown discoloration, due to the decomposition of iron pyrites, or other ferruginous matter present in the rock. These deep discolorations have led to a belief in the presence of iron ore deposits underneath, and in several cases development work has been undertaken, in the hope of discovering iron ore, but with no success. However, magnetic iron ore has been found near Bryson, in this limestone, sometimes in disseminated, sometimes in compact form, as small lenses or pockets.

East of Bryson, a considerable area of syenitic and gneissic rock, merging at some places into an almost pure hornblende rock, occurs, and it is in this latter formation that magnetic iron ore has been found, in pockets and in a disseminated form.

The rocks in the northern and eastern part of Calumet island are principally composed of rusty and grey gneiss, and flesh coloured syenite, the latter mostly of a coarse character. Intrusives of diorite are frequent, and it is in these diorite intrusions that blende and galena have been discovered in large deposits, the most important of which are on the Bowie property. Magnetite has been found on the shore of the Ottawa, on lot 2, range ix, in a quartzose and gneissic rock, but the deposits appear to be of little economic importance. Farther inland it has been discovered on lots 7, 8, 11, and 12, range v, and lots 11 and 12, range vi, associated with quartz, in crystalline limestone, but as the work done on these outcrops is only of a superficial character, the extent of the deposits cannot be studied.

The Roche Fendu channel, on the south side of Calumet island, is very rocky, and broken by numerous heavy rapids and chutes. The rocks are limestone, underlaid by rusty grey gneiss, but the syenitic and dioritic intrusions are frequent, and masses of the limestone are often caught in the intrusive rocks.

From the town line between Litchfield and Clarendon, down, the Ottawa river exhibits excellent sections of the various formations, from the Laurentian to the highest member of the Trenton, and in many places the intricate foliation of the crystalline limestones and greyish gneisses can be studied. Intrusive syenitic, pyroxenic, and dioritic rocks, are also well displayed, and at places form a conspicuous part of the rocks exposed.

At the Cheneaux rapids, near the boundary line between the townships of Clarendon and Litchfield, a succession of white crystalline limestone strata, on the left bank of the Ottawa, presents a width of about 2,000 feet, interstratified with harder rock. The dip is about N. 15° E., giving a thickness of 400 feet, and upwards, of which not much more than one-fifth consists of gneiss; it is probable that the section is but part of a larger series of the same rocks, interstratified with one another, much in the same proportion.

The western part of Clarendon is mostly taken up by black weathering hornblende rock, or gneiss, largely rust coloured, with bands of limestones interspersed. The boundary of this gneissic range, towards the west, may be fairly indicated by the road from Bryson to Portage du Fort, in Litchfield, while in Clarendon, a line drawn between lots 22 and 23, and from ranges ix to i, would very nearly coincide with its eastern outline. The average breadth of this gneissic range is close upon three miles. Towards the Ottawa, and in proximity to Portage du Fort, this width rapidly diminishes, until at the shore of this river, and in the extreme front of Clarendon, the whole body of rock is confined between the mouth of a small stream, in lot 24, and the town line of Litchfield. These rocks apparently cross the river, for, on the Ontario side, the hills exhibit black and rust coloured rock. No exposures of limestone can be noticed along the eastern border of this gneissic range, in Clarendon, between ranges ix and iii, but in this last range, and in proximity to the small stream, running through lots 21, 22 and 23, limestone may again be seen in considerable body.

On the gneissic range above referred to, deposits of iron have been known for a number of years to occur. East of the town of Bryson magnetite occurs on lot 27, range vii, of Clarendon, in a coarse hornblende diorite. Impregnations of iron ore have been found also at several places in this range towards the south, the most westerly occurrence, so far known, being a hematite, on lots 24 and 25, range ii; while on lot 26, to the east, an apparently large deposit of iron pyrites has been discovered.

Proceeding farther to the east we find that dark greenish and grey gneisses are again abundant, between lots 10 and 15, striking through ranges i, ii, and iii, and perhaps farther north, and on lot 10, range iii, we once more encounter limestone, of the same quality as heretofore met with.

This limestone belt has a general north and south course, dips to the east, and extends south to the Ottawa river, and east to the town line of Bristol. From the above description of the front of Clarendon, the structure of the shore of the Ottawa may be easily inferred. Thus, below Portage du Fort we find that the limestone is underlaid by mica and granitoid gneiss, which strikes northeast, with easterly dip. Much of the shore to lot 15 is taken up by limestone, and between lots 15 and 11 dark and grey gneisses, with dioritic intrusions, were found to occupy a prominent position in the rock structure of the shore. This gneissic range runs into the Ottawa, on a southwesterly strike, with a nearly vertical dip. The width of the river at this point is about one mile and a half, and its course is directly across the strike of these rocks. The gneissic hills on the Ontario side, which can be seen from Clarendon, are undoubtedly the extension of the gneissic range above referred to. Below lot 10 we find the shore is mostly occupied by crystalline limestone, here and there interrupted by small outliers of gneissic strata.

The northern part of Clarendon is covered almost entirely with a heavy mantle of drift. No rock exposures were noticed, and for this reason the geological structure cannot be studied.

Proceeding farther eastward, to the township of Bristol, we find that the limestones, which commence on lot 10 of Clarendon, extend eastward into Bristol, with a general strike north-northeast, and with a steep dip to the eastward.

Near Bristol landing a small outlier of gneissic strata sets in, which occupies the shore of the river as far as the centre of the front of Bristol; but farther east of this the limestone again occupies the shore. This limestone is coarsely banded with darker or lighter layers; it dips to the northward at an angle of 15 to 20°, and clearly underlies the gneiss above alluded to. Almost the whole valley of the river, along the front of Bristol, is occupied by the same banded limestone, and it is evident that, in this direction, their extension is in narrow limits.

Farther inland from the shore, towards ranges ii and iii, the limestone is overlain by a volume of dark hornblendic and red granitoid gneiss, the latter rock forming the horizon of magnetic iron ore in that part of the country. On this horizon are situated the openings known as the Bristol iron mines. The ore forms here a series of beds, interstratified with reddish syenitic gneiss, and glistening, micaceous, hornblende schist. These rocks can be traced to the east for several miles, while to the west, and north, they are concealed by extensive sandy and clayey drifts.

The northern parts of the townships of Clarendon and Bristol are covered by another and extensive drift of yellow sand, which conceals, for some distance, the outcrops of rock. The crystalline limestone, however, is again met with on the townline between Clarendon and Bristol, on concession viii, and at another point, about three miles to the northward of this, in lots 8 and 9, concession ix and x, of Bristol. In both these positions the strike is to the northeastward, and the dip to the southeastward. Beyond these positions, in Clarendon, all trace of limestone is again lost, in the flat sandy country which immediately adjoins to the northward, but in Bristol township exposures of limestone, with easterly strike, and southerly dip, can be observed for some distance in concessions vii and viii, and in concession xii a marble quarry has been opened up on a very extensive body of beautifully banded limestone, which strikes in a northwesterly direction.

Returning to the Ottawa river, we find that the limestone occupies a portion of the shore, contiguous to the point where the old steamboat wharf for the horse railway was situated, almost opposite Arnprior.

At the Chats, below the town line of Onslow, the falls and rapids, which extend for over a stretch of three miles, are covered by a heavy dike of reddish syenite, which here crosses the river, as a spur from the great syenitic masses on the northern bank of the river.

One of the most prominent geological features in the country north of the Ottawa, is the great ridge of red syenite, composed, in places, almost entirely of flesh-red feldspar, which cuts across the strike of the gneiss and limestone, from King mountain in Hull, north of Ottawa, to beyond Quyon village. This great ridge rises like a wall fronting the Ottawa river, to a height of 800 to 1,000 feet, and has a breadth of from 6 to 8 miles, extending almost to the Pêche river, in the township of Masham. The syenite is generally massive, without stratification, and very often without foliation. The exposed breadth of the limestone area, thus cut off by this mass, is from 8 to 10 miles, extending from east of Fitzroy Harbour to beyond Arnprior, on the Ontario side.

The Eastern, or Gatineau Division.

This section comprises the country north of the city of Ottawa, on both sides of the Gatineau river, as far north as Maniwaki. With the exception of a strip of from one to four miles wide along the Ottawa river west of Hull, the whole area under consideration is taken up by the crystalline rocks of the Laurentian formation, similar to those already described as occurring in Pontiac county. The formation in the strip above alluded to is composed of rocks of Palæozoic age, especially those members constituting the part of the Silurian formation.

For the sake of completeness of the geological description of the whole area dealt with, a brief outline will be given of the various kinds of rocks found in this Palæozoic portion, and which have been fully described by Dr. Ells of the Geological Survey, in his report on the natural resources of the area included in the map of the city of Ottawa and vicinity.

According to this report, the approximate boundary lines of the area covered by these rocks may be described in the following manner: from a point 2 miles east of the village of Gatineau Point, on the Ottawa river, in a northwesterly direction to Wright Bridge on the Ottawa, thence to the southwesterly corner of lot 7, range v, of Hull, thence again in a northwesterly direction to lot i, range vi, Eardley, and from there in an approximately eastern direction to the Ottawa river. It must be mentioned, however, that the wide-spread mantle of drift, found all over the area, has made an exact location of the above lines impossible, therefore the extent of the various formations is rather conjectural than otherwise, and additional data must be obtained before these boundary lines can be exactly laid down.

The various formations recognized in the area may thus be enumerated: first, the lowest of the Silurian, or the Potsdam sandstone, then the Calciferous, next the Chazy shales and limestones, then the Black River, and finally the Trenton.

The Potsdam sandstones form a prominent escarpment about one-quarter of a mile south of the Canadian Pacific railway, west of Templeton station, and the contact with the crystalline rocks is seen on the branch railway leading to Templeton mills, on the shore of the Ottawa, where they have a rather flat dip. They extend west, parallel to the shores, and are supposed to terminate westward on the Gatineau river in the vicinity of Wright Bridge.

The dolomitic limestones of the Calciferous, which overlie the Potsdam, occupy the north shores of the Ottawa river, west of Ottawa, extending inward towards the Gatineau a little below its junction with the Ottawa river, and terminate against the Laurentian ridge, on the west side of the Gatineau.

The Calciferous is overlaid by the Chazy shales and limestones, and these occupy the greater part of the country immediately north of the city of Ottawa. The shales are generally greyish in colour, with shades of green, and have a sandy texture. Occasionally beds of sandstones are met with, and they become coarse in the lower strata. Reddish shades may be noticed in the shales along the Ottawa river, at several points, with interstratified bands of limestone. Most of these shales are in a horizontal position, but near the lines of fault they are often highly inclined. These shales come into view west of Hull, about two miles east of Deschenes mills. They are also well exposed along the line of railway to Aylmer, in numerous cuttings, and the strata are all nearly horizontal. They form a belt about a mile in width, past the town of Aylmer, where they are well developed, and continue westward, as a narrow belt, to a point below Breckenridge station. Along the road west of Aylmer, and also along the Canadian Pacific railway, exposures are numerous. The northern margin of the Palæozoic strata, against the crystalline series, is also occupied by these shales, and the latter continue southeastward to lot 7, range v, of Hull, where they are cut off by a fault, but appear again northward on both shores of the Gatineau.

The limestones of the Chazy formation cover most of the Palæozoic area north of the Ottawa river, from Tetreauville westward. They are concealed, however, over a large portion of their development, by heavy deposits of clay and sand, but are supposed to extend northward from Aylmer, in a width of three miles and a half towards the foot of King mountain, composed of the crystalline rocks; from east to west they occupy the country for about 10 miles, or from Tetreauville nearly to Breckenridge station.

Along the north shore of the Ottawa the limestones appear, from beneath the Black River formation, in nearly horizontal strata, and continue along the shore, from a point just west of Tetreauville for a mile and a half to the underlying shales. West of this, with a curving outline, the southern border of these limestones is supposed to cross the road branching off from the Aylmer road to Deschenes, about midway between the latter road and the electric railway. Thence the southern margin continues northwestward, and the contact with the Chazy shales is seen in the road north of Aylmer. The course then continues about parallel with the river, into the township of Eardley, follows then the old colonization road for several miles, and finally disappears northward under the heavy mantle of drift. The most easterly recognized outcrop of limestones of the Chazy is near the road between lots 8 and 9, ranges iii and iv, of Hull, and these beds are rich in fossils.

The Black River limestones occur only in small detached patches in the Palæozoic area. The more easterly one is in the vicinity of Tetreauville, underlying the Trenton to the east, the strata being much tilted and broken near the contact. Northward, this formation extends west of the Beaver meadow, in the direction of Fairy lake. Farther west it rests upon the Chazy limestone of the area east of Aylmer. There is also a small detached portion of Black River limestone to the west, covering several lots, from 18 to 22, in range iv, and a part of some lots on range v.

The Trenton limestone occupies the area immediately north of the city of Ottawa, extends westward to the outcrop of Black River limestone, and also to the line of fault, northerly from Tetreauville to the contact with the crystalline rocks.

The northern limit of the formation is about two miles north of the Ottawa river, but, owing to the heavy mantle of drift, the boundary lines are to some extent conjectural. To the north, this formation is bounded by a fault, which separates it from the Chazy, and which extends eastward towards the north end of Leamy lake. East of this the Trenton is cut out by several faults, and crosses the river to the Ontario side.

Having described the principal geological features of the country immediately adjoining the Ottawa river, forming the southern part of the Gatineau or eastern division, we now come to the consideration of the rock formations on both sides of the Gatineau, from Wright Bridge up to the town of Maniwaki. Here the rocks are all of the Laurentian or crystalline varieties, and are confined more or less to the great Grenville series, or fundamental gneiss, now regarded by geologists as representing the older Laurentian.

We find in the area under consideration red granitic and hornblende gneisses, with bands of crystalline limestone, red orthoclase gneiss, quartzite, and pyroxene strata, rust coloured gneisses, pyroxene and feldspar rocks, with small bands of crystalline limestone, and rust coloured garnetiferous gneiss, rust coloured quartz, and orthoclase rock, bands of crystalline limestones with serpentine and pyroxene. Considerable masses of clearly intrusive rocks occur in the form of dioritic and pegmatitic dikes, pyroxene, granite, and greenstone, while dikes of diabase are also found. The frequency of these intrusives has exercised a marked influence upon the regular deposition of the gneissic and calcareous strata, and it is doubtless to these intrusions that the country along the Gatineau owes much of its mineral wealth.

The outcrops of calcareous rocks, in this section, are very numerous; but, owing to the heavy drift covering which fills up the intervening valleys, they cannot be traced for any distance, and what will be said regarding their extent, in what follows, must, consequently, be in great part conjectural.

The southern border of this Laurentian area is formed by the great Eardley and Hull mountains, which form one of the most prominent geological features in the country north of the Ottawa. They strike through Hull, Eardley and in a northwesterly direction, cross the Pontiac line, and terminate in the vicinity of Quyon village. This great ridge rises like a wall fronting the Ottawa river, to a height of 800 to 1,000 feet, and has a breadth of from 6 to 8 miles, extending almost to the Pêche river, in the township of Masham. In its eastern portion it consists of red granitic gneiss, and hornblende gneiss, coarse porphyroid gneiss, with flesh coloured feldspar; to the west it partakes of a syenitic character, in being composed in places almost entirely of red, flesh coloured feldspar. This syenite is generally massive, without stratification, and very often without foliation. It cuts off the great limestone belt referred to on page 25, in a width from 8 to 10 miles from Chats falls to a point on the Ottawa river opposite Arnprior. After passing the great wall of syenite the limestone comes in again on the Pêche river, in Masham township, and continues in a broad and uninterrupted belt along the Gatineau river for over one hundred miles, to the north.

In its eastern, or more gneissic portion, extensive limestone belts are frequent, and in one of them, which has an approximate width of nearly three-fourths of a mile, the well known Forsyth, and Baldwin magnetic iron ore mines are located, on lots 1 and 2, range vii, and on lot 14, range vi, of Hull. Here the magnetic ore occurs in association with very dark hornblende rocks, striking a little north of west, through the great band of crystalline limestone above alluded to.

From observations made so far in the field it appears that most of the limestone bands in this district have a northerly, or a northeasterly strike, and form tongue-like, and where exposed, well marked outliers in the Laurentian formation. Their dip, however, changes a great deal; it is sometimes to the east, sometimes to the west, sometimes steep, and again flat, apparently conditioned by synclines, or anticlines; in the formation. Wherever they come in contact with intrusives their coarse crystalline character changes, and that part coming into direct contact with, or in immediate vicinity to these has been changed into marble.

Besides the two limestone bands above mentioned, there can be recognized a number of others, all through the townships of Hull, Wakefield, and Masham. Thus, at the crossing of the Gatineau at Wright Bridge, outcrops of calcareous rocks can be seen. This band, which has a width of half a mile, can be traced northeasterly into Templeton township, where it is interstratified with bands of rusty gneiss, in its lower portion.

Another band crosses the road to Wilson Corners, on lot 6, range x, and takes a course parallel to the one just described. It is probably an extension of the great limestone belt near Ironsides, above referred to, in which the Forsyth and Baldwin mines are located. Near Kirks Ferry another band crosses the river, and an extension of the same can be noticed in a southwesterly direction in Old Chelsea.

There are a number of limestone bands crossing Hull, Wakefield, and Templeton townships, too numerous to mention, and these, as a general rule, exhibit those features already referred to. Apart from the great development of these crystalline limestones, the various typical gneisses of the Grenville series predominate through the townships of Hull, Wakefield, and Templeton. Very considerable masses of intrusive rocks occur, such as pyroxene, granite, and pegmatite; while dikes of diorite, and diabase rocks are also found. A large area is covered with a heavy mantle of drift, and, throughout this portion of the Ottawa district, there seems to be a greater predominance of the igneous rocks, which have exercised a marked influence on the regular distribution of the gneisses and limestones.

Apart from the occurrence of iron ore at the Forsyth and Baldwin mines, there are scattered through the district a number of iron locations, which, however, so far as investigated, do not indicate the development of an iron range of considerable extension, but represent simply sporadic deposits, whose mode of occurrence, and volume, do not seem to point to a direct or indirect connexion with each other. I refer to several deposits situated along the town line between Templeton and Hull. Here are exhibited quite a number of iron outcrops, the most important of which is the Haycock iron location, on lot 28, range vi, Templeton. The rocks in which the iron ore here occurs are referable to the higher portions of the Laurentian series, and consist of micaceous and gneissic strata, with a northeast and southwest strike, thus coinciding with the strike of the limestone bands of the district. They dip towards the northwest, at an average angle of from 45° to 50°.

Proceeding farther east, from the town line of Templeton and Hull, we find a very large development of a gneissic apatite-bearing formation, around McGregor lake, and farther east, in the Buckingham district. Alternations of limestone and gneiss can be noticed following the roads going in eastern directions; pyroxenic dikes, some of them of very considerable extent, reddish granite, pegmatite and dioritic dikes, cut through the stratified gneiss, sometimes at right angles. The whole formation, compared with that found on the west side of the Gatineau, is of a different aspect, and it is also characterized by the frequency with which economic minerals, principally apatite, occur. Iron has been found also in scattered deposits; but as very little attention has been paid to these occurrences, no important data bearing on their extension or character could be collected.

The interior of Wakefield township is practically unexplored, with the exception of the shores of the Gatineau river, and lakes farther inland. Crystalline limestone may be seen on the southeast extremity of Lake St. Germain, while the principal rocks seen were at Dam and Clear lake. These were mostly a reddish granitic gneiss, cut through by quartzose and feldspathic dikes, and these rocks apparently occupy a large portion of this township. On lot 23, range vi, Wakefield, and other lots in the vicinity, magnetic iron ore occurs in hornblendic gneiss, associated with quartzose rocks. Syenitic gneiss, cut by diorite and limestone, is also met with, and forms the prevailing rock of the country lying to the northward. Along the valley of the Gatineau river exposures of limestone are very frequent, while gneissic strata occupy the long mountain ranges farther inland.

The country north of the townships of Wakefield and Masham, along the Gatineau, presents about the same features, from a geological point of view, as that just described. At Kazabazua a wide sandy plain strikes in a westerly direction through the country, which entirely conceals the underlying formation. Of the gneisses on the western side of the river it may be said that they are recognized as representing the lowest members of the Laurentian formation, and consist of red granitic gneiss, or hornblende gneiss, with small bands of crystalline limestone. On the eastern side of the river the rocks are mostly composed of rust coloured gneisses, and pyroxene and feldspar rocks, with small bands of crystalline limestone, and cut by numerous intrusive dikes of diorite, pegmatite, and sometimes diabase. As mentioned above, it is perhaps due to the presence of these intrusions that this part of the Laurentian formation is more productive in economic minerals than the one in which these intrusions are absent, and for this reason, perhaps, we find that the country east of the Gatineau river, or between this and the Lièvre river, is far more productive of economic minerals, such as apatite, graphite, and mica.

Of the country adjacent to the Gatineau river, that between the latter and Thirty-one-mile lake, in the township of Cameron, is of special interest, because in the gneissic hills, running generally in a north-south course, several discoveries of iron ore, some of them of importance, have been made. The shores of this lake show the usual arrangement of pyroxenic and reddish orthoclase gneisses, and limestone, the former being prominently developed.

From the west side of Thirty-one-mile lake a creek leads into Round lake, at about lot 30, range vii, and this creek cuts through limestone, with several bands of a reddish gneiss. In fact limestone forms the greater part of the bed of this lake, as well as the islands in the centre. Round lake is connected with Rat lake by a small creek, of about 50 yards in length, flowing over limestone, which occupies also the eastern portion of the latter lake. Limestone, striking a little northeast, crops out further on lot 30, range ii, and if we take into consideration also the strike and characteristics of all the limestone outcrops below the village of St. Gabriel, we come to the conclusion that all these outcrops belong to one and the same belt, which, commencing between Round and Rat lakes, at the point above indicated, strikes in a southwestern direction, for some distance down, along the Gatineau river.

On this limestone belt a large outcrop of magnetite iron ore was discovered many years ago, on lot 30, range ii, Cameron, while several indications of the ore have been found on various points along the limestone belt just referred to.

On Post creek, through which Rat lake discharges into the Gatineau, a large development of gneiss can be seen all along its course, forming a broad area, but limestone comes in again under the lower part of the creek, and can be followed down to the Gatineau, a distance of half a mile.

At the Six Portages post office the gneiss underlies the limestone, on the west bank of the river, its strike being northwest, with an easterly dip.

Around Maniwaki, at the confluence of the Désert river with the Gatineau river, numerous outcrops of rock can be noticed, and from these it appears that the formation consists mostly of quartzose and granitoid gneiss, striking northeast, with a dip to the north; limestone bands, dikes of pyroxene and pegmatite cut at many places the gneisses at right angles. There are also granitic and quartzose intrusions, carrying phlogopite and muscovite mica. Near the Désert river, on the other side of the bridge leading over this stream, the country rock consists of a mica gneiss, distinctly foliated and banded. The limestone found in the village usually contains scales of graphite and slaty matter, and for this reason is difficult to burn in kilns. No iron ore of importance has been found around Maniwaki; but fine dissemination of the same through the limestone has been noticed. The gneissic strata, at some places, have a rust coloured surface, undoubtedly due to the decomposition of iron pyrite.

CHAPTER III.

THE ORE DEPOSITS.

The iron ores found in the region may generally be divided into three classes:—

(1.) Magnetite.
(2.) Hematite.
(3.) A mixture of both.

Although no mining of these iron ores is being done at the present time, their occurrence at numerous places is well known. They were, indeed, the first economic minerals in the Province of Quebec to attract attention, and were the subject of study as early as 1845. They are destined to play an important part in the future development of the country, as soon as their economic value is fully appreciated, and modern concentration and smelting methods are adopted.

The iron ores of the Laurentian system are, for the greater part, of the magnetic species, and are similar in geological relations, and in mineralogical character, to the ores which occur in the same system in the Adirondacks in northern New York, and in the highlands of southern New York, and New Jersey, where they have been extensively mined for a long period.

The Mineville group of mines in the Adirondacks has been in practically continuous operation since 1846, and has shipped to date about 14,000,000 tons of ore. The shipments of ore during the last five years have amounted to 1,368,390 tons.

Similar ores occur in Norway and Sweden, where they abound in rocks of the same age, and furnish high-grade iron, which, on account of its exceptional qualities, is famous throughout the markets of the world. A large portion of both Norway and Sweden is occupied by gneisses of the Laurentian system, similar to those constituting the greater part of the Province of Quebec. This geologic resemblance, with somewhat similar conditions of soil and climate, should stimulate interest in the study of the conditions which led to the successful iron industry in those countries. Data collected in connexion with the development of the Scandinavian iron ore resources should be of great value to those who would exploit the Canadian deposits.

MAGNETITE.*

This is the most abundant iron ore found in the district. When in a comparatively pure state it consists of 72·4 parts of iron, and 27·6 parts of oxygen; but it invariably contains foreign matter, either mechanically

*Named from the locality Magnesia, bordering on Macedonia. But Pliny favours Nicander's derivation from Magnes, who first discovered it, as the fable runs, by finding on taking his herds to pasture, that the nails of his shoes and the iron ferrule of his staff adhered to the ground. (Dana).

mingled, or chemically combined, which reduces, more or less, the percentage of iron. Its name is derived from the fact that it is attracted by the magnet. It rarely has the power of attracting particles of iron itself; but if it is endowed with polarity it constitutes the native magnet or lodestone. Magnetite ore has a specific gravity of from 4·9 to 5·2, is iron black in colour, and when ground gives a black powder. Its degree of hardness is 5·5 to 6·5, and its chemical composition FeO, Fe_2O_3, which is a mixture of iron sesquioxide 69·00, and iron protoxide 31·00. It is hard and brittle, and with a shining, more or less metallic lustre. In the district under consideration it is sometimes fine grained and compact, and at other times coarsely crystalline and granular, but it is rarely in crystals. Well defined cubes of magnetite, with replaced edges, have, however, been found at the contact of the iron ore with crystalline limestone, near Portage du Fort.

Its crystallization is isometric, the form most commonly met with is the octahedron, also the dodecahedron, with striated faces, Fig. 1. Cubic forms

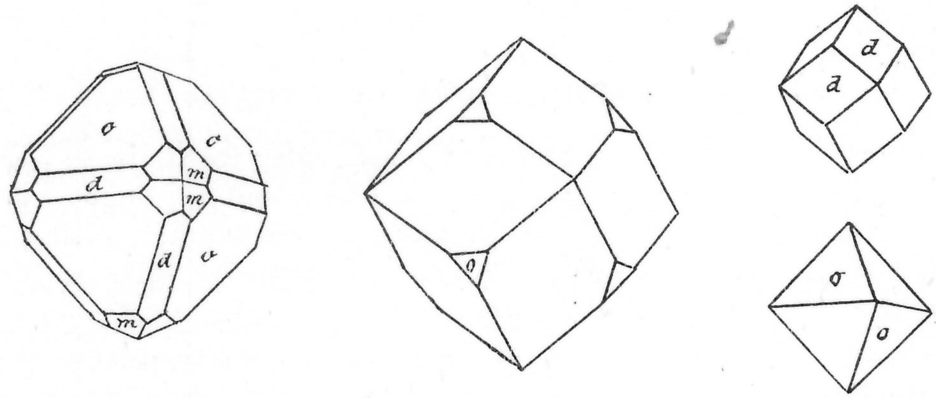


Fig. 1.—Magnetite crystals.

are rare. Its cleavage is mostly imperfect, streak black, and colour iron black. It is opaque in appearance; but in very thin dendrites, or mica, it is sometimes transparent, or nearly so.

Before the blowpipe it is, with difficulty, fusible. In the oxidizing flame it becomes non-magnetic. It is soluble in hydrochloric acid, and with fluxes in the furnace acts exactly like hematite. The ore is very often disseminated in grains through the Laurentian gneiss, but the great masses are generally associated with crystalline limestone.

The magnetite from the Laurentian rocks is occasionally mixed with hematite, or specular iron. It sometimes contains up to 17 per cent titanic acid, or other impurities, the most common of which are small portions of carbonate of lime, of mica, and hornblende, quartz, and calcite, more rarely actinolite, and very often scales of graphite.

Hematite.

This ore, which is sometimes called oligistic iron, constitutes the specular micaceous and earthy red iron ores, and is frequently found in the Gatineau district, though less abundantly than magnetite. It is found either in a pure state, or in association with magnetic iron ore. When pure, the most common species met with in the district is the so-called specular variety. Its chemical composition is Fe_2O_3, or iron sesquioxide containing theoretically 70 per cent iron, and 30 per cent oxygen. The lustre of the ore is highly metallic, or shining. Its fracture is uneven; it is very brittle in compact form, and has often a lamellar structure. It is elastic in thin laminæ, and soft and unctuous in some loosely adherent varieties. The colour is dark steel grey; in very thin particles red by transmitted light; when earthy, red. The streak is cherry red, or reddish brown. Some varieties are magnetic, but this may be due to the presence of magnetite. Its hardness is from 5·5 to 6·5 Mohs' scale; its specific gravity 4·9 to 5·3.

Before the blowpipe hematite is infusible; on charcoal in reducing flame it becomes magnetic; with borax it gives the iron reactions, and with soda on charcoal in reducing flames is reduced to grey magnetic, metallic powder. It is soluble in concentrated hydrochloric acid.

The Iron Ore Deposits along the Gatineau River.

As outlined in a previous chapter, the area along the Gatineau river, in which iron ore in commercial quantities has been found, is composed principally of a series of gneisses, with which are associated white crystalline limestone, calcites, hornblende rocks, cut and traversed by dikes of diorite, pegmatite, and sometimes of pyroxene.

The most important member of this formation, and the one which is of special interest, for the purposes of this report, is the crystalline limestone, and in the following, a general description is given of this important part of the formation, and its connexion with the iron ores found in the same.

The Crystalline Limestones.

The crystalline limestones which constitute the principal members of the formation, containing iron ores, especially magnetite, are usually white, light grey, or pale reddish, or fading blue in colour, and are sometimes veined and spotted with yellow, green, bluish-grey, and other tints. They present most commonly a fine and coarse granular structure, much resembling that of loaf sugar, but some varieties are more or less compact, and others present, in places, a fibrous aspect, from intermingled tremolite, or greenish white to white hornblende.

The masses of limestone are in general crystalline in a high degree, and occasionally they are composed of an aggregation of rhombohedral crystals of calcspar, with faces an inch square. Usually they are coarse grained; but sometimes also granular, though it rarely happens that they are so fine in texture as to be entitled to the designation of compact. In large masses their general colour is white; they are often barred with grey in the direction of the strata, and are occasionally wholly grey. They are sometimes partially salmon or flesh-red, but this tinge has not been diffused throughout a bed, or penetrated to any great distance. It is seldom that beds are composed of pure carbonate of lime. Many accidental minerals are usually associated with this, and they may vary in quantity and kinds in different parts of a group of strata, both horizontally and vertically. The most frequent minerals embedded in the limestone are serpentine, pyroxene, hornblende, tremolite, elastonite, mica, graphite, apatite, quartz, scapolite, iron pyrites, zircon spinel, fluorspar, tourmaline, and copper pyrites.

Hornblende is a most frequent constituent of the crystalline formation, and in many places, as in the Hull ore deposits, it is associated with magnetic iron ore. Beds of hornblende rock, and hornblendic schist, seem often to be more abundant near the interstratified bands of crystalline limestone than elsewhere, and, it has often been noticed, that impregnated magnetite has been noted at the selvage planes of the two rocks. They constitute layers, sometimes many feet thick, and the iron ore occurs in these in parallel streaks and beds, sometimes attaining several feet in thickness, the interstices among them being filled with limestone, quartz, calcite, or dolomite.

Serpentine is found frequently associated and disseminated through the limestone formation, in grains varying in size from 0·10″ to 0·25″. It forms also round, concretionary masses, which show gradual transition into the limestone on the outside, while in the case of an ellipsoid ring-like deposit, the inner part, or the core, exhibits no transition, but an abrupt change from serpentine to limestone. Grains of magnetite have been found in association with such serpentines, but so far they have not developed into deposits of such shape and size as to warrant exploitation.

When the serpentine occurs in grains, or larger scattered masses, the grains, more or less closely aggregated, sometimes run in bands parallel with the beds, and clearly mark the stratified character of the rock. The serpentine can be easily distinguished from the other rock, in which it is embedded, by its colours. These are usually some tinge of green, to oil green and pale greenish yellow; sometimes the mineral is resin coloured, and occasionally masses of pale yellowish green are spotted with crimson or blood red patches, from disseminated peroxide of iron, as seen near the Calumet falls, below the town of Bryson, Pontiac county.

Pyroxene is also met with occasionally forming massive beds, but its presence in large masses has not been noted in the immediate vicinity of iron ores. The limestone beds are sometimes characterized by grains of pyroxene, disseminated in the rock, in the same banded arrangement as the serpentine; but not in such abundance, and occasionally they run with the stratification masses composed of cleavable pyroxene, associated with several other minerals, making a very coarsely crystalline rock; but these perhaps may sometimes constitute veins of segregation, rather than beds.

Mica and graphite very generally accompany one another in the calcareous beds, and some of these beds, of larger dimensions, are rarely without them. It appears to be finely disseminated graphite that occasionally imparts to large masses of the limestone a grey colour, and the greater or less accumulation of it in different layers produces the bands of darker or lighter grey above referred to. Graphite is also in some localities intimately associated with magnetite, and the Hull ore contains, in some places, flakes a quarter of an inch in length. Sometimes it occurs in small veins of $\frac{1}{2}''$, or less, in thickness, in the limestone, or on the contact with some other rock, and when found in this condition it is mostly pure, and not intermingled with iron ore, or any other mineral.

The principal variety of the mica is the phlogopite, which can be readily recognized by its sugar brown, sometimes brownish yellow, also dark tints. Muscovite mica is also frequently met with, as scaly glistening particles, of silvery or pearl white colour.

Crystals and grains of iron pyrites are often abundant in the calcareous formations, and are, at some localities, thickly disseminated through the formation, or occur in accumulations so as to form a solid bed, as on lot 25, range ii, township of Clarendon. They frequently accompany the crystals of mica and graphite, arranged like these in parallel bands, holding a greater or less abundance of the mineral.

Pyrite often characterizes large nodules and lenticular masses of gneiss, or gneissoid pyroxenic rock, subordinate to the calcareous beds; and strata of this description, weathering to a rusty brown, and holding disseminated graphite, very often limit the great masses of limestone, and afford a useful guide in tracing out their distribution.

Pyrite is often associated with magnetite, or hematite iron ores in the district, and has, if associated with these in appreciable quantities, a most detrimental effect upon the quality of the ores.

Apatite, although so abundant generally in the limestone formation, has not been met with, at least as far as the writer is aware, in the limestone series in which the iron ore occurs.

Some of the larger limestone belts, which contain iron ores, have been involved in folding and disturbances, which have affected some parts of the calcareous, gneissic strata.

The direction of these crushing forces is not well established, though in some cases, as in the Hull mines, where they could be better studied, it appears that the disturbances had a northeast and southwest direction. The result of these disturbances can be well seen in those parts of the limestone formation where a displacement of the strata, and also of the mineral veins, has taken place. For instance, on lot ii, range vii, and also on the adjacent lot No. 12, of Hull, the iron ore deposits have been cut off and thrown in a southwestern direction.

Some of the bands of limestone are of great thickness, and passing to them from the gneiss there is occasionally an interstratification of smaller calcareous beds.

When one of these calcareous beds—or a collection of them—is traced for some distance, and then compared with the gneiss, it will be noticed that the limestone, as a whole, is conformable with the beds of gneiss, and parallel with those beds and streaks with which they are marked. This relation is not so evident, when only small portions are compared, for it often happens that while an overlying or underlying mass of gneiss will exhibit very regular and even lamellation, the subordinate layers, dividing the calcareous bed, will display contortions of a most complicated description. The gneissoid beds, which form the subdivisions, will be bent and folded in a very extraordinary manner, or partially broken up into fragments surrounded by limestone.

THE FORSYTH AND BALDWIN MINES.

The Forsyth and Baldwin Mines have been known for over 75 years: the first reference to them appearing in a paper read by Lieut. Bradley, R.E., before the Literary and Historical Society of Quebec, in the year 1830. Lieut. Bradley described this deposit in the following manner: "This deposit forms a vein, or bed, from 10″ to 12″ thick, and appears to traverse the mountain in a southwest course, having a vertical position as regards the walls of the vein. On the opposite side of the mountain, at the distance of upwards of a mile, and in the direction of the vein, ore was again seen in great abundance."

In the publications of the Geological Survey, we first find reference to these deposits in the report for 1845–46. The width of the principal deposit is there stated to be not more than 20 feet, and as regards the extension, the following note is interesting: "On the southern part of lot 11, range vii, Hull, the ore is in a bed, of which the strike is north-northwest and south-southeast, and being again met with in the rear of lot 12, on the same range—which is precisely in the direction of the strike—there is a probability that it will be continuous the whole distance between the two points, which is about a mile. But as the range of the rock appears to be running in irregular course; occasioned by undulations in the stratifications, it seems probable it will gradually bend round to the eastward, and cross the Gatineau farther up."

And as to the quantity of ore in sight the report goes on to say: "The quantity of iron the Hull bed contains must be considerable. If its breadth be assumed at 20 feet, every fathom forward in it, with a vertical depth of a fathom, would probably yield not less than 50 to 60 tons of pure metal."

The ore itself is described as coarse granular, carrying a considerable amount of graphite scales in some places. An average specimen of the ore analysed by Dr. Sterry Hunt gave:—

Magnetic oxide of iron.	96·09
Silica and graphite.	3·18
Metallic iron.	69·65

In a subsequent report of the Geological Survey, the width is stated as 40 feet, and the graphite as assuming sometimes the form of veins of several inches in thickness.

It seems strange that the Hull deposits were known for such a long period without being further investigated as to their extent and quality. It was only in the year 1854 that actual explorations and development work were begun, by an American firm, The Forsyth and Co., of Pittsburgh. This firm realized the high value of the magnetite, from the very beginning of mining operations, and supplied its works in Pittsburgh for a number of years with the ore. It is reported that in 1855 about 5,000 tons were raised. As there was at that time no direct railway communication between the mines, and Ottawa, and the United States, the ore had to be shipped by way of the Rideau canal to Kingston, and from there by lake vessels to Cleveland, Ohio. Operations were suspended for some time, owing to the discovery of a new ore bed in South Crosby, Ontario, which being situated directly on the Rideau canal, offered greater advantages as to transportation.

Operations, however, were soon resumed on the Hull property, and it is reported that, up to 1858, about 8,000 tons were shipped, averaging 60·70 per cent of metallic iron.

In 1867 a blast furnace was erected, and it is reported that smelting operations were conducted in 1867, and a part of 1868.

The ores treated, according to Dr. Hunt,* showed the following analyses:—

Black ore:—

Magnetic oxide of iron	73·900	(metallic iron 53·20)
Magnesia	1·880	
Alumina	0·610	
Silica	20·670	
Water	3·270	
Phosphorus	0·027	
Sulphur	0·085	
	100·442	

Red ore:—

Peroxide of iron	66·200	(metallic iron 58·78)
Protoxide of iron	17·780	
Oxide of manganese	trace	
Lime as silicate	0·760	
Magnesia as silicate	0·450	
Carbonate of lime	2·660	
Silica	10·440	
Graphite	0·710	
Phosphorus	0·015	
Sulphur	0·280	
	99·295	

*Report of Progress, 1866–9, pp. 255–256.

The furnace was in operation from April 27, to October 6, 1868, or 163 days, during which time there were consumed as follows:—

Hull ore.	1,835 tons
Arnprior (McNab) ore.	60 tons
	1,895 tons

Scrap iron.	7·2 tons
Limestone.	211 "
Charcoal.	242,782 bushels
Wood.	251½ cords
Peat, 80 tons yielding coke.	21·65 tons
Pig iron produced.	1040·15 tons

The cost of iron thus produced was as follows:—

Ore, fuel, wages.	$22.60
Salaries and general expenses.	3.10
	$26.50

If we deduct from the total amount of iron produced the scrap iron added, we obtain as the average results during the time of the experiments, in 1868, the following figures:—

Daily production of iron.	6·5 tons
Yield of ore per ton.	54·5 per cent
Charcoal consumed per ton.	235 bushels
Peat coke.	47 pounds

Leaving out the amount of peat coke consumed, we have a consumption of 37·75 cwts. of charcoal for a ton of iron, while of hard wood charcoal there were consumed from 34 to 35 cwts.

In Sweden the average consumption of charcoal for smelting similar ores was from 16 to 17 cwts., for the ton of white and mottled iron, and about one-third more, or from 21 to 22 cwts., for the ton of grey metal suitable for foundry purposes, or of Bessemer steel. At Langskytta, in Sweden, the consumption was as low as 13·5 to 14 cwts., while the very poor ores of Taberg, where the charge contained only 20 per cent of iron, required as much as 50 to 60 cwt. of charcoal per ton.

At the large blast furnaces of Port Henry, on Lake Champlain, where magnetic ore, similar to that of Hull, is smelted with anthracite coal, the average consumption was from 1·10 to 1·14 tons, equal to 22 to 23 cwts. of anthracite, to the ton of pig iron produced.

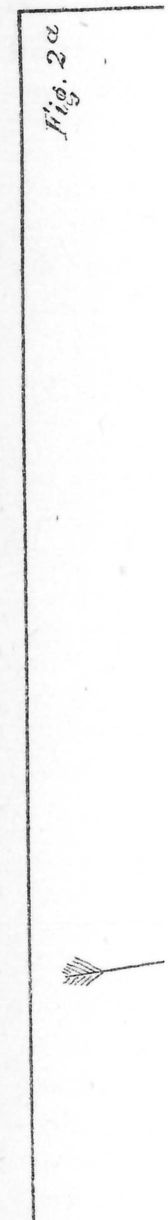
The composition of the charge of the Hull furnace was very poorly calculated, for besides limestone, considerable amounts of clay and siliceous sand were used, which were entirely unnecessary, not only decreasing the capacity of the furnace, but also increasing the consumption of charcoal, which was excessive, being 235 bushels per ton. This alone appears sufficient to explain the failure to produce iron profitably at Hull, where the quality of iron manufactured was indeed excellent.

Other reasons were advanced in explanation of the failure of smelting operations, and amongst these were the absence of transportation facilities, and the lack of fuel.

In comparing these locations with other mines, we find, however, that there are some important points in favour of the former, that is, ore and flux occur together in close proximity. The Londonderry mines, in Nova Scotia, at that time were working under great disadvantages as to the flux and fuel supply. The latter had to be brought from Springhill, in the raw state, and coked at the mines, or as coke from Pictou, a distance of 80 miles; the flux had to be transported from Brookfield, 44 miles distant. Again, the ores at Londonderry were not nearly so rich in metallic iron as the magnetites from Hull, and sometimes they also had to be carried long distances. Taking, therefore, all things together, it appears more than probable that the unsuccessful operations were not only due to the lack of transportation facilities, and fuel, but also to the inexperience of the management, which seemed to be incompetent to deal successfully with the important questions arising out of the gradual development of the enterprise. The consequence was that the mines were shut down, the old furnace was removed from Ironsides village, near the bank of the Gatineau river, about 1880. The mines have been lying idle ever since.

In order to form an idea of the extent of the operations carried on in this mine, and also of the character and quality of the ore bodies, the following description, based upon a thorough investigation, is given. It must be borne in mind, however, that, owing to the long suspension of actual mining work, all the pits and cuts were filled with water and debris, that some of them were covered with brush, underwood, and even trees, and that on this account the examination was not as complete as could be wished for. Prospecting pits and ditches, which, at an earlier period, served to throw light on the extension of the deposits, were filled with waste, and covered with dense vegetation. But in some places, where the expense was not excessive, these were cleaned out; in the majority of cases, however, such a procedure would have involved a heavy outlay, for which no provision had been made.

The principal operations carried on at the Forsyth mine were confined to the southern portion of lot 11, range vii, of the township of Hull. (See fig. 2). They consisted of a long, shallow, open-cut (fig. 2b), commencing near the road to Old Chelsea, and continuing into a hilly range, which traverses the country in a north-westerly direction. The main strike of this open-cut is a little north of east and west, its length is 735 feet, its width from 10 to 80 feet, and its average shallow depth from 25 to 50 feet. There are two levels in this open-cut. One commences near the road, and represents an open-cut, I



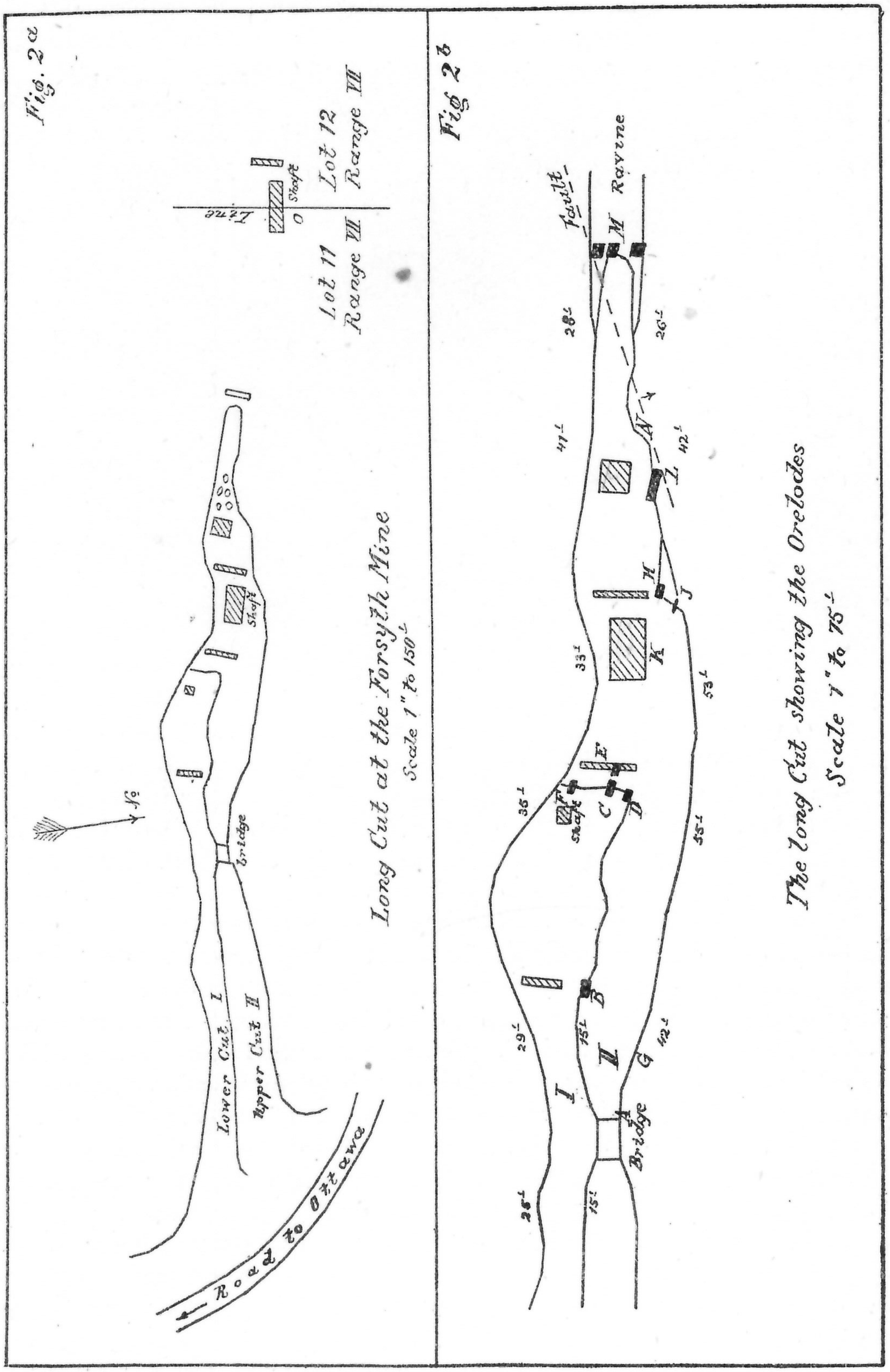


FIG. 2.—Long cut and pits of the Forsyth mine at Ironsides, Hull.

(fig. 2b), approximately on the same level with the road; and the other, marked II, in the same figure, 10 feet higher than I, being the main level upon which all mining operations were carried on, and which extended for the full length of the main open-cut, that is, for 735 feet.

This open-cut runs through a belt of crystalline limestone, which strikes in a northwesterly direction, and has an approximate width of over a mile. The open workings of the Forsyth mine afford good opportunity to study the character of the ore containing formation, the limestone. In looking at the crystalline limestone formation, as a whole, we cannot but come to the conclusion that it has—at least where the Hull iron range is located—been involved in a series of folding and disturbance. The direction of the crushing force was apparently from the northeast to the southwest, and it included also the masses of iron ore associated. The results of these pressure forces can be well studied, by examining closely the walls of the long cut in the formation. In several places the rock has assumed a decidedly slaty and schistose character, as will be noticed on the northern side of the cut, close to the lower bridge (see fig. 2b), about 280 feet from the entrance. Here a highly decomposed, blackish, graphitic hornblende rock has been cut off by a nearly horizontal fault, which, along the lines of fracture, exhibits magnetic iron ore of a crystalline character.

An analysis of the ore, which occurs here in the form of small pockets, gave the following percentage composition:—

Silica	14·160
Ferrous oxide	23·660
Ferric oxide	51·870
Sulphur	0·230
Phosphorus	0·004
Metallic iron	54·710

In following the lines of fracture, we noticed that decomposed, greenish, slaty material had filled up the cracks, which at some places present slicken-sided surfaces, as a sign of movements of the rocks. Immediately under the little bridge (A in fig. 2b), a number of pockets of magnetite can be noticed. Their form and arrangement in the wall are very irregular, and adding to this the crushed condition of the containing rock, it appears that this part of the formation has undergone a considerable amount of disturbance. There is no doubt that the little pockets, above referred to, are parts of an ore lode which has been opened up and followed in the lower cut (I), but which has been thrown out of its course towards the north, and cut up by dynamic forces; this is also indicated by the widening out of lower cut (I) towards the location of the pockets of magnetite, at the places under consideration, which necessitated the construction of a bridge on the level of cut (II).

The ore deposits, themselves, sometimes show many fractures, especially along the contact with the wall rock. The individual layers, where hard

PLATE III.

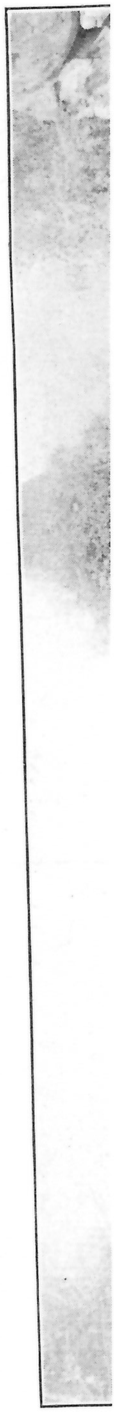
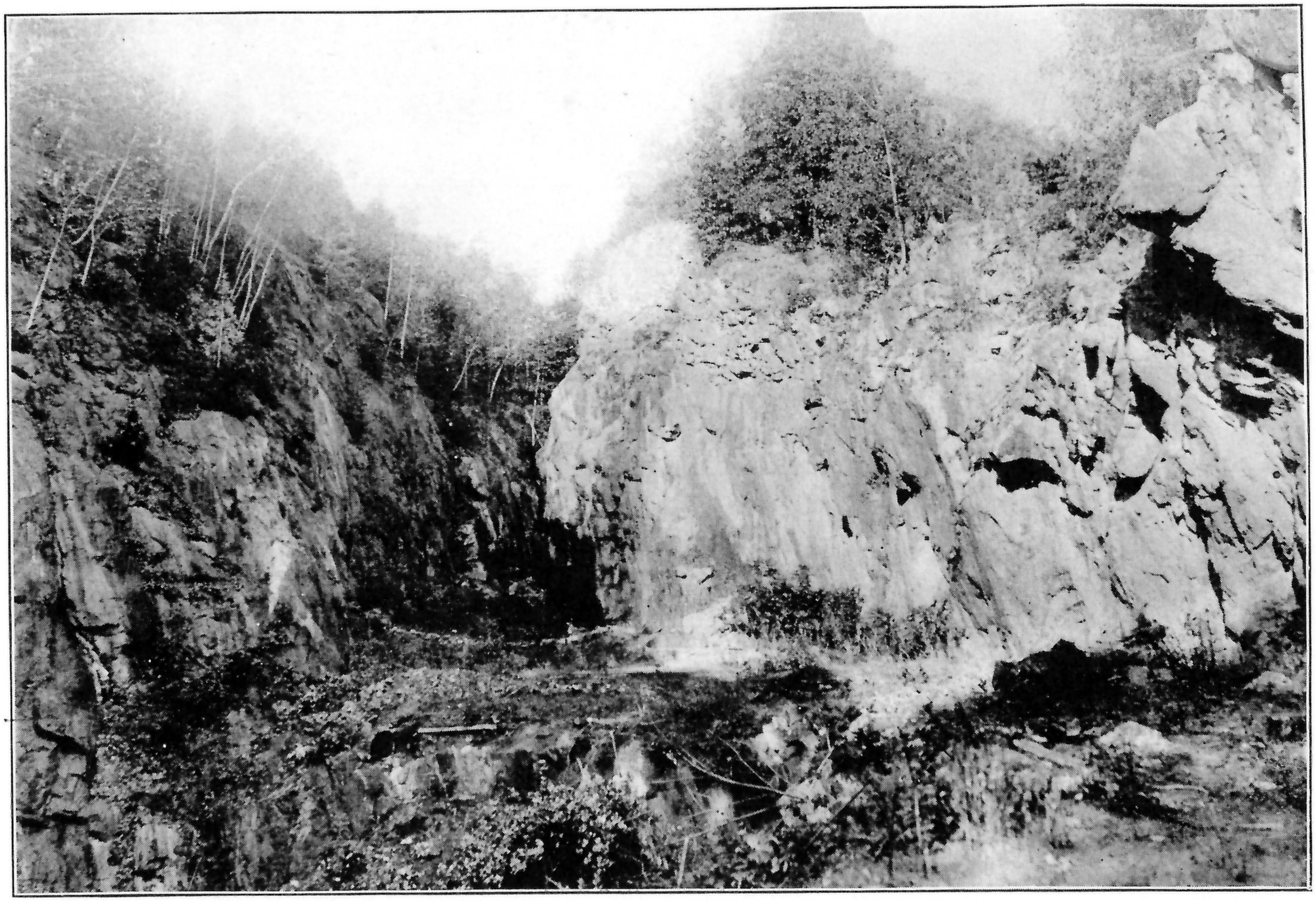


PLATE III.



Open-cut in the Forsyth mine.

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enough, are broken into small blocks, by fractures, which, in the main, are independent of those in the layers surrounding the same. Also, occasionally, joints and faults cut across the ore deposit. For the most part there is little displacement along fractures, and where displacement does occur, it is measured by inches rather than feet.

In following the lower cut (I), we find along the northern wall a number of outcrops of magnetite, which seem to constitute the continuation of ore lodes partly worked in the lower cut. The first ore lode of larger dimensions we meet is at a distance of 325 from the entrance, marked B in fig. 2b. This outcrop seems to correspond with a vein, C, which appears on the northerly face of the lower cut (I). Magnetite ore, but some of it of impure character, can be seen all over a width of 4 feet. It occurs here more as an accumulation of smaller pockets than in a vein-like form, and in the vicinity of this place, in the bottom of the lower cut, a number of pockets may be noticed. Some of the ore is composed of very pure magnetite, while a large portion of it is an intimate mixture of hornblende rock, magnetite and hematite, with flakes of graphite distributed through the whole mass.

Another outcrop, D, appears near the face of the lower cut, on the northern wall. This ore is here irregularly distributed over a width of 4 feet; much of it, however, is associated with country rock. The outcrop in C is in the form of a vein, with northwesterly strike, and dip to the north; it has a width here of approximately 5 feet, is made up of parallel streaks of ore, of country rock, or of a mixture of both, and continues westward. This may be seen in prospecting ditch E, which shows distinctly that the ore lode constitutes a very strong lead, extending, not only horizontally, but to the depth as well. An analysis of a sample gave the following percentage composition:—

Siliceous matter	6·000
Ferrous oxide	26·100
Ferric oxide	51·800
Sulphur	0·075
Phosphorus	0·010
Metallic iron	56·560

Near the southern wall, in the face of the lower cut, at F, fig. 2b, appears another outcrop of ore, of a width of 4 feet, dipping a little north, and striking in a westerly direction; its whole habitus is veinlike, while the ore itself is composed of a number of streaks of pure ore, and a mixture of black hornblende rock, with magnetite. A sample of this ore analysed gave the following:—

Siliceous matter	11·580
Ferrous oxide	24·430
Ferric oxide	48·410
Sulphur	0·370
Phosphorus	0·004
Metallic iron	53·880

Its continuation in a westerly direction is indicated by a streak of magnetite ore, several inches in width, along the southern wall; apparently forming a part of the more southerly portion of the vein.

Near the southwestern corner of the open-cut is a small shaft, measuring on its surface 6 feet × 3 feet. This shaft is reported to have served as a manhole during the operations, and to connect the shaft at 50 feet depth with the main shaft, which is located farther north. At the time of the examination this little shaft was full of water, and nothing of any importance could be detected on the exposed walls near the surface.

Returning to the little bridge at A, we find in the upper level (II), a number of outcrops of magnetite all along the northern wall; also at a point G, about 40 feet from A, at the bridge, in a western direction. Here, in a crushed zone, a number of small lense-shaped deposits can be seen, whose largest dimensions do not exceed 4 feet. These small patches appear to be the remnants of larger deposits already worked out from the upper level, or a portion of a number of small, limited, pockets of ore. Following along the wall just referred to, we notice the results of dynamic pressure, in the limestone masses. In some parts the rock has assumed a decidedly slaty or schistose structure throughout, with the development of talcose matter. Numerous cracks and faults can be seen on both the southern and northern wall, and, on account of the great irregularity in which these small fissures are arranged, it is very difficult to arrive at a definite conclusion as to the direction of these crushing forces. This shearing, and consequent faulting, has undoubtedly affected the value of some of the ore lodes above alluded to, in cutting and splitting them up into smaller patches and pockets, and depositing them sometimes out of the general range of the ore lodes. Slickensided surfaces can be noticed, and the sides of these fissures are often coated with a soft, greenish, slippery material, probably finely crushed chlorite, and hornblende, as a result of the action of the thrust movement.

At a point about 560 feet from the entrance, and near the main shaft K, two parallel veins set in, sections of which may be seen in the northern wall, at H and J. The ore lode at H corresponds, in the detailed arrangement of its section, as well as strike and dip, with vein at C, and may be said to be identical with the latter. The ore lode has a width of 4′-3″, and consists of a number of streaks, composed partly of clean magnetite, and a mixture of the latter with a greenish black hornblende rock, but the whole of the vein appears to be of very promising character. At a distance of 8 feet, to the north, another vein, J, can be noticed. This ore lode has a width of 20″, consists of alternating streaks of pure and lean ore, has the same strike and dip as the ore lode in H, and can be seen in the wall up to the crest of the hill, a height of 42 feet.

At a distance of 40 feet from vein H another promising ore lode, L, is noticed. Conforming with the strike and dip of all the other veins so far described, it has a total width of 4 feet. A section is given in fig. 3.

As will be seen from the figure, the ore is aggregated in sheet-like zones, which are distinguished from the containing formation by their contents in magnetite.

The ore lode has no well defined walls, as the relation of the ore to the limestone is one of gradation, conditioned by the presence of hornblendic material. The character of the ore varies rather widely. The average grade may be said to consist of about equal proportions of magnetite and gangue

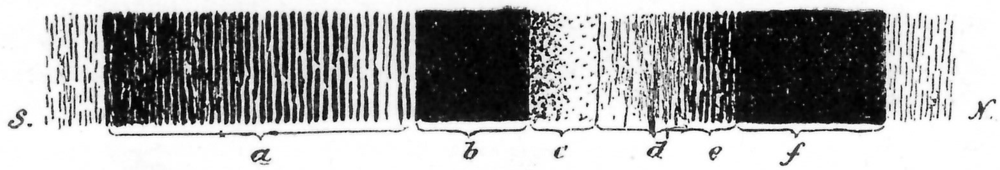

FIG. 3.—Section of ore lode (see Fig. 2, b). Scale 1 inch to 1 foot.

a. 18″ streaky ore; *b.* 7″ clean, very hard ore; *c.* 4″ green syenitic rock; *d.* 6″ mica schist (chloritic); *e.* 3″ streaky ore; *f.* 9″ clean hard ore. (Both walls of the ore lode are composed of hornblende rock.)

materials, though zones of pure ore may be noticed in two places. The gangue consists principally of dark greenish hornblende, sometimes of a schistose character, with streaks of chlorite, and other minor constituents of the wall-rock. In the leaner portions the magnetite is evenly disseminated through the rock, while fine green streaks of chlorite with large scales are frequent. In the selvage planes sometimes a film of scaly mica, with graphite, can be noticed, the latter consisting of aggregations of fine and larger scales.

An analysis of a sample of the ore gave the following:—

Siliceous matter	16·000
Ferrous oxide	30·730
Ferric oxide	46·090
Sulphur	0·440
Phosphorus	0·026
Metallic iron	56·650

In examining more closely the upper portion of all the veins, J, H, and L, we notice that a fault has cut off all of them, and that no trace of the veins can be detected, above the fault, close to the crest of the wall. This fault apparently strikes northeast-east, with a northerly dip, and its continuation can be traced to the southern wall. The ideal profile of the ore lodes described above is given in fig. 4, which represents a cut vertical to the bedding planes.

We see from the above cut, that of a total of 17 feet, 9 feet is taken up by ore lodes, and 8 feet by country rock, a fact to which the writer will refer later.

In proceeding beyond vein L, we notice no more iron outcrops of importance, until we reach the end of the long cut. Here, unfortunately, the whole face of the cut is hid by debris, but at a height of 25 feet, in a prospecting ditch 26 feet long, 3 feet wide, and 12 feet deep, crossing a ravine, we find several outcrops of good ore, with layers and streaks of greenstone, probably hornblendic rock. Of a whole breadth of 24 feet, the ore is distributed over 15 feet in the manner indicated in fig. 5.

An analysis of a sample of ore gave the following:—

Siliceous matter	11·000
Ferrous oxide	26·100
Ferric oxide	57·310
Sulphur	0·390
Phosphorus	0·014
Metallic iron	60·460

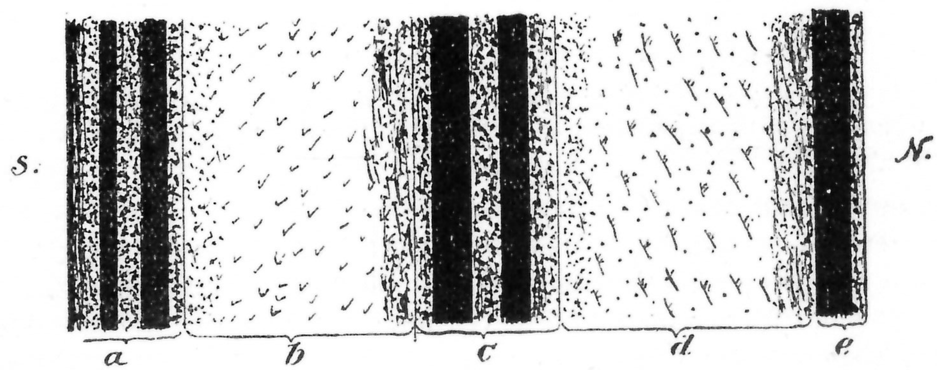

FIG. 4.—Section through ore lodes at J.H.L. Scale 1 inch to 8 feet.

a. 47″ of ore (see Fig. 3); *b.* 8″ of hornblende, with streaks of ore; *c.* 5″ of clean ore mixed with concentrating ore; *d.* 9 feet crystalline limestone; *e.* clean ore from 15″ to 20″ wide.

Most of the ore here consists also of parallel rich, and lean zones, and is bordered to the north and south by crystalline limestone.

In comparing these outcrops with those occurring at L, H, and J, especially their strike and dip and general habitus, one arrives at the conclusion

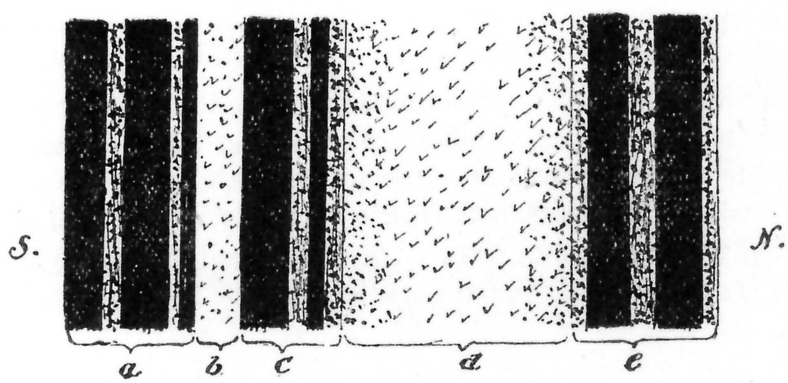

FIG. 5.—Section through ore lodes at M. Scale 1 inch to 8 feet.

a. 6 feet of ore; *b.* 20″ of hornblende rock; *c.* 3′-6″ of ore; *d.* 8 feet greenstone (hornblende rock?); *e.* 5′-6″ of ore.

that, apparently there is no relation or connexion between the two series; and that, therefore, they should constitute two distinctly separate ore bodies, which have been worked from the upper level. We should then also judge that a continuation of this strong ore lode at M should be met with in the long cut, either in the bottom or in the walls. As little could be seen in the latter to justify this contention, and as the bottom of the long cut was entirely filled with debris, excluding from view any possible exposures of ore, it was out of the question to study the problem based on the appearances and facts presented. But information received concerning the working of the ore bodies in the western portion of the long cut, seems to point to the probability that little ore was mined between the big shaft K and a point N (see fig. 2b), except that which came from the vein, J, H, and L. Moreover, taking into consideration the fault which cuts off the veins at H and G in their higher portions, as above referred to, it would seem that the veins at H, L, and M, are the same, the former one having been cut off, and its western portion thrown out of its course in a southerly direction, by disturbing forces. One fact, however, seems against this supposition, and that is, the apparent lack of uniformity of both ore lodes. While in H and L, out of a total of 17 feet, 9 feet is taken up by iron ores, and distributed over only two veins of a mixed character, in M we have, out of a total of 24′- 6″, altogether 15 feet of ore, distributed over three veins. From what can be noticed in the big cut, as well as in other mines of like character, the same ore lodes are subject to great variations; they sometimes split up into smaller veins, which may again coalesce and form a wider vein; they suddenly take the shape of a drawn out lense, and so on. For this reason the lack of uniformity seems to form a weak criterion in this case.

Following the ore lodes from M, in a westerly direction, we find no outcrops in the little ravine, for over 150 feet, but proceeding farther, to a point where a deep natural cut commences, we find several exposures of ore, some of which, however, may be large lumps of iron ore from the dump. At a distance of 180 feet from M, a longitudinal opening has been made in the strike of the ore lode, measuring 80 feet in length, and 12 feet wide, but the depth of the shaft, on account of the latter being filled with water and debris, could not be measured. From reliable information, however, it has been ascertained that this depth is 106 feet.

The only exposure of ore in this shaft was at the western face, where about 4 feet of ore, intermixed with country rock, could be seen. This width of ore is reported to have been maintained to the bottom.

It must be mentioned that the line between lots 11 and 12 crosses shaft 0 exactly in the middle (see fig. 2a), and that operations on lot 12 are of much later date than those of the Forsyth mine. On this property not much development work has been done, and the only outcrop which has not only an economic but also a scientific value, occurs in the direction of the long cut, about 350 feet from shaft 0. The workings consist of a rather shallow cut into the side of a hill, following a vein of iron ore, for a distance of 22 feet, and a width of from 4 feet to 6 feet. The occurrence of iron ore appears to be somewhat complicated on this spot, because a vein of 2 feet width, of excellent ore, occurs at the face, and also in the bottom of the cut, while there is

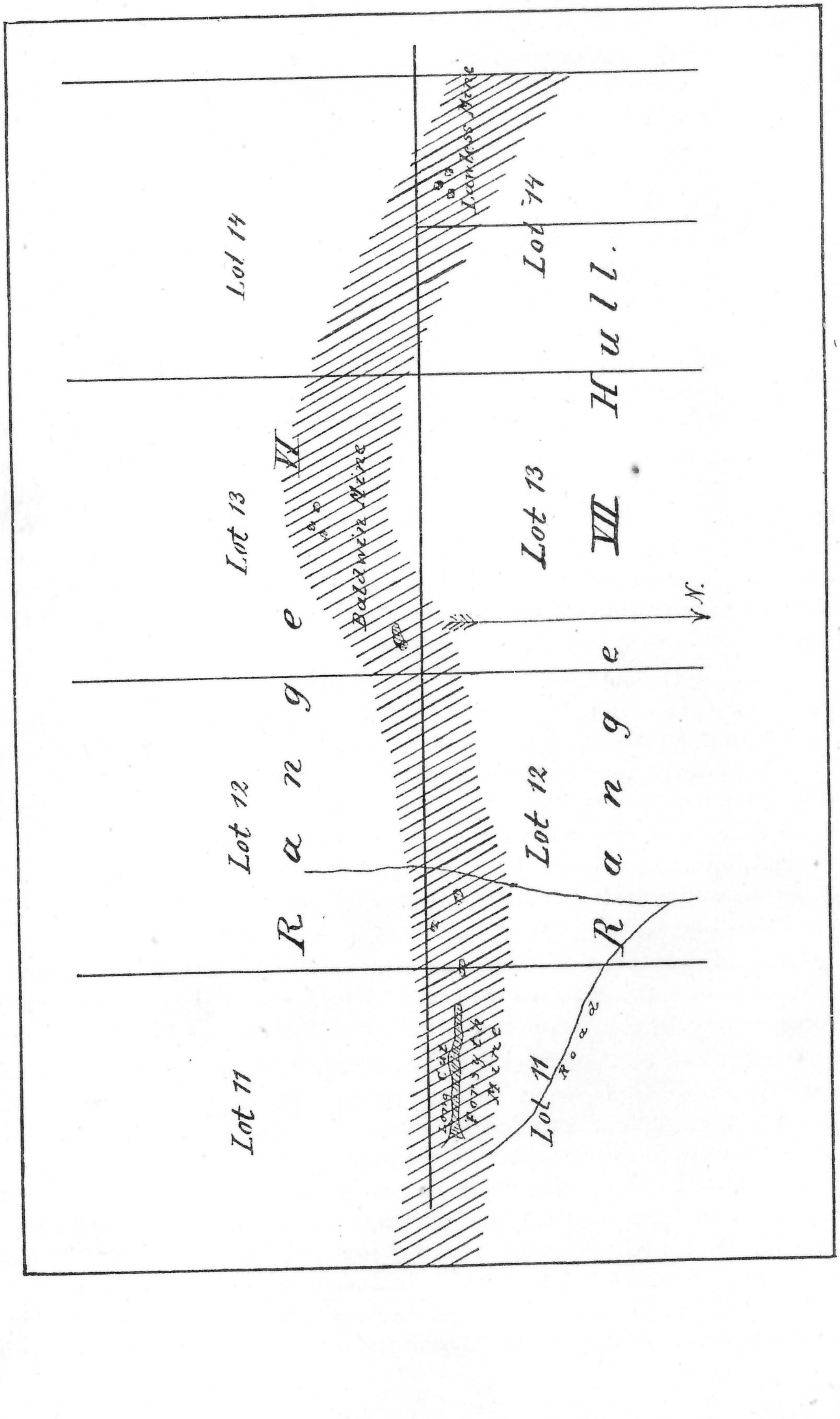

FIG. 6.—Hull-Forsyth iron range. Scale 1 inch to 1,000 feet.

apparently another vein immediately to the left of the entrance to the cut, forming a so-called blanket vein. The vein in the face of the cut seems to have been exposed to disturbing forces, because its vertical course is of a winding character, changing from a northerly steep dip in its upper portion to a rather flat dip to the south in the bottom of the pit. The whole phenomena could not be studied very well on account of the water in the workings. However, two theories may be advanced in explanation of the same. If the vein appearing in the bottom of the cut was found to continue throughout, and connected with the one in the face during the course of operations, though that cannot now be determined, then the vein appearing on the side, north of the drift, has no genetic connexion with the one just described, and its position must be explained by other agencies than faulting movements. If, however, no ore was mined from the vertical vein, except perhaps in the lowest portions, and at least for the distance the horizontal bed appears, then the latter must have been part of the vertical vein, and has been subjected to distributing forces, which probably broke off the vein, and placed the same, with the containing crystalline limestone, in the present position. Be this as it may, the whole formation has been subjected to a series of folding and disturbance, which cannot be well studied on account of the little development work done in that part of the property.

A sample of magnetite, from the ore lode near the entrance, was analysed, and gave the following results:—

Siliceous matter	8·000
Ferrous oxide	26·870
Ferric oxide	58·890
Sulphur	0·473
Phosphorus	0·006
Metallic iron	62·120

Another opening on lot 12, farther south of the one just described (see fig. 6), consists of a shallow cut into the side of a hill, about 20 feet long, with a face of about 25 feet high, and 15 feet wide. There does not seem to be a regular lode of the character met with in the great cut of the Forsyth mine; the ore occurs here rather in lenses and pockets, and streaks of an irregular character, apparently constituting a veinlike body. It contains a great deal of iron pyrites, and its value for smelting purposes, on that account, is diminished.

An analysis of a sample, supposed to be the average of 4 feet of ore, gave the following:—

Silica	17·220
Sulphur	1·071
Phosphorus	0·040
Metallic iron	57·130

5

Fig. 6.—Hull-Forsyth iron range. Scale 1 inch to 1,000 feet.

The Baldwin Mines.

These mines are situated in the northern part of lot 14, range vi (see fig. 7), and form the continuation of the iron bearing formation described in connexion with the Forsyth mines. What has been said in general respecting this formation, fully applies to the Baldwin mines also, with the single exception, as regards the ore deposits, that they do not show such regular veinlike bodies as are observed at the Forsyth mine. Although very numerous, and quite extensive, the ore deposits constitute rather an accumulation of small, and large pockets, lenses, disseminations, and deposits of irregular shape, following, more or less, the general trend observed in the Forsyth locations. The veinlike character is pronounced in a few places only, and it seems that the formation, in general, has been subjected to disturbing forces, which are, to a large extent, responsible for the detached position of some of the ore bodies. The occurrence of the ore is confined to a hilly range, in the northern part of the property, with east-westerly strike, and is distributed over a length of approximately 1,100 feet. The ore is covered, for long stretches, with a capping, and only occasional outcrops in the latter indicate its course, and continuation in an east-westerly sense. There has been a great deal of work done all over this part of the property, but it is of a more scattered

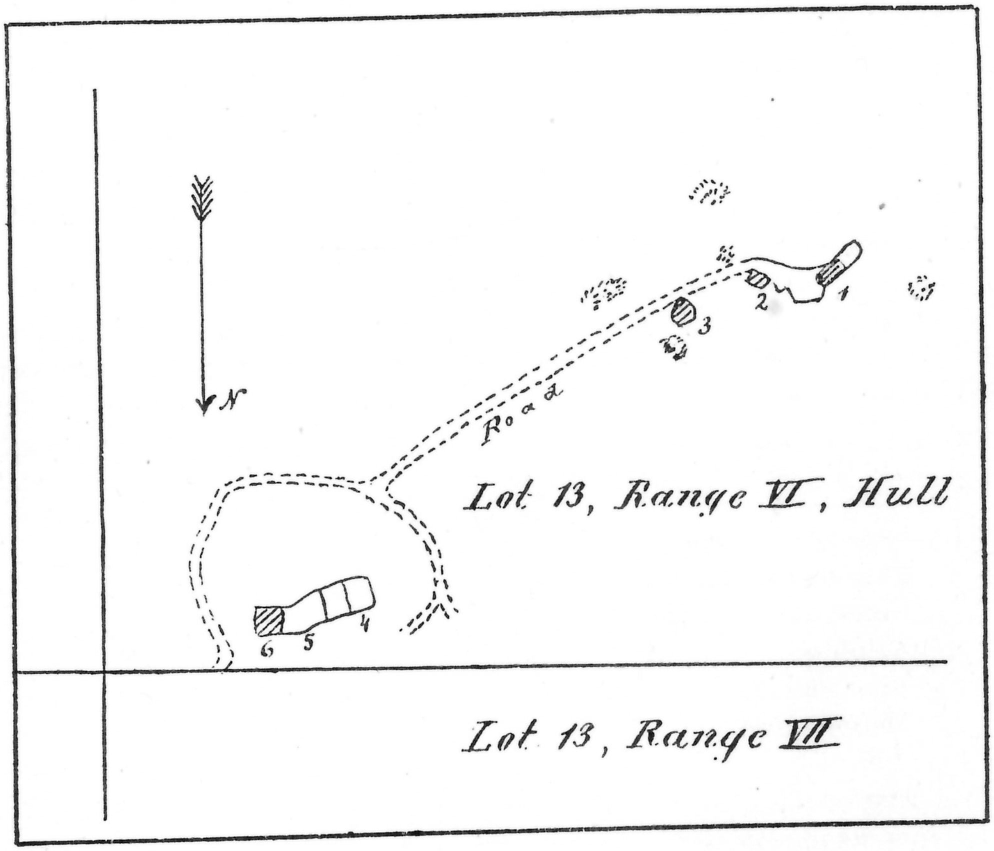

Fig. 7.—Baldwin locations. Scale 1 inch to 300 feet.

nature than that of the Forsyth mine, and confined to the iron range, over a length constituting nearly the whole width of the lot. This work consists mostly of open-cuts, pits, excavations, and other work of varied description.

The most westerly pit (No. 1), has a width of 20 feet, a length of 40 feet, and an approximate depth of 50 feet. When visited it was filled with water, and a thorough examination of the wall and bottom could, therefore, not be made. The pit has a general east-west trend, and on the eastern face a vein of iron ore 30″ in width can be noticed, in a coarsely crystalline limestone.

A sample of ore from the dump gave the following analysis:—

Siliceous matter	11·000
Ferrous oxide	30·600
Ferric oxide	46·990
Sulphur	0·263
Phosphorus	0·006
Metallic iron	56·690

The ore is not pure, hornblende rock being the principal admixture. It occurs in parallel streaks, and gradations, due to the presence of impurities. To the west of this pit the vein can be noticed again, turning more to the south, in a width of 4′-6″. Streaks of rich ore occur in the southern parts of the vein, while impurities are more frequent in the remaining parts. About 70 feet to the east is another opening (No. 2), 20×10 feet and 25 feet deep, in the course of the vein found in No. 1; but as this pit was also filled with water, and as no ore could be seen near the collar except a few small pockets, no further details can be given.

A sample of ore from these pockets gave the following analysis:—

Siliceous matter	6·780
Ferrous oxide	29·190
Ferric oxide	60·790
Sulphur	0·173
Phosphorus	0·012
Metallic iron	62·980

Northward from this pit several outcrops of iron can be seen, some of them of high quality, but as the work was rather of a superficial character, the extent of the deposits could not be well established. From what can be seen, it appears that the ore occurs in pockets, and small lenses, having no connexion with the vein described in pits 1 and 2, but forming detached, isolated masses.

About 80 feet from No. 2, northeasterly, another pit (No. 3), has been sunk, in what appears to be considerable accumulations of irregular deposits of iron ore. This pit measures approximately 45 feet × 31 feet, and its depth is about 25 feet. On the western side of the shaft a number of pockets appear, but whether they form part of a larger deposit, or of a veinlike occurrence, could not be determined. Much of the rock, which consists mostly of the usual dark, greenish, hornblende variety, and which can be seen all around the pit, as well as on the surface, contains ore in streaks, in lenses, irregular pockets, and impregnations. In some places it occurs in small, but pure, patches, of the size of one's fist.

A sample of ore gave the following analysis:—

Siliceous matter	5·360
Ferrous oxide	28·800
Ferric oxide	61·860
Sulphur	0·170
Phosphorus	0·006
Metallic iron	63·460

At a distance of about 540 feet from pit No. 3, in a northeastern direction, a good deal of stripping and blasting has been done, over quite an extensive area, No. 4. The rock is rusty looking, sometimes greenish and blackish, and the ore seems to maintain its irregular distribution throughout this rock as observed in pit 3, but much of the ore is of excellent quality.

A sample of this ore analysed gave the following percentage composition:—

Siliceous matter	15·380
Ferrous oxide	31·240
Ferric oxide	48·510
Sulphur	0·054
Phosphorus	0·018
Metallic iron	58·260

At a distance of about 100 feet from pit 4, an area measuring about 60 × 40 feet (No. 5), along a bluff of rock, has been thoroughly stripped, and in some places blasts have been put in, which, more or less, exhibit iron ore. The formation is the same as observed on No. 4, being blackish green, hornblende, occasionally grading into a mica diorite, of which the rich bluff just mentioned consists. In many places the ore is adherent to the rock, and no distinct selvage can be seen. Impregnations are frequent, and sometimes accumulations of the latter form considerable parts of the formation. No distinct veins, or veinlike occurrences, could be recognized, and the nature of the rock, so far conducted on that spot, seems to substantiate this statement.

Just below No. 5 an open-cut into the hill, 80 feet in length, and 30 feet in width, has followed a deposit of ore, which appears to be of considerable dimensions. At one place, at the western terminus of this cut, in the face, a vein of iron ore of a mixed character can be noticed. This deposit, at the western side, has a width of 11′-6″, but of this, however, only several parallel streaks are really good ore, the remainder consisting of hornblende rock, impregnated with magnetite, and sometimes mixed with iron pyrites.

A sample of ore taken from the principal vein gave the following composition when analysed:—

Siliceous matter	7·680
Ferrous oxide	30·700
Ferric oxide	57·370
Sulphur	0·200
Phosphorus	0·012
Metallic iron	63·870

THE LAWLESS MINE.

This mine is situated in a northwesterly direction from the Baldwin mines, on the southwestern part of lot 14, range vii, and on the crest of a steep hill. The principal opening is 15 × 15 feet, and about 30 feet deep, and is sunk in a white, coarse grained limestone. On the eastern side of this pit some mixed ore can be noticed; impregnations are frequent but no regular vein is met with. This pit was filled with water, and no reliable information could be obtained regarding the results of the work in the same.

Below this pit, about 120 feet directly eastward, is another opening, 20 × 10 feet, which was also filled with water. On the eastern side of this pit some pockets of ore were noticed, apparently of very good quality, but, apart from this, the exploration work has yielded nothing of importance on the surface. In comparing this property with the Baldwin mines, the absence of the dark hornblendic rock, in association with the iron ore is noteworthy. The surface, and the various dumps, do not exhibit its presence, but what was found in the bottom of those two pits is not known. The ore which can be seen appears to be of an excellent quality, and generally free from objectionable impurities. As mentioned above, no solid ore body of extent can be seen on the surface; the latter, however, exhibits limited pockets, lenses, and disseminations, through the limestone.

This mine, as well as the Baldwin mines, offers great facilities for mining operations. Both are located on the slopes of mountainous ranges. There is also a good supply of wood and timber, for general purposes, on the premises.

THE ORES OF THE HULL IRON RANGE.

The principal constituent of these ores is magnetite, intermixed at some places with hematite, and associated with a gangue material. The character of the ore, therefore, varies rather widely. Sometimes pure magnetite, is met with; sometimes a mixture of both magnetite and hematite: the latter recognizable by the generally red streak it makes, accompanied by more or less gangue material. In the absence of data regarding the average character of ore from previous shipments, it seems that the average grade would consist of about three-quarters of magnetite, sometimes mixed with hematite, and one-quarter of gangue materials; the latter comprising all the minerals enumerated and described below. Nowhere is the magnetite uniformly distributed over the whole width of the veinlike occurrences, but very often this is the case in the smaller parallel streaks of which they are composed. The ore is aggregated along sheet like zones, which are distinguished from the country rock, only by their abnormal richness in magnetite. It might be said that no well defined walls with a selvage exist, as the relation to the containing limestone is one of gradation. Occasionally lenses and pockets, or irregular bodies of ore, are met with, but they occur mostly as companions to the veinlike occurrences, and are seldom isolated. The ore in these is of the same character as that met with in veins, that is, it consists mainly of magnetite, with some hematite, and more or less gangue material. Most of the magnetite is highly crystalline, and occasionally small crystals are found, in the form of cubes, or cubo octahedrons. The colour is generally black, the greenish tints sometimes observed are due to the presence of hornblendic, or chloritic material. The lustrous black of the magnetite, the clear white, sometimes pink, calcite or quartz, and the green tint of the chlorite, give this lean ore a brilliant appearance, which, however, is excelled by that portion of the ore body frequently met with, where the purer mineral is found, and where innumerable crystal faces reflect the rays from the sunlight. The ore is generally of hard texture, but when exposed to the air for some time, especially the impure variety, crumbles, and the particles separate easily, offering then satisfactory conditions for producing concentrated ore from the lean material.

Minerals Associated with the Hull Magnetite.

The magnetite of the Hull mines is associated, as a rule, with several other minerals, which, on account of their importance in the production of the iron from these ores, will be described separately. Among these associated minerals the more important ones are calcite, chlorite, graphite, hornblende, hematite, pyrite, quartz, and pyroxene.

The calcite occurs frequently in crevices of the ore, in the form of small but perfect crystals, in hexagonal prisms, and in scalenohedra. Rhombohedral crystals have also been observed, but these seem to be less frequent than the other forms. There are also granular and cleavable aggregations of this mineral, and this occurrence is characterized by its arrangement in small parallel veins in the ore. In limited quantities, calcite cannot be regarded as an injurious accompaniment of these iron ores, because, if it is not present in the latter, it has to be added, in order to produce slag in the smelting process.

Chlorite is a frequent concomitant of the Hull ores. It is often found on bedding or selvage planes of the ore, and causes the latter to be easily detached from the wall-rock. It is found also in small veins, and streaks, sometimes in lenses through the ore body, and gives the latter a peculiar greenish tint. Sometimes a pure massive variety, made up of a confused aggregation of small scales, occurs with quartz. It also occurs disseminated in dark green scales through the ore. The chlorite has an eminently foliated structure, often of large scales, and resembles talc on the one hand, and the micas on the other.

Graphite occurs in the form of scales, mostly of larger size, from 4 to 6 mm. long, disseminated through much of the magnetite of the Hull mines. It commonly occurs in micaceous or scaly forms, seldom in aggregations, but mostly in isolated patches or scales. Sometimes the contact with the wall-rock is characterized by a film like arrangement of large graphite scales, and at first sight the ore has more the appearance of graphite than of iron ore. In the large veins at the Forsyth mines, it appears that the graphite scales in some parts of the ore are arranged, for the most part, parallel to the contact planes, which gives the ore a streaky appearance. It is not found in such a pure state that it can be readily separated from the ore; it is, moreover, intimately mixed with the latter, and in some parts of the ore-bearing formation it constitutes the principal ingredient. When separated from the iron the graphite scales are very pure, yielding, as analyses have shown, from 95 to 99 per cent of carbon. They have a highly metallic lustre, are soft and flexible, and possess great colouring power.

Hornblende is the most frequent of all the mineral associates of magnetite. This mineral is of a dark greenish to blackish colour, and forms the principal gangue material of the iron deposits. It occurs in scattered bunches, and is also uniformly disseminated through the ore. Conditioned by the presence of this mineral, the ore forms gradations in the deposits, and sometimes a gradual change from a fine grained into a coarse grained hornblende, and from this into pure iron ore, can be noticed, the whole appearing as a parallelism of streaks. Hornblende does not occur in cleavable masses; it is massive, and is, as a rule, adherent to the ore or wall-rock. As mentioned above, sometimes streaks, and small long drawn out lenses and veins of chlorite, are met with, associated with the hornblende, or forming the contact between this and the wall-rock. A gradation from chlorite into hornblende is also observed, and small crystals, or crystalline aggregations of magnetite, form the principal part in the transition. Most of the hornblende associated with the magnetite is ferruginous, and some parts have a red flesh colour resembling hematite. The presence of hornblende rock in a limited quantity is rather an advantage than otherwise, unless the ores have to be transported for long distances; for besides a certain portion of iron, they contain constituents essential to the formation of slags.

Hematite, often of the specular variety, is also associated with magnetite. Its presence is sometimes manifested by the red, or reddish colour of the ore. At other times the ore is black, or greyish black, but is shown to consist in part of hematite, by yielding a decidedly red powder to the drill. It is probable that in the latter case the hematite is present in the crystalline condition, while in the former it is earthy. Some of the magnetite collected shows the fine interstices between the crystalline aggregates taken up by fine veins of a red hematite, imparting to the ore a streaky appearance. Other specimens exhibit magnetite, with streaks of hematite in various directions. Small veins of calcite, quartz, and a very fine grained iron pyrites can also be noticed, while large scales of graphite, and brilliant black hornblende, are disseminated through the ore. One specimen consists of two parallel layers, each about 1″ thick, one of coarsely granular magnetite, and the other of compact red hematite, not at all magnetic, the two being somewhat intermingled for half an inch at the junction. Grains of greenish feldspar are disseminated in the magnetite, and both it and the hematite contain embedded crystalline plates of graphite, about 3 millimetres long. A film of scaly graphite coats the free surface of the hematite layers.

The occurrence of pyrite at several places on the Hull iron range is more frequent than desirable; however, in all cases where this mineral is associated with magnetite it can be easily removed by hand picking, as it is rarely observed in quantity. There appears to be only one deposit, and that of apparently limited extent, where the magnetite is intimately mixed with pyrite, prohibiting its use for furnace practice; and that is on lot 12, range vii. Occasionally it is well crystallized; but more frequently it occurs in minute grains scattered through the ore, or in little strings, streaks, and veins. At the Baldwin mines the ore seems to be nearly free from it, but it appears more frequently in the Forsyth mines, where it occurs both in disseminated grains and little veins. One hand specimen before me is composed of several small alternating layers of magnetite, reddish calcite, quartz, fine grained iron pyrites, and hornblende, intermixed with some biotite mica. The finally crystallized iron pyrites is sometimes met with at the selvage between the iron deposits and the country rock; it is found also in small cracks, and the crystals exhibit here a more perfect shape. It forms also occasional masses of several inches in diameter, but in this condition it can be more easily removed than when in the more finely disseminated aggregates.

Pyroxene is also a frequent associate of the magnetites, in the Hull range, though not so common as the hornblende. At the Forsyth mine the crystalline limestone, adjoining the magnetite veins, contains crystals of pyroxene, some of which are green, others are greenish yellow, and also transparent. One of the rocks associated with the big ore deposits is a diabase, and, therefore contains pyroxene as one of its constituents. The pyroxene also occurs in small streaks in the hornblende rock, and sometimes also in association with the ore itself.

Quartz is not abundantly met with in the Hull ores. It is usually found in small veins and cracks accompanying the magnetite, is of highly crystalline character, and of glossy, transparent appearance. It follows irregular joints and fault zones, and occasionally the bedding for some distance. Fine red streaks of hematite are occasionally met with, while magnetite crystals are sometimes found embedded in the same.

Talc is also found in association with the magnetite at the Hull ore bed, apparently in the form of steatite, the earthy variety. In the latter case it appears to be the result of the alteration of actinolite. This talcose, slippery material, is also frequently found in association with the ore, in places where the latter has been cut off by faulting, and the ore has then more or less slickensided surfaces. A specimen was observed where steatite covered the slickensided, or polished surface of the magnetite, in a layer of several inches in thickness. In another specimen a mass of steatite formed the wall of a small quartz vein, the latter attached to magnetite.

There are several other minerals found in association with the magnetites of the Hull range, but these are considered of no importance, and as having no material influence upon the character of the ore, or its economic usefulness.

Chemistry of the Ore from the Hull Iron Range.

From the following analyses (page 58) it will be seen that the Hull iron ores—if some attention is paid to the separation of the crude ore from the accompanying gangue—contain all the way from 53 per cent up to about 67 per cent of metallic iron; the highest percentages being always obtained from magnetite ores free of hematite.

The sulphur is present in the form of iron pyrites, and is in some cases confined only to the edges of the deposit. The writer believes that in actual mining these parts of the deposits can be passed by, or the iron pyrites can be eliminated by cobbing, thus reducing considerably the content of sulphur.

The great variation in silica is due to the fact that, the iron ore grades into ferruginous hornblende. Rocks can be obtained, showing all percentages of iron and silica; but those containing a sufficient amount of iron to be classed as ores, contain an average of from 8 to 10 per cent of silica.

As phosphorus, in considerable quantity, prevents the use of ores for the Bessemer process, the phosphorus content in an ore is of the greatest importance. The requirement of such an ore is, that the percentage of iron must be at least 1,000 times the percentage of phosphorus. In looking over the analyses we find that only in one instance—and that is in the analysis of the second column—the phosphorus contents were higher than the permissible limit. All the other ores analysed, contain very little phosphorus.

Summary of Investigations Regarding the Hull Iron Range.

Having described in detail the iron ore bearing formation, together with the ore deposits so far discovered in the same, it remains now to consider the iron range as a whole, its extension and prospects, and also the further investigation of the iron ores with regard to their commercial value.

In fig. 6 the areas containing iron ores of present commercial value have been shaded. It must be said, however, that the ore deposits do not occupy all the areas shaded, but each of the latter contains some iron ore of more or less economic importance. The following features of distribution may be

Analyses of Iron Ores from the Hull Iron Range.

Constituent	1*	2*	3*	4	5	6	7	8	9	10	11				
Ferrous oxide	73·90	93·82	66·20 17·78	23·66	26·10	24·43	30·73	26·10	26·87	......	30·60	29·19	28·80	31·24	30·70
Ferric oxide				51.87	51.80	48.41	46.09	57.31	58.89	......	46.99	60.79	61.86	48.51	57.37
Oxide of manganese	none	0·12	traces	......	......	......	......	......	......	......	......	......	......	......	......
Alumina	0·61	0·79	......	......	......	......	......	......	......	......	......	......	......	......	......
Lime	none	0.45	1·85	......	......	......	......	......	......	......	......	......	......	......	......
Magnesia	1·88	0·94	0·18	......	......	......	......	......	......	......	......	......	......	......	......
Phosphorus	0·027	0·08	0·015	0·004	0·010	0·004	0·026	0·014	0·006	0·040	0·006	0·012	0·006	0·018	0·012
Sulphur	0·085	0·11	0·28	0·230	0·075	0·370	0·440	0·390	0·473	1·071	0·263	0·173	0·170	0·054	0·20
Silica	20·27	3·75	11·11	14·16	6·00	11·58	16·00	11·00	8·00	17·22	11·00	6·78	5·26	15·38	7·68
Titanic acid	none	......	none	......	......	......	......	......	......	......	......	......	......	......	......
Graphite	......	......	0·71	......	......	......	......	......	......	......	......	......	......	......	......
Water	3·27	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Insoluble matter	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Carbonic acid	......	......	1·17	......	......	......	......	......	......	......	......	......	......	......	......
	100·042	100·06	99·295												
Metallic iron	53·51	67·94	60·17	54·71	56·56	53·88	56·65	60·46	62·12	57·13	56·69	62·98	63·46	58·26	63·87

*Samples 1, 2 and 3 have been analysed by Dr. B. J. Harrington. (Geol. Survey Rept. 73–74, page 211). No. 1, black ore; No. 2, a picked specimen; No. 3, the so-called red ore, a mixture of magnetite and hematite.

noted. The deposits are quite numerous in the extreme eastern part of the range, but are lacking—at least so far as present investigations have shown–or thin out, in the extreme western portions. The total extent of the iron bearing area may be put down as having a length of, approximately, 6,800 feet, while its width ranges from 40 feet up to 100 feet. Commencing at its eastern portion, the iron range takes a northwesterly course, as far as the outcrops on lot 12. It turns then a little to the southeast, taking in all the deposits at the Baldwin mine; and at the lines between lots 13 and 14 it takes again a northwesterly course. Indications of iron ore have been noticed farther west of lot 14, beyond the Lawless mine, but so far no large deposits have been discovered. Towards the extreme east of the range the limestone is overlaid by a heavy mantle of humus. As far as the writer is aware, no serious investigations as to the extent of the iron bearing range have been made in that part of the country, although such should prove very interesting. While no ores of commercial importance have been found so far to the north or to the south of the range, it is not satisfactorily proved, by actual drilling, that iron ore deposits do not occur in those parts of the crystalline limestone.

Towards the west, on lot 14, the deposits apparently thin out, but no adequate reason is known why extensive ore bodies, or veins of the same quality as those found in the Forsyth mine, should not be found there in quantity.

As to the extent of the ore deposits in depth, it must be said that, apart from conjectural evidence, no reliable data, or facts, are at hand. It is reported that the greatest depth attained from the bottom of the upper cut, in shaft K, is 180 feet. Cross-cuts to the south and to the north have been driven, but with what result is not known. In addition to this, during the summer season of 1906, extensive diamond drilling was undertaken, by a large steel company of the United States, under the management of Mr. Herbert N. Westaway, an experienced mining engineer and diamond driller, having the above object in view. A series of holes were put down along the northern side of the long cut in the direction of the latter, under angles varying from 40 to 70 degrees from the horizontal. For private reasons, the results are kept secret, but it is reported that they are satisfactory. At the Baldwin mines the greatest depth obtained was 60 feet, but the results obtained in such a shallow depth cannot carry much weight in judging the probabilities for the extension of the ore bodies with depth.

In the absence of reliable data, then, it is very difficult to intelligently deal with these intricate questions, and any opinion advanced must of necessity be of a conjectural nature. There is no reason to suppose that there could be any material change in the character of the ore bodies, or of the quality of the ore, at least for a depth of several hundred, or even a thousand feet. The crystalline limestone belt in which the deposits occur is strongly developed, having a width of at least 200 feet, and extending for 1¼ miles, and there is no evidence—at least from a geological point of view—that the same, as an integral part of the Laurentian formation, should change its structural, as well as mineralogical character, in the limits considered. If then, from a genetic point of view, the deposits have an origin which excludes their superficial character, we may say that all conjectural evidence submitted points to the probability that the deposits will continue with depth.

Another, and not less important question may be asked, what are the prospects for an immediate ore supply? In answering this question we have to consider the amount and character of the exploration work done all over the range. While it is true that most of this work does not admit of a calculation based on actual measurements of exposed ore bodies, still the great amount of ore exposed at the Forsyth mines leaves little doubt that, with proper mining methods, a large quantity of iron can be mined. The writer believes that at one point alone—between point M, the easterly terminus of the long cut, and the shaft—at least 40,000 tons of ore can be readily mined, not considering the various strong ore lodes which are exposed on the northern wall at J, H, and L. How many tons of iron ore have been raised during the course of actual operations cannot be said with certainty, as reports are rather conflicting. But on the adjacent lot 12, the writer has authentic information, that from the little pit described on page 47 of this report, from October 1, 1900, to February 1, 1901, the large amount of 1,034 tons of high grade ore were shipped.

No authentic information is at hand as to the shipments of the Baldwin mines. Here the quantity of ore exposed, although scattered, is of sufficient importance to justify mining operations on a large scale, and if the latter were confined to one or two long open-cuts into the hillside, taking in a number of the deposits exposed in the same manner as at the Forsyth mines, the results would doubtless be very satisfactory.

The Hull-Templeton Town Line Locations.

This group comprises a number of deposits along the boundary between the townships of Templeton and Hull, of which the most important one is the so-called Haycock iron mine, on lot 28, range vi, township of Templeton.

The rocks generally met with, in this region, are mostly composed of:—

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

(2.) Dark red, or brownish, coarse grained syenitic gneiss, composed of dark hornblende, and red orthoclase feldspar, in nearly equal proportions, with a very small admixture of quartz, and occasional crystals of iron pyrites.

(3.) Masses of flesh red orthoclase feldspar, often mixed with black or brownish mica.

The above three varieties of rock graduate one into the other. They appear to be the base upon which all the following rocks 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 rarely showing parallelism. Occasionally, however, where the mass is much broken up by atmospheric or other agencies, large annular blocks are met with, in which the faces are covered with a fine layer, or coating, of mica. Pockets and lenses of specular iron ore have been found in these rocks, but no exploitation has been done to show their true character and extent. There is also some dark coloured syenite observed, consisting for the most part of greyish and greenish hornblende, greyish feldspar, and a sparing addition of quartz and iron pyrites. In this rock, also, specular iron ore, in disseminated patches, has been found. In the district under consideration the occurrence of pyroxenic rocks is frequent, the latter being generally of a bottle green colour. These pyroxenic rocks are especially important, as they are intimately associated with the occurrence of apatite. They often run along lines of stratification, and have generally been regarded as integral parts of the containing gneiss. In many places they break directly across the course of the gneiss like dikes, veins or intrusive masses.

Their association with iron ore has been sparingly noticed, but it has been reported that in several pits, now not accessible, this green rock was very often a companion of the ore. Sometimes, it is asserted, the latter occurred at the contact of both the pyroxene rock and the gneiss.

The Haycock Location.

Before entering into a description of the various discoveries of iron ore on this property, it must be said that the examination, speaking from a mining point of view, was rendered more or less difficult, owing principally to the fact that no work had been done for over 30 years. All the larger pits were filled with water, while the smaller excavations were covered with such an amount of heavy vegetation, sometimes with trees, that the iron ore, in situ, or any outcrops, were entirely hidden from view.

In some more important places the vegetation or debris was removed. This was impossible in a great number of cases, because of the costly labour necessary, for which no provision had been made. The reader will, therefore, readily understand the difficulties encountered in the proper examination of the proposition in question, and that any opinion expressed on the value of the iron ore deposits must of necessity be, to a large extent, conjectural.

The Haycock iron location comprises an area of about 400 acres, and is covered by the following lots: The north half of lot 1, range xi, Hull, comprising 100 acres; the adjoining lot 28, range vi, Templeton, comprising 200 acres; and the south half of lot 27, in the same range, comprising 100 acres.

The principal deposits, and those which have been worked to some extent, are all situated in the northeast corner of the south half of lot 28, range vi, Templeton. For over 40 years it has been known that iron occurs on this lot; and in the report on the mineral resources of Canada, in 1866, Logan refers at length to the occurrence of hematite on the lot above mentioned. In all, nine outcrops of specular iron ore were mentioned, and of the quality of the ore it is said that, "the ore is very pure, being unmixed with any spar; in fracture it is fine grained and steel grey." However, the property, which belonged to Messrs. Darby, was not worked until the fall of 1872, when Mr. Haycock bought the same, and an additional 200 acres in the township of Templeton. In April, 1873, extensive operations were begun, which lasted, with few interruptions, until the fall of the following year. During this time a number of dwelling houses, offices, storehouses, residence for manager, stables, and powder house, were built, and the property put in shape generally for work on an extensive scale. There were also built four charcoal kilns, a forge of four fires, in which some very good blooms were made, a crusher house, and all accessories for combined mining and smelting operations. A tramway, 3 feet gauge, 6¼ miles in length, was built from the principal pits, through the property, along the town line between Hull and Templeton, to the Gatineau river, where connexion was made with the Canadian Pacific railway and all connecting railway and steamship lines at Ottawa and Montreal.

In addition to the above, a steam sawmill of 20 horse-power was erected, with all facilities for cutting timber and logs.

As to the results of these operations, which extended over several years, no authentic information can be obtained. It appears, however, that while the quality of the ore was excellent, the quantity necessary to keep the furnaces permanently in operation seems to have been lacking.

With the exception of some diamond drill borings, which were undertaken early in the eighties, near the present iron locations, and of which no records are now at hand, work has not been taken up since the year 1874.

As regards the topographical features of the property, it may be stated that the latter, on the places where the iron ores occur, is traversed by a number of more or less broken ranges, or high lands, running roughly parallel in a general northeasterly direction, with intervening stretches of somewhat marshy ground. The specular iron ores occur principally in highly feldspathic gneiss, of a reddish colour, interstratified by occasional grey bands, the whole being referable to the lower part of the upper portion of the Laurentian formation, as described under No. 1, on page 89. These strata have a general northeast and southwest strike, and dip towards the northwest, at an average angle of from 45 to 50 degrees.

Outcrops of bands of iron ore, running parallel with the stratification, occur more or less throughout the property, and are especially frequent on the slopes of the ridge along the central line of lot 28. The strata exhibit here sundry foldings and corrugations along their course, and thus it may happen that outcrops opened on the face of the ridge, although at somewhat different levels, and, therefore, apparently on distinct beds of ore, may be really on the same bed. Altogether 11 pits could be noted, centred in the northeast of lot 28, range vi, Templeton, as per fig. 8. Pit No. 1, fig. 8, is situated on the slope of a mountainous range, running through the property in a north-easterly direction. Its dimensions are 70 × 21 feet, while the depth, on account of its being filled with water, could not be accurately determined; however, it was learned from the original owner, Mr. Darby, that this depth would not be more than 20 or 25 feet. The writer was informed that this pit held a large body of iron ore, and that upwards of 2,000 tons have been

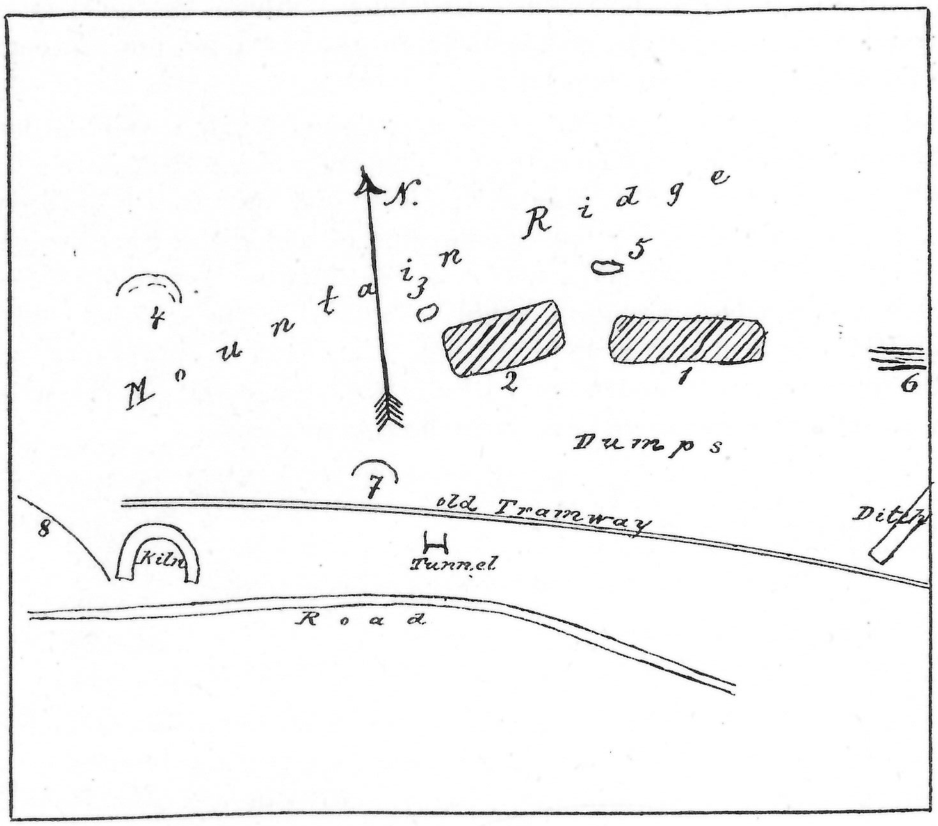

FIG. 8.—Haycock mines. Scale 1 inch to 100 feet.

mined from it. If this is true, the deposit must be a large isolated pocket, because no extension of the same, either in a northern, or in a southern direction on the exposed rock surfaces, towards pit 2, could be noticed.

A sample taken from the dump gave the following analysis:—

Silica	3·000
Titanic acid	3·520
Lime	0·100
Magnesia	0·600
Phosphoric acid	0·029
Phosphorus	0·012
Sulphur	0·004
Metallic iron	65·560

Pit No. 2 is an open shallow cut, 30 × 50 feet, running east and west. On the southern side a deposit of hematite has been followed towards the depth, but this pit also was filled with water, and a clear idea of the character of the deposit could not be gained. The high bluff, on the northern side of this pit, consists of a red granitoid gneiss, interstratified with some bands of lighter and darker grey. In some parts of this bluff a fine grained hornblendic rock can be noticed, which has undergone apparently a series of disturbances and faults, with slickensided surfaces, and containing fibred hornblendic material, or actinolite. Hematite is distributed through the rock, in small lenses and pockets, especially on the northern wall of the pit, but nowhere are there indications of a large deposit.

On the top of the high bluff, in an excavation, No. 3, a veinlike deposit of hematite, 7 feet long, can be noticed. This body has in the centre a width of 20″, has the form of a blanket deposit, and dips gently towards the east. It seems to run along the stratification of a reddish orthoclase gneiss, but its extent horizontally is limited, as no continuation beyond the 7 feet, in northern and southern direction, could be noticed in the exposed rock surfaces. The ore is of a very hard texture, is brilliant in appearance, and is almost free from objectionable impurities. An average sample, taken across 20″ in the middle of the vein, gave the following analysis:—

Titanic acid	8·100
Phosphoric acid	0·002
Phosphorus	0·001
Sulphur	0·008
Metallic iron	61·150

At a distance of 125 feet from pit No. 3, in a westerly direction, an open shallow cut, No. 4, together with a number of excavations, can be noticed, following the strike of the formation, which consists here of a coarse grained gneiss, which is composed of red feldspar and quartz, the former predominating. The open-cut is made in the slope of a big ridge, striking through the property in a nearly east-westerly direction. Numerous small lenses and pockets, as big as a man's fist, can be seen, arranged in parallel stringers along the stratification of the rock. The ore seems to occur here only in isolated pockets, having no connexion with each other, and, although blasting has been done all over an area of about 30 × 50 feet square, nowhere could a deposit of importance be noticed. On some places the occurrences resemble small chain like accumulations, extending for a length of from 7 to 12 feet, and then disappear. In one place apparently a large pocket of the ore was struck, but it seems that it pinched out with depth. In another place of this area a small vein, 3″ wide, occurs along a fissure in the rock. Its extension in a northeasterly direction is only 4 feet, but, judging from various indications, this deposit might increase with depth.

A sample taken from the parallel stringers, described above, gave the following analysis:—

Silica	1·330
Titanic acid	6·000
Lime	0·080
Magnesia	0·390
Phosphoric acid	0·006
Phosphorus	0·003
Sulphur	0·009
Metallic iron	65·740

At a distance of about 30 feet, in a northerly direction, from a point between pit No. 1 and No. 2, at the top of a bluff, iron ore can be noticed in a small excavation, No. 5, running in the form of a small bed or vein, from 6″ to 9″ wide. The character of this deposit could not be studied, as there was not enough work done on the same, and the place was thickly covered with debris and underbrush.

At a distance of about 15 feet, still farther north, impregnations of iron ore in the rock can be noticed, but the work done has not disclosed any deposit of commercial value.

A sample of the ore body in No. 5, analysed, gave:—

Silica	10·500
Titanic acid	0·900
Lime	3·900
Magnesia	2·300
Phosphoric acid	0·012
Phosphorus	0·006
Sulphur	0·009
Metallic iron	47·230

No. 6 is an exposed rock surface, on a high bluff, and exhibits a number of small, chain-like accumulations of iron ore, similar to those found in pit No. 4. The strike of the rock, which is at this place a reddish banded gneiss, is east and west, with a dip of a high angle towards the south. The stratification lines, at some places, are dotted with small, but very pure lenses of hematite, free from any admixture, with a brilliant lustre. In their entirety they show strikingly the manner in which the iron has been deposited, and any observations made in this respect, on these occurrences, may be safely applied to those all over the property.

A number of indications of iron ore, in the shape of small disseminations through the country rock, can be noticed all over the gneissic ridge, but as they contain nothing of importance, a detailed description of them is omitted.

At the foot of this ridge, in a southwesterly direction from pit No. 1, a tunnel has been driven into the hillside, apparently for the purpose of tapping the ore lodes opened in pits above, and to drain the latter. This tunnel has a length of only 15 feet, and besides exhibiting the structure and the composition of the country rock, shows nothing in the way of iron ore deposits.

Just above this tunnel, on the mountain side, pit No. 7 forms a semicircular excavation, of about 15 feet in diameter. Here an outcrop of pure iron ore can be noticed, having a width of 18″, striking northwest 20 degrees, with a dip of 30 degrees to the east. The iron is very pure, and occurs in the form of a vein, with very irregular shape and trend. Apparently a good many tons of good ore have been taken out, and it is probable that a great deal more could be obtained by sinking to a greater depth.

The deposit terminates abruptly towards the north, while to the south it is overlaid by a capping. An average sample, across 18″ of ore, gave the following analysis:—

Silica	11·410
Titanic acid	1·760
Lime	0·550
Magnesia	3·690
Phosphoric acid	0·108
Phosphorus	0·047
Sulphur	0·018
Metallic iron	50·780

Farther westward from pit No. 7, near the old kiln, is an open-cut, No. 8, along the slope of the hill. This cut exposes an ore body for a width of 15 feet, apparently in the form of a blanket deposit, composed of a number of detached smaller ore lenses and pockets. The average width of these is 20″. The ore is not high grade, and is in striking contrast to the quality of the ores met with in the other deposits, above described. It contains to a great extent an admixture of feldspathic and hornblendic material, but would give a good concentrating ore. Here and there are small pockets of pure ore, distributed throughout the deposit, but these form the smaller portion of the ore lode. In spite of the impure character of the ore, it would have been very interesting to further test this ore body by sinking and tunnelling, since in the shape it presents itself to-day, not much can be said about its extent.

A sample, taken across the full width of 20″, gave the following composition:—

Silica	5·550
Titanic acid	2·960
Lime	0·150
Magnesia	0·530
Phosphoric acid	0·149
Phosphorus	0·065
Sulphur	0·036
Metallic iron	62·370

At a distance of about 500 feet from pit No. 1, on the side of an eminence, there are a number of outcrops of hematite. In some of them the ore occurs in small veinlike deposits, while in others the occurrence is more in lenses and pockets. As a great many of these places were covered with heavy underbrush, and as there was also very little work done, an opinion on the value of these must be deferred.

At a distance of about 1,200 feet, in a southwesterly direction from pit No. 1, above described, two small pits were noticed, near the road leading to the mine. One of them was filled with water, while the other, 10 feet long, 7 feet wide, and 2 feet deep, showed a good outcrop of iron ore, about 24″ long, and 15″ wide, apparently extending in the same dimensions towards the depth. The ore seemed to be of the usual excellent quality, and while but little work had been done to justify the expression of an opinion on the same, it must be said that the ore body looks very encouraging.

A sample from the ore, in situ, gave the following percentage composition:—

Silica	0·960
Titanic acid	5·950
Lime	0·250
Magnesia	0·410
Phosphoric acid	0·023
Phosphorus	0·010
Sulphur	0·036
Metallic iron	66·920

On the north half of lot 1, range xi, Hull, belonging also to the Haycock mine, a number of places can be found, in the southeast corner, where good hematite ore outcrops. One vein 12″ wide, of clean ore, occurs in reddish granitic gneiss, along the lines of stratification. A number of prospecting trenches are in evidence, but having been worked some 35 years ago, they were all covered with debris and bushes.

In the northeast corner of the same lot, an open-cut, in an east-westerly direction, in the solid rock, uncovers good hematite ore, but here again a thorough examination was impossible, for the same cause. There are a number of small showings, of limited extent and of little economic importance. Their occurrence is sporadic, and excludes all theories regarding the existence of a definite iron range in that region.

Other Iron Ore Locations in the Vicinity of the Haycock Mine.

On the south half of lot 1, range xi, Hull (belonging to Mr. Darby, of Ottawa), iron ore occurs in the northeast part of the lot, on the bluff of a little hill. The country rock is a reddish syenitic gneiss, striking in an east-westerly direction, with a dip of 50° to the south, and cut through by dikes of mica pyroxene. The ore occurs in small veins and lenses along the stratification lines of the gneiss. It is brittle and streaky, but very pure, and shows occasionally a laminated structure. The deposit as it presents itself is of little value, but a good deal of float iron ore has been found in the humus that covers the surroundings of this outcrop, and it is not unlikely that, upon further investigation of this lower land, a deposit of economic value might be found. The outcrop above described, consisting as it does of small lenses arranged over the surface of the rock, may be proven to be simply an outlyer, or offshoot of a large deposit in the immediate vicinity. The float of iron ore in the soil is particularly numerous, in a southerly direction from the outcrop under consideration, and big pieces of iron ore, though intermixed with country rock, can be dug out at a number of places.

A sample from the outcrop, analysed, gave the following results:—

Ferrous oxide	34·10
Ferric oxide	45·26
Titanic acid	16·80
Metallic iron	58·21

On the southern part of lot 3, range x, Hull, the property of Mr. Theophile Viau, a promising deposit of hematite ore occurs, in a syenitic formation. The vein has an irregular winding course, but its trend, on an average, is about northwest and southeast. The average thickness is from 8″ to 10″. In one place, where it splits into two branches, of 10 and 12″ in width respectively, it has a thickness of 20″. The ore lode is exposed for over 30 feet, and disappears, on both sides, under the soil, or a heavy capping. With the exception of a few blasts, there has been no work done on this showing, although the appearance of the latter justifies further serious investigations. The ore is of a brilliant lustre, and seems to be free from foreign matter. An analysis of an average sample, taken from a width of 20″ near the forking of the vein, gave the following results:—

Titanic acid	13·58
Metallic iron	50·98

There are two other properties which might be included in the group under consideration, although they are located some distance from the town line between Hull and Templeton, viz., lot 22, range ix, and lot 23, range vii, both in the township of Templeton. On lot 22, range ix, a low ridge of orthoclase, and syenitic gneiss, occupies the northern side of Rainville creek, Much of this gneiss is of a reddish colour, but it is interstratified, at intervals. with bands of lighter and darker grey. The general dip of the gneiss is westward, at an average high angle. Along the southern side of this ridge, on a steep precipice of a bank 40 feet in height, several isolated exposures of hematite ore occur. A number of these exposures, not one of them, however, exceeding 3 feet in length, or diameter, are included in a space about 20 feet square. In all of these the ore is very pure, being unmixed with any spar, and it often displays large striated faces, while in fracture it is fine grained, and of steel grey colour. The largest of the exposures has apparently been blasted down, because large blocks of solid iron ore can be found amongst the debris lying in front of the precipice. The ore along the latter is visible for over 200 feet. It does not occur, however in a solid body or vein; most of the ore is found in disconnected bodies, isolated lenses, and pockets, sometimes connected with each other by small outlyers. On one point the ore has a breadth of 18″; it continues in this width for several feet, then it gradually diminishes to a wedge point; it becomes then covered with debris from the cliff, and with soil and vegetation. Numerous loose blocks of ore, however, are met with, at the foot of the cliff, for some distance, showing evidently that the ore lode in question was of somewhat larger dimensions. Farther east, along the gneissic ridge, scattered small outcrops are frequent, but none of them are of sufficient importance to require description.

A sample taken from one of the larger outcrops was analysed and gave:—

Silica	1·860
Titanic acid	5·970
Lime	0·250
Magnesia	0·300
Phosphoric acid	0·012
Phosphorus	0·006
Sulphur	0·046
Metallic iron	59·700

On the other lot, No. 23, range vii, float of hematite iron was found, at various places, inside an area of about 25 acres, in the southern part. Several trenches were made, for the purpose of locating an ore body, and in one of them ore in situ was found, but as there was very little work done, the expression of an opinion on the value of the same is deferred. An analysis of a sample taken from this outcrop gave the following:—

Silica	3·960
Titanic acid	0·250
Lime	0·270
Magnesia	0·330
Phosphoric acid	0·409
Phosphorus	0·179
Sulphur	0·004
Metallic iron	64·720

The Ore from the Deposits Along the Hull–Templeton Town Line.

The ore in these deposits is very remarkable, in being principally a specular hematite, with a considerable portion of magnetite. It is very hard and compact, showing in some cases distinct cleavage. Its specific gravity is equal to 5. Most of it occurs in lumps, from the size of a walnut up to a few cubic feet, scattered through the rock, which in most cases is a coarsely crystalline aggregate of a pinkish feldspar and quartz, with rarely a small amount of hornblende, and mostly in association with the feldspar. Its colour is, as a rule, black or steel grey, with a highly metallic lustre. Sometimes it has a banded, lamellar, or micaceous structure, and in this case it often contains small veins of the rocks of the enclosing formation. There are, as a rule, no selvages, or bedding planes, between the ore bodies and the adjacent rocks—the ore is generally adherent to the latter—which seems to constitute a great difficulty in producing pure ore, without an admixture of the country rock, especially in the smaller deposits. When exposed to the weather, the freshly broken ore, which exhibits, as a rule, a highly metallic lustre, acquires a dull black colour. It does not break up like the granular magnetite, but retains its hard texture, even when exposed for years to the atmosphere. The ores are, as a rule, non-magnetic, but in places they exert a feeble action on a delicately suspended needle, and also show slight polarity. Of the minerals mostly associated with hematite in this district, may be named, feldspar, both pinkish and white, hornblende, calcite, quartz, magnesite, mica, pyroxene and pyrite.

Under the general term feldspar, several species may perhaps be included, but their true nature has not been investigated. At the Haycock mine, reddish orthoclase is the most frequent association of the specular ore, not only forming, as has been outlined before, the principal constituent of the enclosing rock, but masses of it being embedded in the ore. Hornblende, though often found in the enclosing formation, is not frequently associated with the hematite, but it occurs sometimes in small streaks, in close proximity to the ore depositions. Actinolite, or fibrous hornblende, occasionally fills small cracks, or faults, through the formation, and is sometimes found coating the surfaces of the ore.

Calcite is occasionally found in association with the ore, forming pockets or irregular lenses embedded in it. It is also, at the Haycock mine, penetrated in all directions by crystals of beautiful, glassy, green pyroxene, from $\frac{1}{16}''$ or less, up to $\frac{1}{4}''$ thick. Rhombic crystals of mica occur in an analogous manner, though more sparingly than the pyroxene. Calcite sometimes forms veins, or lines, in the walls of little cavities in the vicinity of the ore bodies. From the dumps of the Haycock location some samples of ore were taken, which showed a parallel arrangement of little veins of calcite, the matrix being a mixture of hematite and orthoclase feldspar. Crystal aggregates of calcite are sometimes stained a pink colour, with peroxide of iron. From a metallurgical point of view the association of hematite with calcite, if the latter occurs with the former in limited quantities, cannot be regarded as injurious, because calcite must be added to an iron ore in the smelting process, if it is not present.

Quartz is also a frequent companion of the hematite. It is mostly found at the selvage between the ore and the enclosing rock. Cavities in the ore, lined with beautiful crystals of quartz, have been found on lot 28, range ix; while small pockets of specular iron were also met with, embedded in a pinkish quartz.

The occurrence of magnetite, in association with hematite, in the locations under consideration, has not been observed generally. At the Haycock mines the magnetite plays a subordinate role in the composition of the ore, and it is, as a rule, so intimately associated with the hematite, that its presence can hardly be detected with the naked eye. The ore, as a general rule, is feebly magnetic, and sometimes not at all. The association of both species is most desirable, since the presence of magnetite increases considerably the percentage of metallic iron in the ore, and the latter is, therefore, much richer. Mica has not been observed in direct association with specular ore, but it plays, at some places, a conspicuous part in the enclosing rocks, and for this reason it is found, in the gangue material accompanying the ore, in mining the latter.

Pyroxene is occasionally found associated with hematite ores. At the Haycock mines the ore is sometimes penetrated by long crystals of green pyroxene, about $\frac{1}{16}''$ in diameter. Similar crystals occur, as mentioned above, in calcite, in the same locality. On lot 22, range ix, pockets of hematite can be noticed, at one place, in close association with a bottle green pyroxene, the latter containing small crystals of iron pyrite. The Laurentian hematites, as a rule, are much freer from iron pyrites. All the analyses of the ores in the district show a very small percentage of sulphur, in fact, sometimes only traces, which speaks for the excellent quality of the ores.

Crystals, or pure streaks of iron pyrite, as found in the ore bed of Hull, have not been found in any of the ores, and if iron pyrites is at all present, which accounts perhaps for the small percentage of sulphur in some of the ores, it must be in such a fine state of division, throughout the latter, that it can only be detected by the microscope, or by analysis.

Of other minerals, which have been found associated with the ore in a very limited degree, must be mentioned barytes, or heavy spar, fluorspar, and graphite. Barytes was observed on lot 22, range ix, Templeton, in connexion with a small pocket of hematite, but this occurrence is regarded as purely accidental, as an association of these two minerals has not been observed elsewhere by the writer. Dr. Harrington[1] refers to specimens from the Haycock mines, in which crystals of barytes were associated with specular iron, calcite, beautiful green fluor-spar, and a reddish feldspar.

Graphite in scales has not been observed with the naked eye in any of the ores, but the analyses of some of them point to its presence, but in limited quantities. It appears that the graphite is distributed throughout the ore, in a very fine state of division, very likely in the crystalline state.

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[1]Report of Progress, 1873–74, p. 220.

Summary of Investigations Regarding the Hull-Templeton Town Line Locations.

In the foregoing discussion of the occurrence of iron ore in these locations, the writer has presented the subject as it appears to him in the light of recent investigations. Some of the results are different from those expressed by other authorities, especially as far as the available quantity of ore in the various developed locations is concerned, more especially in the Haycock mines. So far as the development work on the deposits discovered has shown, the iron ore does not occur in very large deposits, thus admitting of easy and cheap extraction. These deposits are confined to lenses, and pockets, most of them of small dimensions; and veinlike occurrences which can be followed for a considerable distance are conspicuous by their absence. It has been frequently reported that in the principal pit, No. 1, of the Haycock mine, a deposit was opened up, which measured on the surface 2 feet in thickness, but that in following the same in depth, it widened out to 12 feet, and showed indications of increase in width, when operations were suspended.

This pit is now filled with debris and water, and could, therefore, not be examined, but from reliable sources I gathered the information that the same was pumped out and cleaned several years ago, on behalf of an American syndicate. It was found that the bottom contained only several small veins, not 3 feet in width in all, showing no signs of coming together, but rather decreasing, as they apparently had done from the surface downward. This case, amongst others, is merely mentioned to show how deceptive appearances on the surface sometimes are, and disproves the standing opinion of some of the interested parties, that "the ore body increases with depth."

All the deposits examined by the writer, so far as surface indications go, are of limited extent, and do not warrant exploitation on a large scale. But this does not mean that the existence of large ore bodies is excluded. There are large tracts of virgin ground, covered heavily with brush and forest, in the region under consideration, which have never seen the pick and shovel of the prospector; indications of iron ore, in the form of float, have been found in various places, and it is not improbable that some day a large deposit of iron ore, which warrants development and exploitation on a large scale may be discovered. The sporadic occurrences of ore, over different properties in the region, show that the original deposition of the mineral, in that particular part of the formation, is not a continuous iron range similar to the Hull range, described above; and, for this reason, each deposit must be tested individually, upon its merits. The economic utilization of these excellent iron ores is desirable, yet it involves questions, similar to those suggested in the discussion of the nature of the deposits, which deserve careful consideration. Thorough investigation will be necessary in each case, to determine the actual value of the deposit.

ANALYSES OF IRON ORES FROM THE HULL-TEMPLETON TOWN LINE LOCATIONS.

	1	2	3	4	5	6	7	8	9	10	11	12			
Ferrous oxide	88·08	89·80	85·45	89·04	......	......	......	......	......	......	......	34·10	......	......	......
Ferric oxide	6·86	7·06	5·24	7·92	......	......	......	......	......	......	......	45.26	......	......	......
Titanic acid	3·17	2·34	2·12	......	3·52	8·10	6·00	0·90	1·76	2·96	5·95	16·80	13·58	5·97	0·25
Protoxide of manganese	0·24	trace	0·15	......	......	......	......	......	......	......	......	......	......	......	......
Magnesia	0·13	0·22	0·17	0·40	0·60	......	0·39	2·30	3·69	0·53	0·41	......	......	0·30	0·33
Lime	0·55	trace	0·41	0·56	0·10	......	0·08	3·90	0·55	0·15	0·25	......	......	0·25	0·27
Phosphoric acid	0·16	trace	0·13	0·21	0·029	0·002	0·006	0·012	0·108	0·149	0·023	......	......	0·012	0·409
Sulphur	0·03	trace	0·07	0·04	0·004	0·008	0·009	0·009	0·018	0·036	0·036	......	......	0·046	0·004
Graphite	0·35	0·43	0·28	......	......	......	......	......	......	......	......	......	......	......	......
Alumina	......	......	......	0·32	......	......	......	......	......	......	......	......	......	......	......
Silica	......	......	......	1·77	3·00	......	1·33	10·50	11·41	5·55	0·96	......	......	1·86	3·96
Insoluble matter	0·26	0·11	5·77	......	......	......	......	......	......	......	......	......	......	......	......
Phosphorus	......	......	......	0·93	0·012	......	......	......	......	......	0·010	......	......	......	......
Total	99·83	99·96	99·79	100·26											
Metallic iron	66·98	68·34	63·88	68·49	65·56	61·15	65·74	47·23	50·78	62·37	66·92	58·21	50·98	59·70	64·72

Nos. 1, 2, and 3, by Prof. Chapman (Supplementary Report on the Haycock mine, Toronto, 1873). Nos. 1 and 2 are analyses from selected samples, and No. 3 of a large sample supposed to represent the average of a heap of about 300 tons. No. 4, by Edward Riley, F.C.S., London, 1884.

Scattered Deposits Along the Gatineau River.

There are many indications, and small outcrops of both hematite and magnetite in the different townships bordering the Gatineau river; but most of them are scattered, distributed at random, and of such minor importance that they do not require any special description; however, they are all enumerated in the list of properties found elsewhere in this report. Many of them consist simply of impregnations of magnetite in crystalline limestone, small lenses of hematite along the stratification of the gneissic strata, or small veins of an inch or so in width of a combined hematite and magnetite. No work had been done on them, most of them were natural outcrops of the ore, and, unless some development is performed on them, an opinion as to their value must be deferred.

Among the more important deposits are the following:—

Lot 23, range vi, township of Wakefield, belonging to Dr. Graham, of Hull, Que. Magnetite is found here, in the form of small pockets, and veins, in syenitic and hornblende gneiss. In the southern part of the property, in a little gully near a small lake, an excavation, 5 × 7 feet, exhibits magnetite ore, of apparently good quality, embedded as lenses in the country rock. The extent of the outcrop could not well be established, but it appears that the ore continues along the little valley, towards the lake. Float, of the same ore, has been found in the soil in that direction, showing the ore in a disseminated state.

Farther down this gully, on a steep precipice, blasting has been done over several square yards, and here the occurrence could be better studied. The ore is closely associated with a coarse, highly crystalline hornblende rock, interstratified with veins and veinlets of quartz. The ore is found in drawn out lenses, of irregular shape, embedded partly in the hornblende rock, and partly interpolated between the quartz and the latter. The country rock is dark coloured, and, upon closer examination, exhibits crystals of iron pyrites distributed irregularly through it, but no such iron pyrites can be detected in the ore. The ore is brittle; when exposed to the weather it disintegrates and crumbles to pieces, taking a bluish tarnish. The country surrounding the location is pretty well covered with timber and underbrush, and not easily accessible.

A sample of this ore, analysed, gave the following results:—

Silica	2·500
Titanic acid	2·980
Lime	1·100
Magnesia	0·590
Phosphoric acid	0·002
Phosphorus	0·001
Sulphur	0·023
Metallic iron	65·140

Lot 30, range ii, township of Cameron, Ottawa county. The occurrence of iron ore on this property has been known for over forty years, but sufficient work has never been done to enable one to form a correct idea about its character and extent. The ore occurs along the course of Post creek, all over the brow of a hill, about 50 feet high, for a length of 150 feet, in nearly an east-westerly direction. There are two small pits made to test the deposit; the more easterly one is an open-cut into the hillside. It cuts a micaceous, rusty looking iron ore deposit, embedded in a coarse, granular, crystalline limestone. The nature of this deposit cannot be studied very well, but it seems to be rather a number of pockets than a true vein. The ore crumbles sometimes into small fragments; it contains a good deal of iron pyrites and graphite in flakes, some of which, of larger size, are distributed at random throughout the deposits. On account of the decomposition of most of the pyrites, by exposure to the open, the deposits are all of rusty appearance.

Along the brow of the hill, above referred to, the overlying soil is distinctly coloured, and has the appearance of ferruginous earth.

This red earth, which may indicate the existence of iron ore beneath, can be followed for over 150 feet, in a westerly direction, along Post creek, and, within this area, several outcrops of solid iron ore can be noticed. One of these outcrops exhibited magnetite, of apparently good quality, free from iron pyrites and other injurious impurities.

The most westerly pit, at 100 feet distance from the open-cut, measures 8 × 10 feet, and is several feet deep. Here the ore consists of a mixture of magnetite with iron pyrites, with an addition of graphite flakes, but as the pyrites seem to predominate, the deposit does not require any further description.

THE BRISTOL IRON MINES.

These mines are situated on lots 21 and 22, range ii, in the township of Bristol, county of Pontiac, at a distance of about two miles north of the Ottawa river. Iron ore was first discovered on these lots by Mr. John Moore, early in the seventies, and the first mining in the same was done in the winter of 1872–73. But it was not until 1885 that mining on a large scale was commenced, and for four years it was continued, with great activity.

The output of the mine amounted to 125 tons of iron ore per day. The mine, it is reported, was chiefly worked on the so-called south vein, by means of several openings, one of which was 150 feet deep, with a drift of 150 feet, and several cross drifts of 20, 50, and 100 feet, all of these workings being entirely in ore. The total output, up to 1888, was about 12,000 tons of high grade magnetite, which was shipped principally to furnaces in Pennsylvania, where a high grade Bessemer iron was produced.

The plant consisted of a complete mining and roasting establishment, together with a standard gauge branch railway, connecting the mine with the Pontiac Pacific Junction railway, now Canadian Pacific railway, at Wyman, $4\frac{1}{4}$ miles distant. The machinery plant consisted of a $14'' \times 20''$ hoisting engine, to operate the inclined shaft, and a small hoisting engine for carrying the ore from the bin at the head of the slope to the top of the roasters. An 18×30 Ingersoll air compressor, the necessary air receiver, and six Ingersoll drills, furnished the accessories for mining on a large scale. A large crusher received the ore, at the top of the roasters, from automatic dumping skips. Two 100 horse-power steel return tubular boilers furnished steam for the whole plant. The ore roasting plant was of the latest approved Davis-Colby type, consisting of two large gas roasters, 17 feet in diameter, and 27 feet high. The roasters were connected with six gas producers, of the Taylor design. The roasting kilns, and gas producers, were protected by suitable buildings, while the shaft mouth was equipped with a substantial gallows frame and shaft house. There were also an office building, several tenements, stable, magazine, a thaw house, and everything necessary for carrying on operations on an extensive scale.

Since the year 1889 the mines and plant have been allowed to lie idle, and although there are large ore bodies available for immediate exploitation, no attempt has been made, in recent days, to exploit them.

In presenting a report on these mines, it must be borne in mind that all the pits which had been worked, with the exception of two, were filled with water, and, on this account, it was impossible to go into the examination as fully as desired. Moreover, there are no reliable reports, and no records, or drawings, available. For this reason, an opinion expressed on the value of the property, and its prospects as a shipper, must be, to some extent, conjectural, and the writer has based the same largely on a comparison with other mines producing similar ore.

The rocks associated with the magnetites in the region under consideration are composed, for the greater part, of grey, speckled hornblende gneisses, of a schistose character, occasionally striped with darker and lighter colours, caused by a greater or less preponderance of black hornblende and blackish brown mica, and reddish syenitic gneisses, composed of red feldspar, translucent colourless quartz, with occasional layers of a greenish black hornblende.

The general trend of the formation is north-northwest, with a general steep dip to the east. Intrusions are frequently met with, and they are composed mostly, either of bands of red feldspar, intermixed with quartz, or greenish black diorite.

Crystalline limestone does not occur in close proximity to the Bristol iron mines, but is found on the shore of the Ottawa river, almost immediately opposite the town of Arnprior. This limestone is overlaid by a volume of dark hornblendic and red granitoid gneiss, with epidote, above, or in the upper portion of which, the horizon of the magnetic iron ores occurs. This limestone, which outcrops on lots 14 and 15, range ii, near the road to Norway village, has a general strike of east-west, with a dip of 45° north.

A sample of the same, taken from a point in the southwest quarter of lot 15, gave the following analysis:—

Insoluble matter	5·95
Ferric oxides and alumina	1·45
Carbonate of calcium	85·55
Carbonate of magnesia	6·67

It is coarsely banded with darker or lighter layers, and follows the course of the quartzose, feldspathic, and hornblende bands. Some of the latter display contortions of the most complicated description, which appear more important in proportion to the mass of limestone in which they occur. Where this is great, the gneissoid beds, which form the subdivisions, and are several inches to a foot thick, are surrounded by limestone, and are bent and folded in a very extraordinary manner, or partially broken up into fragments. The limestone in this region is free from impurities, and produces an excellent lime. It appears distinctly stratified, and intrusive dikes in the same are not frequently met with.

As to the iron bearing rocks, immediately associated, the distinguishing character is the great parallelism which they maintain, over a large extent of country, and the steep dip of the strata. The strike is N.N.W., and the dip is almost always over 45°, generally 60° to 80°, while perfectly vertical strata have been observed. As to the succession of the rocks inside the Bristol iron range, I think some general order may be observed. For instance, the red and grey syenitic gneisses almost invariably immediately succeed, and overlie, the iron ore, or iron bearing rocks. These are followed by gneisses, in which hornblende becomes an important ingredient, and which almost imperceptibly graduate into the micaceous gneisses, schists, and hornblende schists of the series.

A similar succession of rocks, however, would appear to be repeated at a distance from the iron bearing rocks. Whether this repetition of precisely the same rock 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 iron ore, which is composed of a mixture of magnetite and hematite, forms a series of beds and pockets, mostly interstratified with reddish syenitic gneiss, and hornblendic schists. The bedding, while in general roughly parallel to the containing strata, sometimes shows discordance with the latter, and the ore penetrates various layers of the formation in an irregular fashion. A folded arrangement of the iron ore deposit is also observed; this is, however, of secondary importance, and is due to the limited dimensions of the deposits so shaped.

In addition to the bedded and folded structures, the ore deposits show fractures, especially along the contact with the wall-rock. The individual layers, where hard enough, are broken into small blocks by fractures, which in the main are independent of those in the layers above and below. Sometimes joints and faults cut across the ore deposit. For the most part there is little displacement along fractures, and where displacement does occur it is measured by inches rather than feet. Occasionally a fault of several feet may be observed, and this is likely to be near the contact of the ore with the wall-rock. The numerous joints and faults suggest that the apparent gentle folds in the iron bearing strata are not due entirely to actual bending of the latter, but are due in part to minute displacements along the closely spaced fractures.

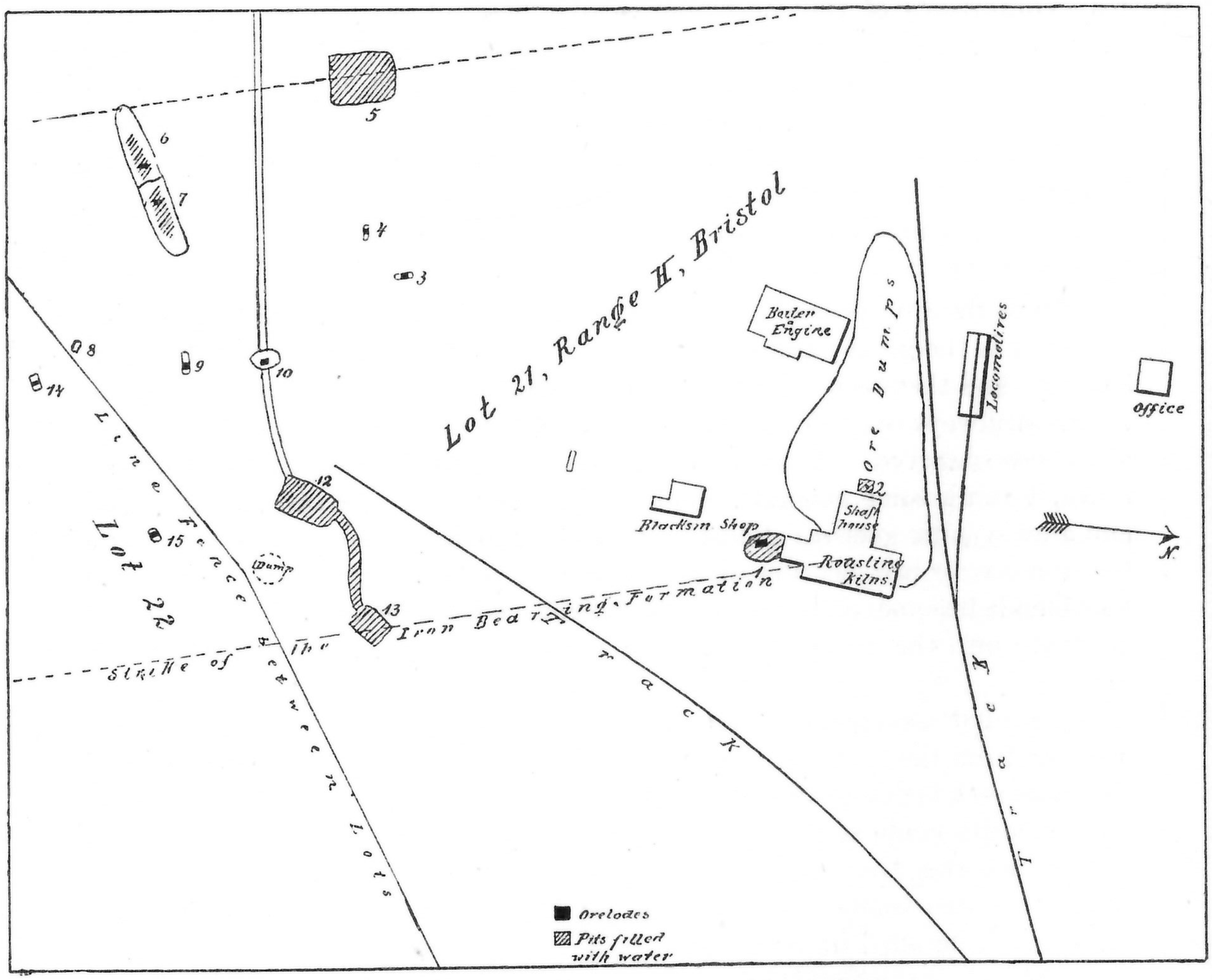

FIG. 9.—Bristol mines. Scale 1 inch to 100 feet.

The Bristol iron mines comprise an area of 200 acres. Nearly all the important work, and the whole original working plant, are located on lot 21, while the continuation of the iron bearing range can be traced for some distance, also on the adjacent lot, No. 22, fig. 9.

As regards the topographical features of the country in general, it may be stated that the latter, where the iron ore occurs, is of an undulating character, and presents a series of low rounded hills, with stretches of farming land between. Most of the country is open, the hills being to a great extent denuded of trees and vegetation, and on this account wood for general domestic and industrial purposes is growing scarce. There are good roads leading from the mine to Quyon, a distance of 8 miles, and to Wyman, a distance of about 4½ miles, both points being stations on the Canadian Pacific railway, leading to Ottawa.

As already outlined above, the iron ore, which consists of a mixture of magnetite and hematite, occurs in layers and beds, interstratified with a reddish syenitic gneiss, and hornblendic rocks. These strata have a general northwest and southeast strike, and dip to the east. Outcrops of iron ore are very frequent on both properties, and, so far as a survey of the locations has shown, they are distributed over a width of approximately 450 feet, while the extension of this iron range, towards the southeast and northwest, is concealed by a heavy mantle of drift. Altogether, eleven pits and outcrops can be noticed over both lots, and in order to give an idea of the extent and character of the ore bodies uncovered, the following description of all of these is given:—

Pit No. 1, near the roasting plant and shaft house, is a stripping 20 × 12 feet and exhibits a solid body of iron ore, which is the largest exposed at present on the property. It consists of massive ore, occasionally with streaks, and pockets of impurities of decomposed country rock, mostly of hornblendic character. As a part of the pit was under water no actual measurements could be taken, but, judging from the exposures, some thousands of tons may be readily mined from this outcrop. Some fine streaks of iron pyrites may be seen, on freshly obtained specimens of the ore. Three samples, taken from various parts of this outcrop, gave the following results:—

	Sample 23	Sample 24	Sample 25
Silica	17·120	17·240	8·880
Titanic acid	0·200	0·120	0·100
Lime	1·660	1·100	0·650
Magnesia	3·700	4·530	0·800
Phosphoric acid	0·016	0·023	trace
Phosphorus	0·007	0·010	trace
Sulphur	0·310	1·350	0·846
Metallic iron	54·250	51·580	61·480

Pit No. 2 represents an inclined shaft, but as the latter was filled with water, nothing definite can be said about the same. It is reported that this slope was 200 feet in depth, that a large quantity of good ore was mined from slopes located to the north of the shaft, somewhere under the present office building, and that the mine was worked by three levels, one at 50 feet, and a second one at 190 feet depth, that it contained drifts and galleries in various directions, and that all these workings are still in good ore. The pit yielded little water, scarcely sufficient for the requirements of the machinery and kilns, and keeping the same dry during operations was, therefore, an inexpensive item. In the immediate vicinity of the shaft there are some dumps of a good grade of ore. Apparently this ore contains little sulphur, is fine grained, but holds a greenish rock, mostly hornblende and mica schists, as impurity. A sample taken from these ore dumps gave the following analysis:—

Silica	8·990
Titanic acid	0·250
Lime	0·800
Magnesia	2·000
Phosphoric acid	0·008
Phosphorus	0·004
Sulphur	0·767
Metallic iron	58·610

At a distance of 390 feet, in a southeastern direction from Pit No. 2, two prospecting ditches—No. 3 and No. 4—exhibit solid, massive iron ore. No. 3 is 10 feet long, 2 feet wide, and 2 feet deep, while No. 4 is only 5 feet long, the other dimensions being the same. The iron ore exposed in these openings appears to be of excellent quality, nearly free from impurities; it shows a highly metallic lustre and has an uneven and sharp fracture. The results of the analyses of two (supposed to be average) samples are given in the following table, in which No. 1 refers to sample taken from pit No. 3 and No. 2 to sample from pit No. 4:—

Silica	12·200	9·370
Titanic acid	0·100	0·120
Lime	0·600	0·100
Magnesia	1·300	2·040
Phosphoric acid	0·006	0·002
Phosphorus	0·003	0·006
Sulphur	0·559	0·696
Metallic iron	55·930	60·390

Pit No. 5, as per fig. 10, measures 50 feet in length and 35 feet in width, and is reported to have a depth of about 70 feet. This is an inclined shaft, towards the engine room, but without any drifts. With the exception of 10 feet, the pit was filled with water, and an examination was, therefore, confined only to a small part of the workings. On the northern side of this pit the rocks, with the containing iron ore, are well exposed, and occur in the following ascending order—see fig. 10:—

(a). Schistose grey syenitic rock, occasionally striped with dark and lighter colours, caused by a greater preponderance of black and greenish hornblende, and also by the presence of disseminated iron ore, and small veinlets of the latter. Towards the bottom some of the layers have thin lines of a reddish colour, occasioned by flesh red feldspar. The thickness of this layer is 2′-6″.

(b). Schistose, hornblendic, micaceous rock. Black layers of an inch are of frequent occurrence, the colour being derived principally from hornblende, and occasionally by fine disseminations of magnetite. The rock splits in the direction of these layers; iron pyrites occurs irregularly, but sparingly, giving, by its decomposition, a rusty brown colour to a portion of the bed. The thickness of the latter is 3′-6″.

(c.) Grey syenitic rock, occasionally speckled by the preponderance of hornblende, and sometimes of blackish brown mica. There are occasional layers of apparently pure feldspar, and there are a few irregular layers, more coarsely grained than the rest.

Fine disseminations of magnetite can be noticed at several places, giving the bed the character of a fahlband, but they are of no economic value. Total thickness, 3 feet.

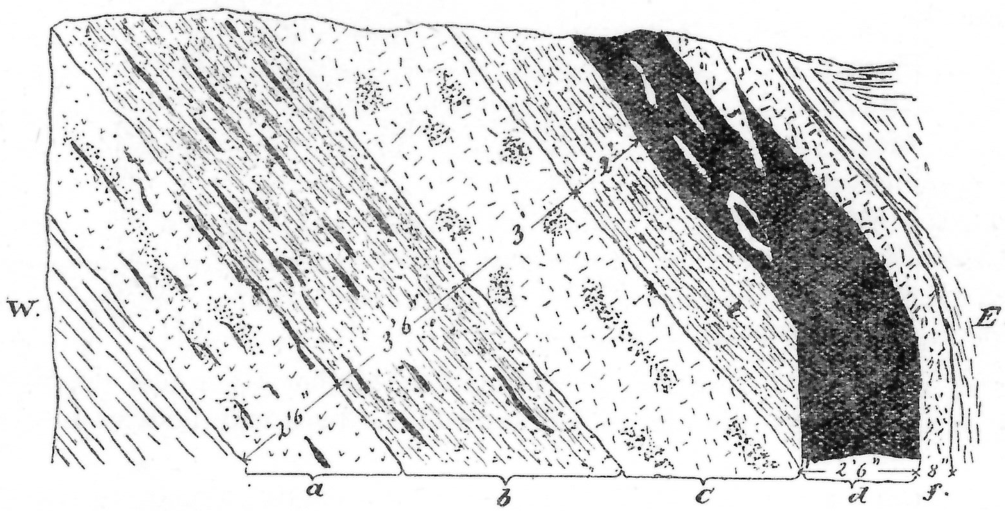

Fig. 10.—Section through formation in pit 5, Bristol mines. Scale 1 inch to 4 feet.

(e.) Dark grey, or nearly black, thin layers, composed chiefly of black hornblende, with some black mica and some crystals of white quartz and feldspar; the whole of this rock is highly schistose; no magnetite can be observed in the same. Thickness of the layer, 2 feet.

All the beds described, so far, have a dip to the east of 50°, but the effects of folding, and lateral disturbances, can be noticed in examining the beds overlying those just described. They change their dip, at a depth of 8 feet, from 50° to 75°, and indications, near the water's edge, point to the probability that the strata assume a nearly vertical position at moderate depth. Bed (e) is immediately overlain by a wedge shaped deposit of iron ore (d), which measures, near the surface, 3 feet. This deposit consists of parallel layers of iron ore, the selvages between them being covered frequently by films of a blackish biotite mica. Long drawn out lenses of micaceous hornblende rock separate the ore beds occasionally, and these gradations can be observed from a pure ore down to a sparingly disseminated ore. Minute veins of a fine grained, pistachio greenish material, probably pyroxene, sometimes intersect the ore, and occasional small aggregations of a dark greenish coarse and nodular hornblende constitute the common impurities. Very small, fine streaks of pyrite, sometimes hardly noticeable with the naked eye, can be detected, but it seems that its presence does not detract from the value of the ore. The wedge shaped deposit, just described, is bordered by another bed of iron ore, 2′-6″ in width. Its dip, in the upper portion, conforms somewhat to the dip of the underlying rocks, but near the water's edge it was 75°, and probably vertical farther down. Most of this ore is very pure, and large blocks can be obtained, which exhibit no sign of foreign matter, and should, therefore, yield a very high percentage of metallic iron. This ore deposit is overlain by red and grey, thin bedded and clearly stratified, syenitic and hornblende gneiss. Most of these rocks are flesh coloured, abounding in red feldspar; in the hornblendic varieties the hornblende is often accompanied by mica, and disseminations, and small veins of iron ore, are frequent:—

Silica	17·650
Titanic acid	0·110
Lime	1·150
Magnesia	1·590
Phosphoric acid	0·026
Phosphorus	0·011
Sulphur	0·747
Metallic iron	52·170

In a southerly direction, a continuation of the strata just described can be noticed, and iron ore, though not so abundant, may be seen in some of them.

At a distance of about 150 feet in a southeasterly direction from pit No. 5, we have a long shallow opening—Nos. 6 and 7—110 feet long, and from 10 feet to 15 feet wide. The rocks exposed here are of the same description as those met with in pit 5; their strike and dip are also the same, while the ore appears in the rock as parallel layers of varied thicknesses.

In the more easterly part of this opening an outcrop of ore can be noticed, in a series of rocks in which syenitic gneiss and hornblende form alternate layers. The ore occurs in a bed, parallel with the strata, in a thickness of 18″, dipping to the north. It contains small, fine streaks of pyrite, but seems otherwise to be very pure. The analysis of a sample taken from this outcrop gave the following results:—

Titanic acid	0·180
Phosphoric acid	0·035
Phosphorus	0·015
Sulphur	1·233
Metallic iron	43·760

No. 8 is a rock exposure near the line between lots 21 and 22, and exhibits impregnations, and small pockets of ore, in a syenitic gneiss, emerging, by its increased contents of hornblende, on one side into schistose, hornblende rock. The ore seems to occur here in too small quantity to be commercially useful, but whatever there is of it is of very pure quality.

Pit No. 9, located at a distance of 90 feet from No. 8, is a prospecting ditch, 15 feet long, 2 feet wide, and 2′-6″ deep.

An ore body, measuring 6 feet wide, striking in a southerly direction, has been laid bare in country rock, which, on account of its decomposed condition, has a rusty appearance. The ore appears to be comparatively pure; no streaks of pyrites can be noticed, while impurities of country rock are rare. An average sample taken all over the ore lode gave the following analysis:—

Silica	28·400
Titanic acid	0·250
Lime	1·970
Magnesia	1·850
Phosphoric acid	0·010
Phosphorus	0·005
Sulphur	0·128
Metallic iron	43·860

At a distance of 50 feet, in a northerly direction from pit No. 9, a shallow opening—No. 10—measuring 15×12 feet, exposes some iron ore, in a weathered, rusty rock. The pit was filled with debris, and ore mined, and for this reason no measurements could be made, nor the character of the occurrence studied. About half a ton of good clean ore could be seen on the dump, and in the pit. An average sample gave the following analysis:—

Silica	16·000
Titanic acid	0·250
Lime	0·050
Magnesia	0·600
Phosphoric acid	0·012
Phosphorus	0·006
Sulphur	2·484
Metallic iron	56·030

No. 11 is a prospecting ditch near the line between the lots, at about 80 feet distance, in an eastern direction, from pit No. 9. It measures 15 feet long, 2 feet wide, and 1′-6″ feet deep, but no solid ore body can here be noticed. Some disseminated ore can be seen, in a greyish, red syenite. Pits Nos. 12 and 13, in a northeasterly direction from pit No. 9, are comparatively large openings, which are reported to have yielded large quantities of a good quality of ore; but as both pits were filled with water and debris, at the time of my visit, nothing of a definite nature can be reported.

On the other side of the line, between lots 21 and 22, on Mr. Killroy's property, several outcrops indicate the continuation of the iron bearing formation, in a southerly direction. One of these outcrops, No. 14, is close to the line, in a southeasterly direction from pit 8, and exhibits iron ore all over an area of 10 feet square. Some of this ore is pure, while other pieces, freshly broken from the outcrops, showed impurities of country rock. As the place was thickly covered with herbage, and also with stones thrown out from the field, nothing further can be said regarding this occurrence. Other outcrops, in the immediate vicinity, seem to indicate that there is a body of iron ore near the line between the lots, the extent and character of which should be investigated by test pits and cuts. Farther east, on Killroy's property, float of iron ore has been found, in a number of places, in ploughing the field; while near Killroy's residence ore in situ was found in digging a well.

In a northwesterly direction from all the outcrops just described, several indications point to the probable extent of the iron bearing formation in that part of the property, and from one pit, about 500 feet in a southwesterly direction from the office, it is reported some fine magnetite ore has been extracted. Judging from the dump of this pit, the ore occurs in a greenish hornblende rock, intermixed with chlorite, and consists of a fine grained crystalline magnetite and hematite. Streaks of iron pyrites in the ore are met with, but whether this mineral occurred occasionally, or in such quantities as to materially detract from the value of the ore, cannot be said, as an examination of the pit was rendered impossible, it being filled with water.

The Ore of the Bristol Mines.

The principal constituents of the Bristol ore are magnetite and hematite, mixed, as analyses of a number of samples show, in variable proportions. The average grade would consist probably of about equal proportions of magnetite and hematite, mixed occasionally with gangue material. Sometimes small crystals can be detached from the ore, which, upon examination, prove to be cubes, or cubo-octahedrons. Much of the ore is found in a crystalline condition, the shining small plates of the magnetite sometimes producing a brilliant effect.

These ores are, as a rule, iron black, with a black streak, and a highly metallic lustre, and are strongly magnetic.

The more fine grained varieties contain sometimes very fine streaks of iron pyrites, sometimes of a brown tarnished colour, running at random through the ore, and producing, by their varied colours, a peculiar effect. Ores rich in hematite have a more even fracture, exhibit sometimes a greasy appearance, and have a dark red streak. If iron pyrites is present, it is generally diffused irregularly through the whole mass as fine impregnations, which take a brown colour, when exposed to the air. The ores have sometimes a dark greenish tint, due to the presence of green nodules of hornblende. Much of the ore is clean, and does not require any cobbing, or roasting, to eliminate the sulphur, especially the ore produced from the interior of large deposits. But the ore which is found in small pockets, or lenses, or veins, is more or less intimately mixed with country rock, of which the more prominent are hornblende and mica schists.

ANALYSES OF SAMPLES FROM THE BRISTOL IRON RANGE.

Constituents	1*	2†	3†	4										
Ferrous oxide of iron	65·44	......	......	......	......	......	......	......	......	......	......	......	......	......
Ferric oxide of iron	14·50	......	......	......	......	......	......	......	......	......	......	......	......	......
Oxide of manganese	0·11	0·15	0·100	......	......	......	......	......	......	......	......	......	......	......
Alumina	0·60	trace	trace	......	......	......	......	......	......	......	......	......	......	......
Lime	3·90	0·92	1·100	......	1·66	1·10	0·65	0·80	0·60	0·10	1·15	......	1·97	0·05
Magnesia	0·45	2·41	2·160	......	3·70	4·53	0·80	2·00	1·30	2·04	1·59	......	1·85	0·60
Phosphorus	trace	0·004	0·005	......	0·007	0·010	trace	0·004	0·003	0·006	0·011	0·015	0·005	0·006
Sulphur	2·74	0·54	0·220	......	0·310	1·35	0·846	0·767	0·559	0·696	0·747	1·233	0·128	2·484
Silica	11·45	5·35	7·55	......	17·12	17·24	8·88	8·99	12·20	9·37	17·65	......	28·40	16·00
Titanic acid	none	......	......	......	0·20	0·12	0·10	0·25	0·10	0·12	0·11	0·18	0·25	0·25
Graphite	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Insoluble matter	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Water	0·14	......	......	......	......	......	......	......	......	......	......	......	......	......
Carbonic acid	1·64	......	......	......	......	......	......	......	......	......	......	......	......	......
	100·97													
Metallic iron	58·37	62·03	62·80	......	54·25	51·58	61·48	58·61	55·93	60·39	52·17	43·76	43·86	56·03

*Dr. Harrington, Geol. Survey Rept., 1873–74, p. 211.
†Laboratory of Monongahela Furnaces, Pa.

The deposits do not, as a rule, exhibit a clean selvage from the adjacent rocks, the ore generally being attached to the latter, and its mechanical separation is, therefore, difficult.

Near the surface of the deposits a partial alteration of the ore may be observed. The magnetite is often partially changed into hydrated peroxide of iron, and the enclosing rocks also frequently present a rusty appearance. It may be found, perhaps, that the origin of this hydrated peroxide of iron, which is mineralogically a limonite, is probably the decomposition of pyrites associated with the ore, rather than an alteration of the magnetite itself.

Of the more important minerals associated with the Bristol iron ores, may be mentioned, hornblende, calcite, chlorite, feldspar, quartz, mica, pyrites, and pyroxene.

Hornblende is the most frequent mineral in the ore, and occurs in several varieties. It is of a dark greenish to blackish colour, and is found in the ore in the form of fine streaks, and sometimes also in a semi-fibrous state, along the contact with the adjacent country rock. The dark greenish colour of the ore is due to this cause. While the ore containing this formation consists largely of hornblende and schists, cleavable along lines of stratification, the hornblende found intimately associated with the ore is massive, and is not easily detached from the latter. In some instances it forms beautiful green nodules, buried irregularly in the light green aphanitic matrix. In some of the pits, the hornblende associated with the iron ore is ferruginous, and has a rusty colour. This rock can be used in limited quantities in the furnace, because, besides a certain portion of iron, it contains essential constituents for the formation of slags.

Feldspar is often present in the ore, because it is a prominent constituent of the containing formation, which consists largely of a reddish syenitic gneiss strata. A great portion of the dumps, near the shaft, is made up of iron ore, associated with feldspathic rocks, and it appears also that large masses of syenitic gneiss had to be penetrated, at some places, in order to reach the ore bodies. At the contact of the feldspar and the ore no selvage or bedding plane, as a rule, can be observed. In many cases both minerals merge into one another, and often a greenish tint is observed on these contacts, but the cause of this cannot be sufficiently explained.

Feldspar in large quantities does not form a good gangue stone for an iron ore, for, being acid in its chemical composition, it would require the addition of larger quantities of lime in order to form a good slag. Quartz is a frequent companion of the ores, being met with in connexion with the syenitic rocks enclosing the deposits. It frequently accompanies the ore, in the form of disseminated grains, or in little veins. Being strictly of acidic composition, its presence in the ore requires, in smelting, the addition of lime, or other basic substances, in larger quantities than would otherwise be necessary.

Mica is a frequent gangue material. Being one of the principal constituents, like hornblende, of the containing formation, it is frequently intermixed with the ore. In general it is of a pale, silvery grey, and sometimes black colour, and occasionally a faded greenish colour can be observed. It belongs to the biotite species of micas. It forms small veins and sometimes pockets in the ore, and frequently the latter breaks up easily, due to the presence of mica veins. Occasionally the ore at the contact with the syenitic strata is covered with a film of silvery grey mica, and in this case it can be easily freed from the containing rock. Some of the mica schists contain impregnations, pockets, and fine veins of ore, which, when hematite is present, can be distinguished by its dark red colour and red streak.

Calcite is not frequently met with in the Bristol ores. In some of the specimens, disseminated grains of calcite could be seen with the glass. Small aggregations of crystals of the mineral were also observed in cavities, but not in direct association with the ore.

Pyrites is a frequent companion of the ore, and its presence, above a certain limit, detracts seriously from the market value of the latter. As outlined above, it occurs in the form of small veins, nests, or pockets, through the mass, some of them nearly half an inch thick. It is found also as fine disseminations, which, when tarnished to a brown colour, give the ore a beautiful, striking appearance.

In the Hull iron range, iron pyrites is met with mostly in a coarse form in certain portions of the ore bodies, and these can easily be separated by hand from the pure ore. The distribution of iron pyrites throughout certain masses of the ore bodies at the Bristol mines, in the form of fine irregular veins, and disseminations, renders mechanical cleaning impossible, consequently, such ores, which from outside appearance contain too much pyrites, must be submitted to a roasting process, in order to keep the contents of sulphur in the smelting ore below the admissible limit. However, the quantity of pyrites which necessitated roasting of most of the ore from the upper workings of the mine, had, according to an examination made by Mr. John Birkenbine, at the time when the mines were in operation, so much diminished in the lower workings, as to render roasting no longer necessary. The effect of sulphur upon iron, as is well known, is to make it red-short, or brittle, when hot.

Pyroxene is an occasional companion or gangue material of the ore, but by no means as common as the hornblende or feldspar. Its association with the ore is very irregular. Sometimes it forms irregular fine streaks, $\frac{1}{16}''$ thick, penetrating the ore in every direction, forming a regular net work. At other times it forms small nests, or pockets, as large as a walnut; again it is seen forming parallel layers, of $\frac{1}{2}''$ and even $1''$ in thickness, at the contact with the enclosing formation. The mineral exhibits no cleavage, or bedding planes; it occurs in a massive form, is intimately associated with the ore, and attached to the latter. It is of a pistachio green colour and very frequently runs in thin, reticulating veins in the syenitic gneiss near the contact with the ore. When the feldspar is flesh red, which is mostly the case, the mixture produces a beautiful ornamental stone.

Besides those above mentioned, there are a number of other accessory minerals found associated with the Bristol iron ores, but they are of no importance, as far as the general character of the ore, or the economic usefulness of the latter, is concerned.

Summary Regarding the Bristol Iron Range.

From the foregoing description of the physical aspects of the various outcrops of iron ore on the property on which the Bristol iron mines are located, we come to the conclusion, that, in general, the ore lies in lenticular bodies, elongated northwest and southeast, with a steep dip towards the east, in parallelism with the enclosing rock, which consists principally of reddish syenitic gneiss, and hornblendic-micaceous schists. Ore bodies vary in size from rich impregnations to large lense shaped bodies, of a width of 20 feet or even more. Mr. John Birkenbine, M.E., who made a report on the Bristol mines, during the time of operation in 1888, says that the mine at that time was opened to a depth of 150 feet, with drifts along the strike for 150 feet, and across the ore bed for 50 feet, in one place, and from 50 to 60 feet in another. Whether these cross-cuts were all in good ore cannot be said with certainty, but it is known that large quantities were raised from these workings, and shipped to the United States.

The ore, though generally called magnetite, is really a mixture of crystalline magnetite and hematite, of varying proportions. The iron bearing formation has, as detailed surveys have shown, an approximate width of 500 feet, and extends from lot 21, on which the mines are located, into lot 22, where, with the exception of several outcrops in the western part, the formation is concealed by a heavy mantle of humus. However, pieces of iron ore have been frequently found as float in plowing the field, while in sinking a well, in the centre of the property, the ore body is said to have been met with. Taking, therefore, these indications into consideration, we have an approximate length of the ore bearing formation of 1,500 feet. As to the extension of the ore bodies in depth, it is known that, in the main shaft, a depth of 200 feet has been reached, and that the ore there is still continuous. In another place, No. 5, as per fig. 9, a depth of 75 feet was reached, and, according to the statement of the foreman who worked this pit, the bottom is still in good ore. There is no adequate reason to suppose that there could be any material change in the character of the ore bodies, at least for a depth of several hundred, or even a thousand feet. The syenitic gneiss formation, in which the deposits occur, is here strongly developed, without any evidence of having been subjected to disturbances which could have had any bearing on the lateral as well as vertical extension of the ore bodies.

As to the quality of the ore towards depth, the writer is not able to enlarge on this subject through personal investigation; because the only pit which attained a depth of nearly 150 feet was filled with water at the time of examination. But here again we have the important statement of Mr. John Birkenbine, above referred to, that the quantity of sulphur which necessitated roasting the ore from the upper levels of the mine, had become so much diminished in that from the lower workings as to render roasting no longer necessary. This statement in itself is of very great importance, because it removes one objectionable feature of the occurrence, upon which, in a more or less degree, the success of the venture depended. It is only to be regretted that operations towards greater depth were not continued in order to substantiate the foregoing statement, by actual production of the ore on a large scale. It seems very likely that, in the event of the deposits yielding ore with sulphur below the admissible limit in greater depth, the enterprise would have been on a paying basis a great many years ago, and its history would be different.

As to the quantity of available ore in the Bristol mines, the writer is not in a position to submit data as to tonnage in sight, for reasons already given. The work so far done on the surface is not of such character as to enable one to make any estimates, and the underground works, which could materially assist in such a task, were all submerged at the time of examination. How many tons of iron ore have been raised during the course of operations cannot be said with certainty, as the reports at hand are rather conflicting. One report before me says that 12,000 tons have been shipped, principally to furnaces in Pennsylvania, making high grade Bessemer. In the absence of reliable data upon which an estimate could be formed, the writer can, therefore, base his opinion of the ore supply on conjectural evidence only, and he comes to the conclusion that, so far as the large outcrops and the results of the underground explorations seem to indicate, there is every reason to suppose that the mine contains quite extensive ore reserves, the exact quantity of which can only be determined by systematic development work.

In conclusion, a word may be said concerning the method of working the mine. The peculiar occurrence of the ore in parallel beds, or lense-shaped bodies, along the stratification of the enclosing formation, from the size of a walnut to deposits of over 20 feet in thickness, and their apparent frequency inside the limits considered, would seem to point to quarrying, instead of underground work, as the best means for extracting the ore cheaply from the rock. There is no reason why this method should not be applied with success to the exploitation of these ore bodies. Wide and long quarries, along the stratification of the rocks, and taking in the greatest possible number of ore deposits, should be established, and worked by a number of cable derricks placed on the long sides of the pit, a practice which is now followed in nearly all large ore quarries. There is no question in the mind of the writer that the ore could be quarried, and broken to suitable size, for sixty cents a ton. The cheapness of the open-pit mining method, as compared with underground mining, is due to the large production possible, to the fact that timbering is not necessary, comparatively fewer men are required, lighting expense is less, all the ore can be moved (while in underground methods more than 10 per cent is lost), the ore can be better sorted, and it has to be handled once only. In the foregoing statement of the case for development in accordance with modern methods, the writer does not claim to have technically exhausted the subject; but he would like to merely submit the facts for further serious consideration.

There is another very important factor to which the writer would like to draw attention, and that is, the utilization of the Chats falls, at a distance of 4 miles, on the Ottawa river, for the production of power. These falls possess special advantages as regards the establishment of an electric power station, and, upon good authority (see Appendix I, page 123), it is stated that from 50,000 to 150,000 indicated horse-power can be generated. There would be no difficulty in transmitting enough power to the mine for general purposes, such as the production of compressed air, which in turn could be utilized for drilling and hoisting, and also, last but not least, for electric smelting of the iron ores on the spot.

As is well known, the great success with which the experiments in the electric smelting of magnetic iron ores at Sault Ste. Marie,[1]—conducted on behalf of the Dominion government, by Dr. Eugene Haanel—have been crowned, has opened a new era for the reduction of iron ore, especially in those places where fuel is difficult to obtain. There should be no reason why, after extensive development work in the mine, the production of pig iron, by electric energy, on the spot, should not be proceeded with; especially in view of the fact that, according to good authority, the water power at Chats falls can be developed at a cost of $4.50 per E.H.P. year.

Other Ore Deposits in the County of Pontiac.

There are quite a number of deposits known to exist throughout the county of Pontiac, but many of them afford a mineral of an impure character, or are too limited in extent to be of any commercial value. Many attempts have been made to develop these deposits, but most of them have failed for the reason that they proved to be composed of small pockets, or impregnations. Amongst the more important ones may be mentioned the following:—

Lot 2, range i, Bristol. Here specular iron, in broad crystalline plates, occurs with quartz, and also with calcite, in what appears to be true veins, cutting the crystalline limestone and the adjoining gneiss. A small deposit of specular iron exists at the junction of the granular limestone, holding mica and pyrites, with overlying reddish syenitic gneiss. Another vein, partially mixed up with limestone, is split up into small parallel strings. The reddish syenitic gneiss, associated with the limestone, occupies the south side of the Chats falls, and here another deposit, of considerable extent, is said to have been discovered. On account of the small amount of work done on all these deposits, an opinion on their general character and extent must be deferred.

[1] For commercial success, see Report on the Investigation of an Electric Shaft Furnace, Domnarfvet, Sweden, by Eugene Haanel, Ph.D., 1909.

Lot 22, range i, Bristol. Near the centre of this property, in the midst of thick brush, an outcrop, of about 2 feet square, exhibits iron ore, of apparently good quality. It occurs in patches, or small pockets and disseminations, through a coarse grained, much decomposed, and rusty looking hornblende rock. As no work had been done, nothing further can be said about this occurrence. Towards the south of the lot the Laurentian is overlain by Silurian rocks, and it appears that the above outcrops occur close to the contact between the two formations.

A sample of the iron ore from this locality, analysed, gave:—

Titanic acid.	11·780
Phosphoric acid	0·006
Phosphorus.	0·003
Sulphur	0·063
Metallic iron.	34·250

Lot 25, range ii, Clarendon. Small excavations, on what appeared to be outcrops of rich iron ore, were made by the writer, when examining this property. The ore is finely crystalline, also with smooth metallic fracture, and, to some extent, impregnated with grains and fine veins of quartz. It has a pronounced red streak, shows no magnetic attraction, and appears to be strictly hematite. The character and extent of the deposit could not be determined, as the work done on it did not admit of a closer study. Most of the iron ore examined was in boulders, buried in a red humus, while little ore could be seen in place. It occurs in close association with a reddish syenitic gneiss, merging in certain parts into hornblendic gneiss, at the contact with lower Silurian limestone. It appears that the iron ore extends in an eastern and western direction, for float has been found, in numerous places, in ploughing the field, while some of the humus is distinctly stained red. An analysis of a sample from the principal outcrops gave the following:—

Silica.	50·030
Ferrous oxide.	1·790
Ferric oxide.	44·670
Titanic acid.	trace
Lime.	1·250
Magnesia.	0·350
Manganese.	trace
Phosphoric acid.	0·004
Phosphorus.	0·002
Sulphur.	0·112
Alumina.	1·250
Metallic iron.	32·650

In the western part of the lot, arsenical pyrites occur in connexion with quartz, cutting a rusty decomposed gneiss. The surface of these rocks, as well as of a number of others in close proximity, is stained quite red, as a result of the decomposition of the iron pyrites, with which the formation at this locality is heavily charged.

Lot 26, range ii, Clarendon. On this lot, near the road leading to Portage du Fort, a deposit of iron pyrites occurs. As far as the excavation shows, it has a width of 12 feet, and is closely associated with quartzose feldspathic rocks. The deposit extends for half a mile towards the river, and is reported to be of considerable width, at some places. As this class of ore does not come under the scope of this treatise, no further investigations regarding the character of the deposits were made.

Lot 27, range vii, Clarendon. This property, belonging to Mr. Ritchie of Bryson, exhibits, in some places, a highly magnetic iron ore, of coarse crystalline fracture, which appears to occur in veins and pockets, associated with a dark, coarse, hornblende rock. Some of the ore obtained was clean and of excellent quality, while other specimens showed an intimate mixture of the ore and hornblende, the latter forming dark green streaks in the otherwise black, glistening ore matrix. A specimen submitted to analysis gave the following results:—

Silica	7·840
Ferrous oxide	27·450
Ferric oxide	46·560
Titanic acid	7·230
Lime	0·860
Magnesia	1·760
Manganese	1·920
Phosphoric acid	0·002
Phosphorus	0·001
Sulphur	0·800
Metallic iron	54·940

On closer inspection, with the naked eye, of a large sample freshly broken, there can be seen irregular dark bodies, thickly crowded in a light green groundmass. With the hand lense, the interstitial matter appears to be finely crystalline quartz, and magnetite, while the rounded bodies appear aphanitic, with uniform colour, and conchoidal fracture. No further investigations of this interesting deposit could be made, as the locality is densely covered with heavy underbrush, herbage, and trees. Indications of magnetic iron ore were also found in several other spots, but nothing definite can be said about these.

Lot 12, range i, Litchfield. This property belongs to Messrs. de Souche, of Bryson, and has been known for many years to contain magnetite. These occurrences consist of impregnations of a coarse crystalline magnetite in coarse crystalline limestone, which strikes N.E. 20°, and dips towards the east, under an angle of 10°. Some work has been done on the steep slope of a hill, near the road connecting Campbell bay with the village of Bryson. This work consisted of several openings, one of them being 8 feet long, 6 feet wide, and 4 feet deep. The ore disseminations appear as pockets and lenses, from 2 feet up to 4 feet in diameter, but these are apparently not frequent enough to justify their economic extraction. The rock on the surface is, in some spots, very coarsely crystalline, and aggregations of rhombohedral forms can be seen in several places, but as a rule they contain no magnetite. It breaks up easily from the magnetite, and if large deposits, or heavy impregnations, were found, no difficulty would be experienced to free the ore with ease from the containing rock. The magnetite itself appears to be very pure, without any detrimental admixture. When exposed to the open it takes a dark bluish to dull black tarnish. There are several openings along the hill, but none of them exhibit ore in paying quantities.

Lot 12, range v, Litchfield. This property belongs to Mrs. Flynn, and was worked for magnetite many years ago. In the northern part of the property a shaft has been sunk to a depth of 20 feet, in what appears to be a pocket, or lense, following the strike of the country rock, which is composed near this opening of coarse grained syenite, merging, by the preponderance of hornblende, into hornblendic rocks. The general strike of the formation is N.W. 50°, with very steep dip towards the north. The pit being full of water no closer examination could be made. The ore is coarse grained, highly crystalline; and an analysis of a 10 pound sample, selected from the dump, gave the following results:—

Silica	4·000
Ferrous oxide	32·470
Ferric oxide	43·900
Titanic acid	13·030
Lime	0·070
Magnesia	2·080
Manganese	0·900
Phosphoric acid	0·008
Phosphorus	0·004
Sulphur	0·921
Metallic iron	55·980

The ore is generally massive, the colour is black, sometimes dark green, the texture finely granular. Scattered crystals of magnetite, through the matrix of the country rock, may be perceived with the naked eye. In one specimen, three bands of magnetite traverse the rock, of which two are very near together, and join. These two are about $\frac{1}{4}''$ wide, while the third varies from $\frac{1}{4}''$ to $\frac{1}{16}''$. Along the edges of these bands is a weathered selvage strip, which is distinguished by its rusty red colour. These bands evidently follow pre-existing cracks. There was no work done on this occurrence, outside the sinking of the little shaft, and it appears that the deposit is not large. Indications of magnetite ore were found on the farms east of lot 12, belonging to Mr. McGuire and Mr. Cole respectively. As no work had been done on these small outcrops nothing definite can be said about them.

Lot 10, northwest half, range viii, Litchfield, the property of Mr. John Hearty. Magnetic ore occurs here, on the summit of a mountainous ridge, striking through concessions viii and ix, in an east-westerly direction. The formation consists, for the greatest part, of quartzose, feldspathic rocks, merging, towards the summit of the range, into rusty gneiss. Blocks of an apparently pure magnetite can be seen strewn all over the hills, and in one place an outcrop of the solid ore can be noticed. No work of any kind had been done on the same, and the place was thickly covered with soil, herbage and underbrush. An analysis of the ore gave the following results:—

Silica	2·750
Ferrous oxide	32·100
Ferric oxide	41·020
Titanic acid	15·750
Lime	0·570
Magnesia	1·160
Manganese	0·400
Phosphoric acid	0·010
Phosphorus	0·005
Sulphur	0·078
Metallic iron	53·680

There seems to be a possibility that, by systematic prospecting work, larger deposits of the ore might be discovered. Outcrops of the magnetite have also been found in an eastern direction from the lot just described, on lots 11 and 14. Samples of the ore show impregnations of magnetite in reddish feldspathic rocks. One of the hand specimens shows two distinct parts. The first is massive, without cleavage jointing or any other parting, and is thickly mottled with small grains of magnetite. The second part is dark grey, banded and heavy with iron. The banding is marked by lighter and darker shades, and there is a parting parallel to the banding. Nothing can be said about the extent and character of the deposits, as no work had been done on them.

Some samples have been brought down from Otter lake, in the township of Leslie, about 12 miles northeast of Campbell bay. From what can be seen on these samples, the ore, a dark glistening magnetite, occurs as small pockets in a matrix of pegmatite, the latter consisting of a flesh coloured, orthoclase feldspar, and a translucent, vitreous and greasy looking quartz.

On Calumet island magnetic ore has been found in several places; some have been known for over twenty years, but they have never been thoroughly tested, and as most of them are now covered with dense bushes and herbage, any opinion expressed must of necessity be of a conjectural nature.

Lot 13, range vii, Calumet. Several outcrops of what appears to be a hematite ore occur here, but little work has been done on them. The country rock is a white crystalline limestone, striking north and south. In one place, which was uncovered by some prospecting ditches, the ore is associated with quartz, and apparently with chert, which, in its hard parts, is banded with alternating fine grey and white lines, and in other places is decomposing to a white powder. Many of the smaller crevices, between fragments of this nature, are filled with translucent crystalline quartz, of the variety that is commonest in quartz veins.

Some of the ore presents a dark brown rock, heavy with iron, and with somewhat of a metallic lustre. There are also scattered residuary blotches, streaks and patches, of a pinkish white rock, mottled with red. Most of the ore is non-magnetic, is of a highly metallic lustre, and appears to be very pure. The form of the deposits could not be well studied, for reasons above explained, but it appears that it is more of a veinlike occurrence, crossing the strike of the formation at right angles.

A sample analysed gave the following results:—

Silica	22·000
Titanic acid	0·250
Lime	0·100
Magnesia	0·060
Phosphoric acid	0·023
Phosphorus	0·010
Sulphur	0·038
Metallic iron	52·670

There are several places, on this property, where the ore outcrops, but as there has been no work done, nothing can be said regarding the extent of the deposit.

Indications of the presence of the ore, as impregnations and small pockets, can be noticed on the adjoining lots, to the east and west, and, from what can be seen of the extent of the ore deposit, it appears that the latter has a general northeast, southwest trend.

Lot 2, range ix, belonging to Mr. Jerry Shea. Magnetite iron ore has been discovered on this lot, on the rocky shore of the Ottawa river, close to the water's edge. The rocks in which the ore occurs are mostly of a syenitic character, merging at places into a granitoid gneiss. They have been subjected to disturbances, as can be seen from the numerous fissures, and cracks, and the eruptive dikes occurring in the rock exposures containing the ore, as well as in the vicinity of the same. Along the cracks formed by these disturbances and movements, the rocks have been impregnated with magnetite, forming sometimes small pockets and bands. In the rock immediately adjoining these cracks the slight schistose structure induced has given rise to selvage bands, where the spotted granular structure has been mainly replaced by a faint linear structure. The ore is not found in large economic masses, but may be described in general as occurring in small lense shaped, or veinlike bodies, from a few inches, up to 2 and 3 feet in width, irregularly distributed through the rock. Some parts of the ore are very pure, free from any country rock, while others are intimately mixed with quartz, the latter occurring as small veins, or as disseminations through the ore.

Lots 4 and 5, range x, Litchfield. Magnetic iron ore occurs on the line between these two lots, on the slope of a high ridge, which strikes in a north and south direction through the country. The country rock is syenitic gneiss, which, by the preponderance of the hornblende at scattered places, merges into hornblende rocks. The ore, which is a titaniferous magnetite, is associated with a grey syenite, the latter being generally coherent with the ore. There is sometimes a spotted, granular structure distinctly discernible in the iron bearing rock, which is caused, either by the presence of clustering patches of magnetic oxide, or occasional associated sheaves of actinolite. Interstices may be found, which are marked by crystalline quartz grains, around the edges of which come the coarser feldspathic rocks, which bear the magnetic iron oxide, either in fine disseminations, or in small pockets.

Most of the iron ore in place appears to be free from admixtures of country rock, and large blocks of clean ore are obtainable. However, owing to the little work done on the outcrops, the character and the extent of the ore bodies could not be studied to advantage. The appearance of the outcrops is encouraging, and certainly more work should be done to prove the extent of the depositions.

A sample collected from different parts of the outcrop was analysed and gave the following results:—

Titanic acid	15·440
Phosphoric acid	0·008
Phosphorus	0·004
Sulphur	0·084
Metallic iron	47·920

As will be seen from the above analysis the ore contains titanic acid. A comment on the usefulness of ores containing titanium will be found on page 105.

It must be mentioned that there is a fine water power on lot 5, range ix, on Bernard creek, at a distance of about half a mile from the iron ore location above described. This water power has a fall of approximately 50 feet, and is at the contact of the limestone with the gneiss. In case of mining operations the same could be utilized to great advantage.

Lots 12 and 13, range vi, township of Sheen, the property of Mr. N. I. Gareau, of Pembroke. An opening of about 15 feet square, and from 2 to 3 feet deep, on the side of a hill, on lot 12, shows ore, in association with quartzose feldspathic rocks. The country rock is fine-grained, stratified granitoid gneiss, with a strike east and west, and a dip of 45° south. This country rock is frequently intersected by dikes of a dark greenish diorite, and a flesh coloured pegmatite, of a width of 10 feet and over. The ore occurs in the opening above referred to, in one of these pegmatite dikes, the latter consisting of a glossy translucent quartz, and flesh coloured orthoclase feldspar.

On the contact of this dike and the country rock accumulations of the ore, in the form of pockets and disseminations, can be noticed, yielding sometimes masses of clean ore, free from any foreign rock matter. In one place, at the contact, the following sections, in ascending order, were taken: quartz 2″, magnetite 3″, quartz 2″, ore 3″, mica-feldspar 2½″. (See fig. 11.)

As far as can be judged from the little work done on the property, it seems that the ore here occurs more in bands, veinlike and lense shaped deposits, through a quartzose feldspathic matrix, which forms dikes intersecting the formation. Sometimes the magnetite forms a net work of veins, in the groundmass, and the ore generally obtained from this source is impure, and intermingled with barren rock. The rich ore is mostly obtained from the band, and lense shaped deposits, and it would be interesting to know the

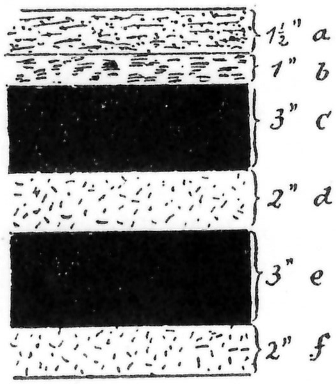

FIG. 11.—Typical succession of rocks in connexion with iron veins on lot 12, range VI, township of Sheen. Scale 1 inch to 8 inches.

character and extent of the latter towards depth. In some of the specimens, persistent but irregular bands of crystalline magnetite may be observed, which appear to follow mechanical fractures in the rock. In some cases the magnetite of these veins is riddled by irregular cavities, and along these, and along the edges, there is an evident decomposition to what appears to be hematite. In other specimens, broader bands of magnetite are seen in a matrix of quartz, but they are marked by the same features as these little veins.

Iron pyrites can be noticed occasionally, associated with the magnetite as fine veins, and sometimes in very small crystals. The small veins when exposed to the air for a long time take a brown and rusty colour, and sometimes seem to form a minute network through the ore matrix. An analysis of a sample collected from the ore in place gave the following results:—

Silica	2·200
Titanic acid	5·910
Lime	0·140
Magnesia	0·160
Phosphoric acid	0·016
Phosphorus	0·007
Sulphur	0·221
Metallic iron	60·710

The Grenville Iron Ore Deposits.

These deposits are located about half-way between the cities of Montreal and Ottawa, to the north of the river, hence are somewhat isolated from those in the county of Pontiac, and along the Gatineau river. They have been known for over sixty years, having been discovered in the year 1846, but they have never been worked to any extent. The most important deposits occur on lot 3, range v. Near the centre of the south half of this lot, a number of openings have been made, on an east and west course, on what appears to be an accumulation of pockets, and lense shaped deposits of magnetic iron ore. All the bottoms of these pits, which were of shallow depth, were covered with debris and water at the time of examination, and it was, on this account, very difficult to form an idea of the character of the ore depositions.

The more easterly pit, on the side of a hill, is 20 by 30 feet, and of apparently shallow depth. This pit was filled with dump, and only on the western side could several small pockets of magnetite, of 1′-6″ and 2 feet in diameter, be seen. The rock on both sides of the pit appears to be a micaceous gneiss, interstratified with bands of grey quartzite. The iron ore is associated with the minerals of the gneiss, sometimes also with hornblende rocks. The ore lode, as far as can be made out, is about 25 feet wide, striking east and west in the pits, and being embedded parallel with the run of the country rock. The most westerly pit measures about 50 feet (north south) by 20 feet. A small drift had been run from this pit, in westerly direction, on the entrance of which several portions of a disseminated and pockety deposit were noticed. On the northern wall of the pit a number of lense shaped deposits occur, but nowhere could the characteristic features of a vein be detected. The ore lode, west of the pits just described, turns to the southwest, and can be traced for over 400 feet.

Syenitic rocks are met with to the north of the gneissic strata; they cut off the latter, and also the ore deposits, in a western direction. The ore, which appears to be a pure magnetite, is highly magnetic, has a crystalline surface, and appears to be mixed, as a rule, with the minerals of the gangue and the containing gneiss. These are, for the most part, a dark fine-grained greenstone, sometimes of a rusty colour, flesh coloured feldspar, quartz, and a rusty hornblende. From what can be seen, these impurities do not as a rule reduce the quality of the ore below a fair workable percentage of iron, because a sample of the ore, which exhibited quite a rusty, grey colour due to such impurities, analysed, gave 57·4 per cent of metallic iron.

Some of the hand specimens show a rusty, weathered, almost black coloured rock, traversed by bands of a much lighter coloured material, most of which is quartz and feldspar. The magnetite, which constitutes most of the rock, occurs in irregular segregations and areas, including feldspar, with a much smaller portion of hornblende, and an aphanitic greenstone.

Some of the ore is porous, and is traversed by cavities, which are lined with crystalline quartz, and in a lesser degree, with feldspathic material, the latter sometimes changed into kaolin.

There are also some indications of magnetite in the north half of the same numbered lot, on range iv, but the occurrence is small in extent, being only 6″ to 10″ wide. The ore is traceable for about 400 feet, by indications on the surface, but none of them uncovered so far warrant exploitation.

On the north half of lot 4, range vii, belonging to Mr. Cousins, some small bands of iron ore occur, in a grey gneiss, and on lot 5, range viii, a small vein of magnetic ore runs in a winding manner, with the strike of the enclosing strata, which is here also of a gneissic character. These two occurrences incline towards one another, and though they are of no value from an economic point of view, they may possibly indicate the presence of an ore lode between them; and it would not be a surprise if a magnetic iron ore deposit of workable dimensions should some day be found in this area.

Summary of Iron Ore Locations in the District under Consideration.

The following is a list of all the localities where iron ore is known to exist in the district under consideration:—

Ottawa County—

Hull—

Range vi, lots 12 and 13.
Range vii, lots 11, 12, 13, 14.
Range x, lot 3 S.
Range xi, lot 1.
Range xiii, lot 14.

Templeton—

Range vi, lot 28 N.
Range vii, lot 23.
Range ix, lot 22.

Wakefield—

Range i, lot 7 N.
Range iii, lots 18 and 19.
Range iv, lots 13, 22, 23.
Range v, lots 13 S, 22 E, 22 W, 23, 24 S, 24 N.
Range vi, lot 23 S.

Buckingham—

Range viii, lot 19 S.
Range ix, lot 17 N.
Range xi, lot 17.
Range xii, lot 26 N.

Cameron—

Range ii, lot 30.

PONTIAC—

Bristol—

Range i, lots 2, 22.
Range ii, lots 21 and 22.

Clarendon—

Range ii, lots 25 and 26.
Range vii, lot 27.

Litchfield—

Range i, lot 12.
Range v, lot 12.
Range viii, lot 10 N.
Range x, lots 4 and 5.

CALUMET ISLAND—

Range v, lots 7, 8, 11 and 12.
Range vi, lots 11 and 12.

Sheen—

Range vi, lots 12 and 13.

ARGENTEUIL—

Grenville—

Range v, lot 3.
Range vii, lot 4 N.
Range viii, lot 5.

Wentworth—

Range vi, lot 26.

GENERAL CONCLUSIONS.

The remarkable industrial activity of the present age is strikingly exemplified in the progress that has been made in the world's production and consumption of iron and steel. This progress has been very marked in recent years. The world's production of pig iron, in 1876, was about 14,000,000 tons; but in 1907 it was over 60,000,000 tons: an increase of over 46,000,000 tons in thirty-one years.

In Canada, however, the iron industry is still in its pioneer stage. The subject of iron manufacture, from Canadian iron ores, has not received the attention its importance demands. It has been urged that, most of the iron ore deposits are of limited extent, involving a large expenditure for their exploitation; or they are of a quality unsuited for the manufacture of iron on a commercial scale; and this, it is further asserted, has been substantiated by the failure of so many iron mines in the Province of Quebec and Ontario. But upon investigating the conditions under which these ventures were conducted as far back as thirty years ago—we find that the failure of most of the mines was not due to the quality, nor to the limited extent of the deposits, but solely to causes which lie entirely outside the mining venture proper.

As investigations on this subject have shown, some of the failures were due to incompetent management; others to the lack of fuel and of transportation facilities; and, last, but not least, to the lack of proper concentration methods for the utilization of lean ores. During the last ten years, however, increasing efforts have been made to utilize iron ores which have heretofore been considered useless; either on account of large quantities of gangue stuff, or owing to the presence of deleterious constituents. In various directions attempts were made, especially in the United States, to separate the good material from the bad and useless, and so to produce a material rich enough, or pure enough, for blast furnace treatment. Conditions of to-day, in this respect, have entirely changed, and where fifteen years ago an ore, giving less than 50 per cent of metallic iron, would not be looked upon as an economic utility, to-day, ore as low as 25 per cent—by proper concentration methods—can be raised to the normal standard of a shipping and smelting ore. It is true that the new discoveries of large hematite tracts in western Ontario have somewhat overshadowed, in the estimation of the trade, the available magnetite deposits in the Province of Quebec; hence there has been a disposition to underestimate the great importance of the latter as a possible factor in the iron industry of Canada. It may be mentioned that the magnetite mines in the Adirondacks, which could not be worked successfully in the early days, owing to the lack of proper concentration methods, are now working with great success, and have become the source of an important ore supply. These mines are not only equipped with extensive ore concentration plants, but with furnaces as well, which are reported to produce iron and steel of excellent quality.

They have been in operation since the year 1849, and have produced, up to the present day, approximately 15,000,000 tons of ore[1]. The ore is shipped as far west as Columbus, Ohio, and as far east as Sydney, Nova Scotia. Two years ago a shipment of 50,000 tons was sent to Germany. The ore is largely used for puddling, and as ore additions to the open-hearth process. Practically all the furnaces east of the Alleghany mountains use it, to a more or less extent, as the base of their mixture in the manufacture of foundry, mill, and basic irons and steels.

The largest firm operating in the Adirondacks is Wetherbee, Sherman & Co., who own nearly all the productive mines at Mineville. It may be of interest to give here a brief account of the operations of this Company, whose progressive policy of improvement, in both underground and surface installations, has had a very beneficial influence on the magnetite mining industry, not only in the United States, but also in other countries. During the past

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[1] In the year 1904 the shipments from the mines amounted to 559,500 tons of magnetite.

year attention has been directed specially to increasing the efficiency of the various plants, rather than to adding further equipment. The most extensive changes have been undertaken in the old mill, and when completed, it is hoped that the milling capacity will be sufficient to handle the full quota of ore. The new mill has worked very successfully. An improved Ball-Norton separator, of the endless belt type, perfected at Mineville, has been installed in place of the machines formerly used, and has been found to be well adapted for treating the highly phosphoric ore from the *Old Bed*. The arrangement of the magnets, in series of alternating polarities, which characterizes this separator, imparts a constant vibratory motion to the particles of ore as they pass from one magnet to another, and gives the entangled gangue matter opportunity to free itself. With its use the *Old Bed* ore, which carries about 60 per cent iron, and often 1·5 per cent, or 2 per cent phosphorus, is concentrated to a product assaying over 65 per cent iron, and from 0·5 per cent to 0·7 per cent phosphorus. The tailings made in the process are re-treated in Wetherill separators, which recover a further portion of the magnetite: which is added to the first concentrates. They also take out the hornblende, as a middlings product. The other components of the original ore consist mostly of apatite and quartz, and constitute the tailings from the Wetherill machines. The tailings analyse about 12 per cent phosphorus, or 60 per cent tricalcium phosphate; they form a valuable by-product, which is sold to fertilizer manufacturers. The hornblende tailings also contain phosphorus, to the extent of 7 or 8 per cent, but they are, at present, mostly held in reserve.

A feature of interest, in connexion with these mines, is the extensive use of electric power for driving the various plants, as well as for lighting, pumping, and hoisting in the mines. A large central power house, erected in 1903, furnishes most of the electric energy that is required. The generator is of alternating type, 750 kw. capacity, and is directly connected with a 1,000 horse-power Nordberg-Corliss engine. A second power house, containing a 200 horse-power engine and 150 kw. generator, supplies current to the old mill. The Company has also an electric generating station at Wadhams mills, on the Bouquet river, the power from which is transmitted to the mines, and used to supplement the regular supply.

From the above general description of the Mineville magnetite mines, it will be seen that much of the success obtained is due to the elaborate system of concentration, and mine equipment, and that the initial difficulties, which had to be overcome in preparing the lean ore for the market, are similar to those in the Canadian mines.

As a result of the examination of the iron ore deposits along the Ottawa river (north shore) and the Gatineau river, the writer comes to the following conclusions:—

(1.) The iron ores, as far as present development indicates, are scattered over a comparatively large area, and the full extent of most of their deposits can only be determined by further development work, or by magnetometric surveys.

(2.) At two places—the Bristol and Hull iron ranges—where considerable work had already been done many years ago, the deposits are extensive, and hold magnetite and hematite ores of excellent quality. In addition to the advantages that warrant confident expectations for the future, based on natural conditions, it may be further stated that the methods of concentration of lean ores, such as have lately been put into practice for low grade magnetites in the Adirondacks, are applicable, on a large scale, in Canada. A particularly noticeable feature, connected with the manner of occurrence of the magnetites, is the abundance of medium grade ores occurring alongside the rich magnetites. The magnetism is well pronounced in these ores, and sometimes can be followed for long distances, although, when carefully examined, the percentage of iron is found often to be lower than furnace practice demands.

The objection is occasionally raised that magnetite ores are not as readily reduced in the furnace as hematites, and are, therefore, not worth as much money to the smelter. In a general way this is true, although one fact deserves consideration, and that is, that magnetites are practically free from moisture, so that freight is not paid on the latter, as in almost any other iron ores. Generally speaking, it is estimated that magnetite involves an extra expenditure, in smelting, of about 25 cents per ton of pig iron, and even this is only a general statement, since there is a considerable difference in the ease with which different magnetites are reduced in the furnace.

But here another interesting subject presents itself for discussion, and that is, smelting iron ores by electricity. As already pointed out in a previous paragraph, the successful experiments in smelting magnetite ores by the electro-thermic process, conducted by Dr. Eugene Haanel, at Sault Ste. Marie, in 1905-6, on behalf of the Dominion government, open an entirely new sphere in the economic production of pig iron. It has been demonstrated on a commercial scale,[1] that pig iron can be produced, economically, at a price to compete with the blast furnace, when electrical energy can be produced at less than $7 per electrical horse-power year. In this connexion, it may be interesting to learn that, according to good authority, the water power at Chats falls can be developed at a cost of $4.50 per E.H.P. year. In addition to these falls, there are a number of splendid water powers in close proximity to extensive bodies of iron ore: as, for example, the comparatively large falls between Kirks Ferry and Ironsides, on the Gatineau river. These falls, located only two miles distant from the Forsyth and Baldwin iron mines, when properly developed, can produce between 150,000 and 200,000 horse-power.

When these powers are owned by the company intending to use them for electric smelting; and peat, coke, and briquetted charcoal from mill refuse—which would probably not cost more than $4 per ton—is employed

[1] See report on the investigation of an electric shaft furnace, Domnarfvet, Sweden, By Dr. Eugene Haanel, Director of Mines, 1909. (Published by the Mines Branch, Department of Mines, Ottawa).

for reduction, the cost of two of the heaviest items, entering into the cost of producing pig iron by the electro-thermic process, will be reduced to one-half.

But, apart from the possibilities of smelting iron ores—especially those containing much sulphur—by electricity, there are other processes by which these ores can be treated successfully for modern blast furnace practice.

As an example of how magnetite ores, high in sulphur, are treated, it may be mentioned that the writer inspected the newly established furnace plant at Port Arthur, of the Atikokan Iron Company, and found there, magnetite ores high in sulphur (up to 1·70 per cent, and phosphorus up to 0·85 per cent), being first treated in Roberts roasting furnaces: hence there is no difficulty experienced in reducing the contents of sulphur below the limit admissible for blast furnace practice.

Modern blast furnace practice has been regulated during the last fifteen years by the conditions of the iron ore market. In the early history of industrial Canada, iron—as a commercial product—was in the form of mineral ore; but to-day, in commerce, is almost wholly in the metallic form of pig iron. The large amount of carbon, however, present in the pig iron makes it brittle and weak, and for that reason renders it unfit for many engineering purposes. It is, therefore, purified by means of either the Bessemer converter, open-hearth furnace, or puddling process. By each of these reducing processes the objectionable impurities—carbon, manganese, and silicon—can be eliminated to any desired degree. But the removal of the phosphorus and sulphur can only be accomplished by special means: mechanical washing in the puddling furnace; the use of basic lining and lime affinity in the Bessemer and open-hearth metallurgical systems; and the application of high temperature in the electric furnace: in which the sulphur can be effectively removed, but not the phosphorus. By no known chemical or electro-thermic process can phosphorus be eliminated from the bath of any of the diverse metallurgical furnaces. It is essential, therefore, that the iron ores used in the manufacture of pig iron should contain as little sulphur and phosphorus as possible. Some 15 years ago, when there was little trouble in obtaining this class of ores, the Bessemer process was mostly in vogue; but since that time, on account of the unsatisfactory condition of the iron ore market, the basic open-hearth furnace has been more and more employed, so that to-day, in the United States, there are 62 Bessemer converters, and 465 basic open-hearth furnaces. This is explained by the fact that the pig iron for the Bessemer furnaces must contain such a small percentage of phosphorus, that after allowing 10 per cent loss of metal during the blow, the phosphorus in the steel should not be over 0·110 per cent. Ores low enough in phosphorus to make this grade of metal are known, therefore, as Bessemer ores. The requirement of such an ore is, that the percentage of iron in it must be at least 1,000 times the percentage of phosphorus. However, the production of Bessemer ores, and ores low in sulphur, has diminished considerably in the last decade, and in order to keep their plants going, the ironmasters are obliged now to cover this discrepancy by utilization of ores high in sulphur and phosphorus, in basic open-hearth furnaces.

As pointed out in previous chapters, a number of the large deposits in the district, covered by this report, contain ores high in sulphur; but, with the perfection of modern roasting furnaces there should be no difficulty in utilizing all these ores by subjecting them to the roasting process, preparatory to treatment in the blast furnace. The resulting pig can then be successfully treated by the basic open-hearth process.

Before concluding this chapter, a word may be said regarding those ores which carry titanic acid. The present disqualification of titanic ores, for use in making iron, keeps these deposits in comparative disrepute. The percentage of titanium, even when small, is considered objectionable. A low percentage of titanium, however, (from 0·75 to 1·25 per cent) if it could be maintained at a low stage, should not debar these ores from present use. We may safely predict that, at some time in the future, these titanic deposits will be found useful and valuable.

The difficulty that has to be met in the use of titanic ores pertains, not to its low grade in iron, nor the presence of phosphorus or sulphur, but to the chemistry of its metallurgy, by which a considerable amount of the iron is lost in the slag, and by which the throat of the furnace becomes quickly obstructed with refractory accumulations. Titanic ore makes a superior iron: the small amount of titanium that remains in the product giving the iron greater hardness and toughness, enabling it to stand greater wear. The iron is also well adapted for making steel. The loss that is occasioned by the smelting of titanic ores is due to the fact that, the only solvents of titanic iron are the double silicates of iron and lime, or iron and alumina and lime, or iron, potash and lime, etc., and as these constitute a part of the slag that runs from the furnace, they carry away a percentage of the iron, and the loss is greater in proportion to the amount of titanium it is necessary to remove.

Titanium has generally been held in disrepute by ironmasters, and they have gone so far as to say, that the result of their experience has been that a mixture containing a greater percentage of titanic acid than 1·25 per cent could not be successfully used. When present in greater quantities, titanium has a tendency to render the slag pasty, and clog the furnace with titanium deposits, if it is not made, by judicious treatment, to pass into the slag. On this account, many deposits of titaniferous iron ore have been neglected as of no value, although such ores are apt to be very free from phosphorus, and are, therefore, especially suitable for Bessemer iron.

In Sweden, and Norway, however, ores containing from 5 to 10 per cent of titanic dioxide have been smelted alone in charcoal furnaces; others containing from 15 to 20 per cent or more, have been smelted in admixture, or even alone; and, lastly, Norwegian ores, containing as much as 40 per cent of titanic dioxide, and only 36 per cent of iron, have been smelted by a company in England with perfect success—as far as the metallurgy of the treatment was concerned—although at considerable expense for fuel.

The successful treatment of these titaniferous ores, to obtain a desired result, depends entirely on the choice of fluxes. Certain natural compounds of titanium, such as sphene, calcium, silicotitanate, and keilhauite, are perfectly fusible in a blast furnace, and the composition of the slag run from the furnace should be made to approximate, in composition, these natural compounds.

The following is the analysis of ilmenite ore, which has thus been successfully smelted in Norway:—

	Per cent
Titanic acid	39·20
Ferric oxide	18·59
Ferrous oxide	30·00
Alumina	2·89
Manganese oxide	0·60
Silica	5·70
Loss	0·22
Iron	36·30

The following was the composition of the slag, compared with natural sphene:—

	Slag	Average sphene
Silica	27·83	31·78
Titanic acid	36·18	40·00
Lime	24·36	24·59
Oxide of iron	1·86	2·00
Alumina	9·18	2·00
Magnesia	0·60	2·00

All the titanic acid of the ore was made to pass into the slag, excepting the small percentage left in the pig metal, perhaps one or two per cent.

APPENDIX.

THE WATER POWERS ON THE OTTAWA AND GATINEAU RIVERS, EMBRACED BY THE DISTRICT UNDER CONSIDERATION.*

The writer does not think the treatise on the iron ore deposits, included in the map sheet, complete, without giving a full synopsis of all that is known to-day regarding the water powers along the Ottawa and Gatineau rivers, in the district under consideration, inasmuch as these will eventually furnish all the power necessary to operate the mines, and all accessory plants in connexion therewith. The importance of water powers to a district so remote from coal mines is not likely to be overestimated. Unquestionably these powers are destined to exercise a wide influence on the development of all kinds of industries, and more particularly iron industries. Reference has already been made, in another chapter, to the possibilities of smelting magnetite iron ores by electricity, cheaply generated from water powers, and it is specially with this object in view that the following report is presented. It is the intention simply to show, so far as possible, how much water is available for use in the two streams mentioned and their tributaries, and to indicate briefly what steps can be taken in harnessing this, one of the greatest dynamics of nature, for the use of man. The data here presented would lack much of the value and completeness they may have, were it not for the generous support of hydraulic engineers and mill-owners. After exhausting all possible sources of information by correspondence, however, it was found that many points of importance could be cleared up only by a personal inspection of the water powers, and for the above reason the following falls were visited:—

I. *On the Ottawa river*:—

- The L'Islet rapids in the Culbute channel.
- The Black River falls.
- The Coulonge River falls.
- The Calumet Island water powers.
  - The Grand Calumet falls.
  - The Mountain, and Dargis rapids.
- The Portage du Fort falls.
- The Chats falls.

*The greater part of the data here presented, was furnished by Mr. P. E. Gauvin, C.E., the well-known hydraulic engineer, Quebec, who has made an exhaustive study of all the Quebec water powers, and whose reports have been published from time to time by the Quebec Government. Additional information, and data were also obtained through the courtesy of Mr. J. P. Brophy, C.E., and from Mr. C. Keefer, C.E., both of the city of Ottawa.

II. *On the Gatineau river*:—

The Six portages.
The Paugan falls.
The Cascades.
The Chelsea rapids.

OTTAWA RIVER.

The L'Islet Rapids.

This water power lies between lots 37 and 38, range ii, of the township of Chichester, on one side, and lots 13 and 14, range i, of the township of Allumette Island, on the other. According to the report of Mr. P. E. Gauvin, C.E., of Quebec, the Dominion Government, in the year 1876, built on the left bank, in Chichester, or rather on the small channel which separates that bank from a small island lying in front of said lots 37 and 38, a canal, with two locks, having a total lift of 16 feet, this being the difference of level between the upper and lower reaches. All the works built there are made of earth and of wood. Between the aforesaid small island and the south or right bank (Allumette Island side), there is a rolling dam about 370 feet long, which was built in connexion with said canal.

These works make it quite easy to utilize the hydraulic power existing there.

Mr. Gauvin gauged the Culbute channel, in the year 1905, near Chapeau village, where its discharge is pretty much the same as at L'Islet rapid. The results of these investigations may be laid down in the following points:— (Gauvin.)

"Useful width of water surface.	264 feet
"Average depth.	10·13 feet
"Area of cross-section	2673·5 square feet
"Mean velocity.	1·633 feet per second
"Discharge.	4304 cubic feet per second

"The velocity of the stream was measured with the Price current meter, at 250 different points, in the five principal spans of said bridge.

"The measurements were made when the river was approximately at its mean level, the low water mark being about 4 feet below this.

"From the results of measurement, and from information obtained concerning the variations of the level of the river, Mr. Gauvin estimates the discharge of the Culbute channel to be 2,240 cubic feet per second, at ordinary low-water, and I believe the discharge of the same can go down to 2,000 cubic feet per second, in round figures, at extreme low water.

"As before mentioned, the difference of level between the upper and lower reaches of the L'Islet canal is 16 feet, in round figures. But the available head there is only about 14 feet.

PLATE IV.

Black River Falls, Que : developed by Pembroke Electric Light Co.

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"The minimum absolute power of the fall, which could be practically used, is 3,180 horse-power, in round figures.

Recapitulation:—

Minimum power which can be developed.	3,180 h. p.
Height of fall which could be used.	14 feet
Minimum discharge.	2,000 cubic feet per second
Distance between the intake and the place of development.	about 400 feet."

In a subsequent report, Mr. Gauvin says, that according to information received, the water level on the day of the measurements was already only $\frac{1}{10}$ of a foot above what had been pointed out to him as low water mark, and which had been admitted as such. Based upon this, it is believed that the power of the L'Islet rapid may go down to 2,000 horse-power, or thereabouts.

The Calumet Island Water Powers.

These may be classified, according to Mr. C. E. Gauvin, C.E., as follows:—

Those on Calumet channel, on the northeast and south sides of the island, and lying entirely in the Province of Quebec:—

Grand Calumet falls.
The Dargis rapid.
The Mountain rapid.
The Sable rapids.

Those on the Roche Fendu channel, including the slide channel, on the southwest side of the island, and lying also entirely in the Province of Quebec:—

Rapid near head of Desjardin island.
Timber slide.
Garvin chute.
Crawford rapids.

Those on the Roche Fendu channel and lying partly in Quebec and partly in Ontario:—

Black falls.
Mice rapid.
Muskrat rapid.
La Barriere.
Long rapids.
Roche Fendu chute.

The total fall, or difference of level, between La Passe, at the head of Calumet island, and Roche Fendu lake, at the foot of same, is 87 feet, according to the returns of the Ottawa ship canal survey.

The following is an abstract of Mr. Gauvin's exhaustive reports:—

Sable Rapids.

"These two rapids (Sable rapid, to the north, and Little Sable rapid, to the south), are situated at the confluence of Calumet and Roche Fendu channels.

"They are situated one alongside the other, as it were, separated by a small island, and not one above the other; their head is only 4′-3″ and their length about 800 feet, according to the returns of the Ottawa ship canal survey.

"The minimum horse-power of these rapids would be about 3,800, but they offer no striking advantage as a water-power.

Rapid, Head of Desjardin Islands.

"According to the returns of the Ottawa ship canal survey, its length is about 1,000 feet, and its head almost 9 feet. Its minimum horse-power would be about 3,000.

Timber Slide.

"This timber slide is between Lafontaine and Desjardin islands. It has been for many years abandoned, the timber now following the Calumet channel.

"The difference of elevation between the head and the foot of same, is 12·30 feet, on a distance of 430 feet.

"The probable minimum horse-power there, would be about 1,400.

Garvin Chute.

"Garvin chute is probably the most remarkable chute on the north branch (north of Desjardin island), of the Roche Fendu channel, and is situated in front of lot No. 18, of range ix, of the township of Grand Calumet, which lot was patented in 1858.

"This chute is, according to the returns of the Ottawa ship canal survey, 10·51 feet high in 200 feet distance. The river, at the head of the chute, is quite narrow—only about 300 feet wide—and is obstructed by rocks and islets, presenting great facilities for damming. Mr. Gauvin thinks that the head could easily be increased to 15 feet.

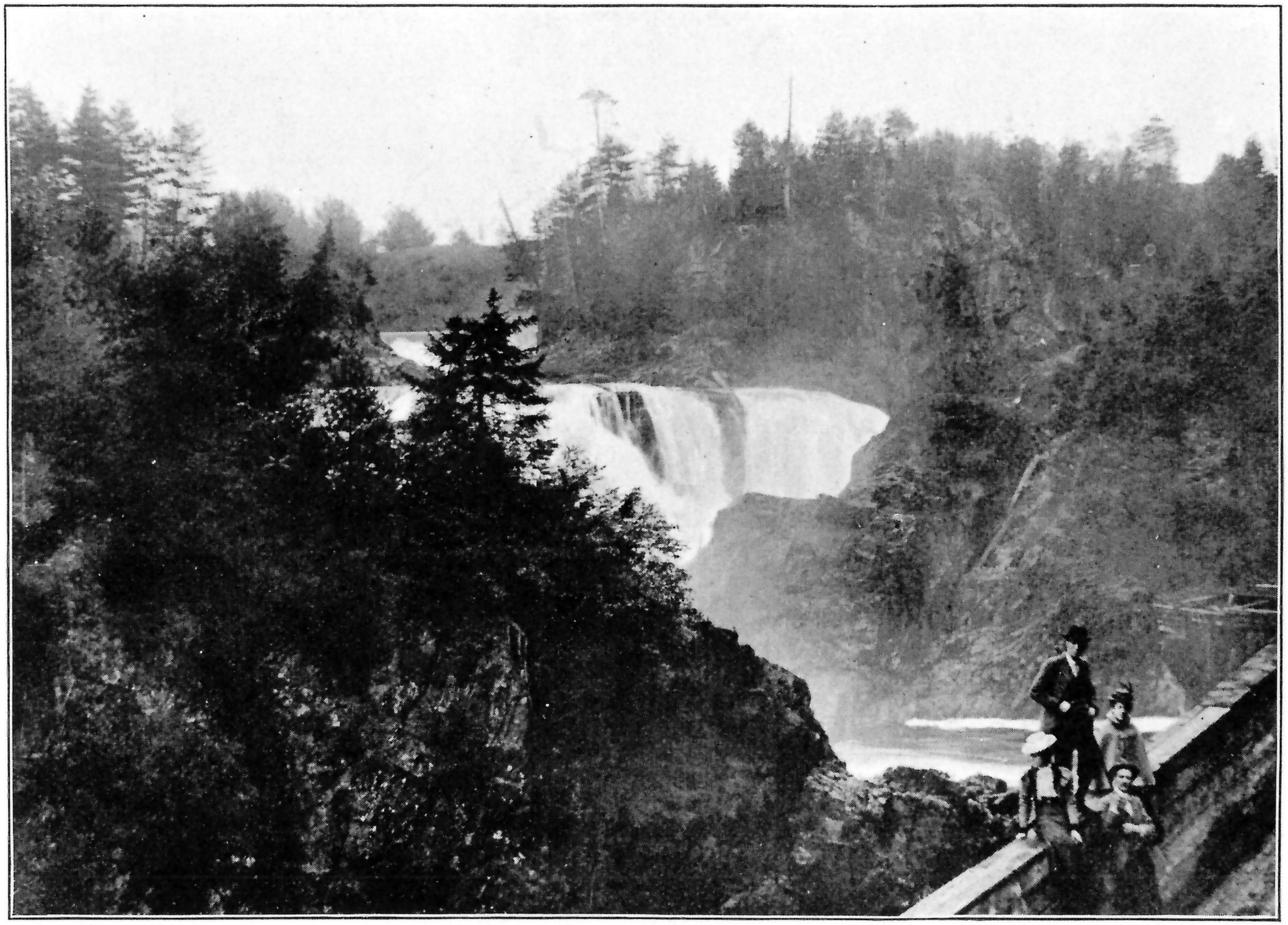
"A fine mill-site, and a minimum horse-power of about 5,000, could be had there. This mill-site is about 6 miles distant, in a straight line from the Pontiac and Pacific Junction railway.

Crawford Rapids.

"These immediately follow Garvin chute, and have a total length of 3,100 feet, and a head of very nearly 20 feet. They might be utilized as water-power in connexion with Garvin chute, as the river could be easily dammed

PLATE V.

PLATE V.



Coulonge Falls, Que.

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across at the foot of the rapids, and a fine mill-site can be found on or about lot No. 15 (sold), range ix, of the township of Grand Calumet. Mr. Gauvin estimates the minimum horse-power of these rapids at about 7,000.

Black Falls.

"These falls are the largest falls of the whole Roche Fendu channel. Their total height is only 10 feet, according to the returns of the Ottawa ship canal survey. Their total minimum horse-power is estimated at about 5,700.

Mice Rapid.

"This rapid has a fall of 3·21 feet, in 4,100 feet, according to the returns of the Ottawa ship canal survey. It does not, properly speaking, constitute a water-power, but, according to Mr. Gauvin, it might be utilized in connexion with the Muskrat rapid below.

Muskrat Rapid.

"Muskrat rapid lies opposite lots Nos. 6 and 7, of range ix, of Grand Calumet. These two lots are patented. The fall there is not great, it is only about 7 feet in 1,300, but there is, on the Quebec side, on a narrow passage between two islands, a perpendicular drop of about 6 feet. Nothing is left now of the mill, which existed there on said narrow passage many years ago, and which is indicated as "old mill" on the plan of the Ottawa river made in connexion with the Ottawa ship canal, in 1859. The greater portion of this rapid lies in the Province of Quebec."

Mr. Gauvin estimates the total minimum horse-power of Muskrat rapid at 7,000. The river might be easily dammed across there, so that the head could be increased to about 15 feet.

Long Rapids.

According to the returns of the Ottawa ship canal survey, they are 4,500 feet long and have, in that distance, a total fall of fully 16 feet. Probably this head, or a portion of it, could be made use of to increase the head at the Roche Fendu chute, in the case of the latter being utilized as a water-power.

Roche Fendu Chute.

This is the last pitch on the Roche Fendu channel; it lies at the head of what is called the Roche Fendu lake. The greater portion of this chute is in the Province of Quebec, in front of lots Nos. 1 and 2 (patented in 1884) of range iv, of the township of Grand Calumet.

"The head there is not very great, being only 5′-6″ in 700 feet, but as above mentioned, could probably be increased by a portion of the head of Long rapids. The total minimum horse-power there, according to Mr. Gauvin, is about 5,600.

The Grand Calumet Falls.

These constitute one of the most remarkable falls on the Ottawa river. They are situated in the county of Pontiac, some 65 miles above the city of Ottawa, on the arm of the Ottawa river known as the Calumet channel, which runs to the east of Calumet island, the latter forming the township of Grand Calumet. They are at a distance of 3½ miles, in a straight line, from the nearest railway station, Morehead, on the Canadian Pacific railway.

The following abstract is given from the report of Mr. Gauvin:—

"They are located between the village of Bryson, on lots 14, 15, 16, and 17, range i, of the township of Litchfield, on the east bank, and lots 2, 3, 4, 5, 6 and 7, range i, of the Government reserve, included in the south range of the township of Grand Calumet on the west bank. They are formed of a succession of cataracts and rapids interrupted by small islands, separated here and there by short level stretches or basins. Their total length measured along the centre line of the river, from the government dam, north of island No. 10, to the foot of the old portage, on Calumet island, is a little over a mile, say 5,550 feet; but the distance in a straight line from the southern extremity of said dam to the foot of the last rapid, almost opposite the landing, on Calumet island, of the old ferry, is only about 4,600 feet.

"The total difference of level between the head and the foot of these falls, that is to say, between the surface of the river, immediately above the government dam aforesaid, and the surface of the river at the site of the old ferry, is 57 feet, in round figures, this being what Mr. C. Gauvin, C.E., found by actual levelling between these two points, in the first days of September, 1900, when the water in the river stood some 2 or 3 feet above its lowest level.

The accompanying figure, No. 12, shows a general plan of the Grand Calumet falls. This plan is the work of Mr. C. E. Gauvin, C.E., for the Quebec government, and represents an extract from maps of the Ottawa ship canal, deposited in the Department of Public Works, Ottawa, with numerous additions made to it, and obtained from the plan of the government reserve on Calumet island, by O. Sullivan, inspector of surveys, from the cadastral plan of the village of Bryson, and also from personal observations of Mr. Gauvin on the ground.

The following is an abstract from the report of Mr. C. E. Gauvin, who made an exhaustive survey of the Grand Calumet falls in the year 1900.

"The Grand Calumet falls may be considered as forming three distinct groups of water-powers (see fig. 12).

"First.—Those connected with islands Nos. 10 (east part), 11, and 12.

"Second.—Those connected with islands Nos. 10 (the south part) 9, 8, 7, 6, and 5.

"Third.—Those connected with islands Nos. 1, 2, 3, and 4.

"In order to estimate the total power of these three groups, or, in other words, the total power of the Grand Calumet falls, I had first to ascertain what is the discharge of the Calumet channel at that place. This, however, could not be easily done on the very site of the falls, and for this reason, I

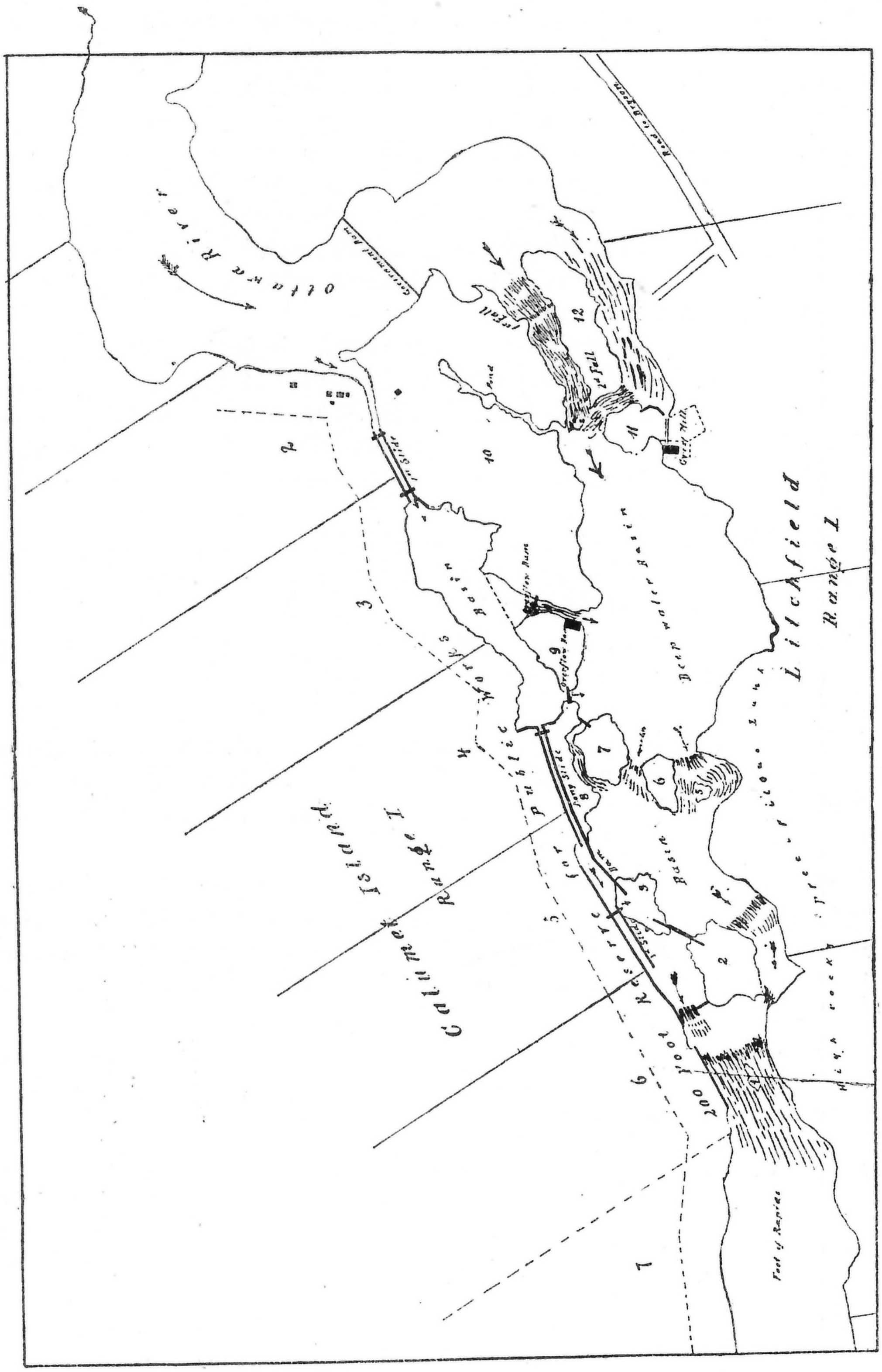

FIG. 12.—Calumet Falls water power. Scale 1 inch to 400 feet.

decided to gauge the stream some four miles higher up, in front of Calumet village, where the discharge is practically the same as at the falls, and where I could avail myself, for the performance of this tedious operation, of the ferry boat, and of its wire cable stretched across the river.

"At the time the gauging was made, the level of the river, according to the party who runs the ferry, was some 3 feet above the lowest level and about 5 or 6 feet below ordinary high water mark. This would give a total difference of level between high and low water of about 8 or 9 feet. With regard to such difference of level generally, on the Ottawa river, I may cite the following, from Mr. Walter Shanly's report on the Ottawa and French River navigation project (1858):—

"'The cost of lockage on the main Ottawa river will be not a little affected by the necessity that will exist for providing lofty guard-locks at the entrances of some of the canals, because of the great fluctuations of the water; the difference of level between extreme high and extreme low water reaching in some places to twelve feet. On no section of the river is it much less than 6 feet.'

"The river then measured across, at right angles with its general bearing at that place, 1,059 feet, and its depth varied from 0 to 14 feet, the average depth being 10 feet, 7 inches.

"The total discharge was found to be equal to 16,565 cubic feet per second, corresponding to a mean velocity of flow, for the whole cross-section, of 1·48 feet per second.

"But these, of course, are not the discharge and mean velocity at extreme low water. They are the results of measurements made when the level was, as already stated, about 3 feet above its lowest stage, or at a point which may be taken as the average summer level.

"At extreme low water, the area of the cross-section of the stream, at the place above referred to, would probably be reduced to about 8,000 square feet, and the mean velocity to 1 foot per second, or thereabout. The total minimum discharge, therefore, may be safely assumed at 8,000 cubic feet per second.

"With this assumed minimum discharge, and the 57 foot total head, the collective minimum power of the Grand Calumet falls would be equal to very nearly 52,000 horse-power.

"A gauging made in the canal, at the head of the slides, gave 190, say 200, cubic feet discharge per second. But the bulkhead, at the head of the slides, was then partially closed, so that the volume of water flowing over the bottom of the slides was very small, and it may be safely admitted that the volume required to properly float the timber in the slides is two and a half times greater than the one measured, or say 500 cubic feet per second.

"If we deduct these 500 cubic feet from the assumed total minimum discharge of the Calumet channel, at the Grand Calumet falls, we have 7,500 cubic feet as the probable total minimum discharge over the Grand Calumet falls proper.

"The total minimum power of these falls, in round figures, may be, therefore, taken at 50,000 horse-power.

"I will now examine the different groups of water-powers to which reference has been made above.

FIRST GROUP.

"At the head of the falls, the river divides into three channels: 1—the channel of the timber slides on the Calumet Island side; 2—the channel between the east bank of the river and island No. 12; 3—the channel between islands Nos. 10 and 12.

"The first group comprises what I have called the First fall (the first one met with, on descending the cascades from their head), between islands Nos. 10 and 12, and the Second fall, between islands Nos. 11 and 12. Another fall existed between island No. 11 and the east bank of the river (Bryson side), but it has been dammed, and the water which used to flow over it, now finds its way partly through the channel between islands Nos. 11 and 12, and partly through the head-race of the grist-mill owned by Mr. Thomas Moran, and built on the east bank at the foot of the latter fall.

"The total minimum power of this first group is equal to about 20,500 horse-power.

"It was not possible to gauge separately the two channels on both sides of island No. 12. There is not, with regard to discharge, a great difference between them; however, the eastern one, between the mainland and island No. 12, seems to have the greatest, and this may be taken, as near as I can estimate it under the circumstances, at 4,100 cubic feet per second, leaving 3,400 cubic feet for the discharge in the channel between islands Nos. 10 and 12.

"With the 24 ft. head available here, reckoning the head from the level of the river immediately below the government dam, the total minimum power of the First fall, which has a perpendicular drop of from 12 to 15 feet, and of the rapids immediately above and below it, is equal to 9,300 horse-power. But the facilities for developing this power are not very great, as hardly any place for a large installation can be found in the vicinity of the fall. The only suitable place that I can see for the erection of a mill is at the small inlet, or bay, on the east side of island No. 10, opposite fall No. 2, which lies between islands Nos. 11 and 12, and at the end of a deep ravine that exists on island No. 10, as shown approximately on the accompanying plan.

"At the bottom of the small inlet, above referred to, a dam could be built across said ravine, which runs from this point, in a northerly direction, towards the head of the island (No. 10), where a short canal, some 400 feet long, and not very deep, would put the head of this ravine in communication with the river above the government dam. A vertical fall, 26 feet high (26 feet is the difference of level between the Ottawa river above the latter dam and the deep water basin immediately below island No. 11), would therefore be created at the said inlet. In that way 1,000 to 2,000 horse-power could be developed there, at comparatively little expense. This site would be well adapted for a pulp mill, or for a sawmill, as the timber could be brought to the very site of the mill, through the canal above referred to, more than half of which has been dug out by nature.

"Fall No. 2, a very fine cataract, cannot be directly utilized on account of being isolated, situated as it is between two small islands, Nos. 11 and 12, and because of there being near it no suitable ground for the erection of a mill.

"Islands Nos. 11 and 12 were patented to the Hon. Geo. Bryson, December 2, 1882.

"Mr. Thomas Moran's grist-mill, to which reference has been made above, is on lot No. 15, range i, of the township of Litchfield, and in the village of Bryson. A gauging was made of the head-race of this mill, and the discharge was found to be 51 cubic feet per second, which gives, with the 17 ft. head utilized, only 100 horse-power.

"The head at this place could be increased to 24 feet, or thereabout, by damming the channel between islands Nos. 11 and 12, and a large power (say 10,000 horse-power) could be very easily developed there. I say very easily, because this 24 ft. head can be got in a space of hardly 150 feet, and with comparatively little expense. A dam has already existed, I believe, in the channel between said islands, Nos. 11 and 12. The remains of an old dam are still to be seen at the southern extremity of island No. 12. The damming of this channel, besides increasing the head at the mill site, would create a splendid basin between the east bank of the river and island No. 12, for the storage of logs.

"The site of Mr. Moran's mill is certainly a very fine one, and the power there, as already stated, can be very easily developed.

SECOND GROUP.

"From the foot of the Second fall to the next cataract, on the main channel, there is a level reach, some 1,400 feet long, and 800 feet broad, at its widest spot, forming a splendid deep water basin, covering an area of about 18 acres. From indications on the rocky banks of the river, the high water level in this basin would be about 7′-6″ higher than the level on September 8, 1907, taken as the average summer level.

"On the west side of this level reach, and about half-way between islands Nos. 7 and 11, a small stream, taking its rise in the expansion of the timber slides channel, between the first and the second slides, pours into the said deep water basin. The difference of level between the latter and the aforesaid expansion of the timber slides channel, is 20 feet.

"On the right bank of this small stream, on island No. 9, is an old sawmill, known as Carmichael's mill. It is now abandoned. The building, a substantial wooden one, is still in pretty good condition, but there is no machinery in it. The bank on island No. 10 is high, steep, and rocky. Carmichael's mill is located at the best place where the power of this stream can be developed.

"The weir, or overflow dam, built between islands Nos. 9 and 10, is about 21 feet long, and at the time of my inspection, the depth of water flowing over it was 6″, giving a discharge of about 23 cubic feet per second. This, with the total head of 20 feet, represents 50 horse-power only. However, this water-power could be increased by allowing a greater volume of water to flow over the upper bulkhead of the first timber slide.

"The small and very short channel between islands Nos. 8 and 9 was dry when I visited the premises, and a wooden overflow dam is built across it. The head there is 20 feet, the same as at Carmichael's old sawmill. A comparatively small power could be easily developed there.

"Between islands Nos. 7 and 8, there is a narrow and crooked channel, what I would call an arm of the main Calumet channel of the Ottawa. Dry at low water, this narrow channel is dammed at its upper end, evidently to prevent logs from entering it at high water. The difference of level between the extremities of this channel, that is to say, between the large deep water basin aforesaid and the next lower level stretch or basin of the river, is 13 feet, but here the head could be very easily increased by 20 feet, which is the difference of level that exists between the large deep water basin of the main channel and the expansion of the timber slides channel at the foot of the first slide, and, therefore, made equal to 33 feet. There is not, however, much room for a large mill there, at the mouth of said small channel, but, in other respects, the situation is very fine, and quite a large power could be cheaply developed there. A penstock from the millsite-mouth of the channel in question, to the upper basin or expansion, on the timber slides channel, would only be from 350 to 400 feet long.

"There is a pretty cataract between islands Nos. 6 and 7, but I do not see how its power could be either easily or profitably utilized.

"The fall between island No. 6 and the east bank cannot be directly utilized, the east bank of the river opposite this island, and in fact all the way down to the site of the landing of the old ferry, being very high, rocky and precipitous.

THIRD GROUP.

"Between the falls of the second group and those of the third, there is a level reach, or basin, some 400 feet × 600 feet, about 5½ acres in area.

"The difference of level between the latter basin and the smaller one immediately below it, at the foot of the third slide, is 11 feet.

"A dam is built between the islands Nos. 4 and 8, and one between islands Nos. 2 and 4. The latter has a gate by which part of the water of the main Calumet channel may be, at that point, allowed to flow into the timber slides channel.

"I do not see that the water-powers of this last group can be practically developed. A mill might be put up at the lower end of island No. 2, near the old dam, where the 11 foot head could be got in a short space; but this site should be specially examined at high water, before the construction of a mill at that point can be pronounced practicable or not. As I have said before, the east bank of the river, opposite this third group, is high, rocky, and precipitous.

TOTAL DEVELOPMENT.

"During the whole time of my visit, I was preoccupied with the idea of how the development of the total power of the Grand Calumet falls, or of a very large portion of the same, could be effected.

"There is, on the west bank of the river, near the foot of the falls, that is to say, at the landing of the old ferry, on lot No. 7, range i, of the reserve, in the township of Grand Calumet, a suitable place for buildings, etc., such as might be required for the utilizing of the total 57 foot head of these falls, with a very large portion of the volume of water flowing in the river, or say 25,000 to 30,000 horse-power; but the question is how a large volume of water, with this total head, can be economically brought to this particular point.

"Informed by one of the residents that there was, on the west side of the river, and not far from the bank, a ravine extending almost uninterruptedly from a short distance above the falls to the landing of the old ferry at the foot of the same, I thought I would examine it, or at least take a walk through it, which I did. The impression I got was so favourable that I decided to make a closer examination of this ravine. I took the elevation of some of the principal points on it, in order to ascertain whether it would be practicable to open a trench or canal along this ravine, so as to divert through it, from its natural course, a large portion of the volume of water flowing in the Calumet channel, and to bring it, on a level with the river above the falls, to within a few hundred feet of the mill-site, referred to, whence it could be conducted to water wheels near the river side, by means of large pipes or penstocks.

"Unfortunately, the creation of such an artificial water-way would be rather expensive, as, supposing the bottom of the trench to be only 6 feet below the ordinary summer level of the river, above the falls, the summit to be crossed would be about 56 feet above said bottom, and the depths of the various sections of the trench would be approximately as follows:—

1,350 of it would be over 40 deep, average 45.
1,000 of it would be from 30 to 40 deep.
1,050 of it would be from 20 to 30 deep.
1,250 of it would be from 10 to 20 deep.
1,550 of it would be about 6 deep; and
6,200 would be about the total length of the trench.

"Decidedly this would not be practicable, and probably the best solution of the problem would be the following:—

"1st.—To raise the Government dam, north of island No. 10, causing thereby a greater volume of water to flow through the canal of the slides, which might be enlarged without very great cost.

"2nd.—To dam the channels (this would cost but a trifle) between islands Nos. 9 and 10, and Nos. 8 and 9, in order to cause the level to rise in the basin between the first and the second, or long slides, to the water level-line of the river above the Government dam, bringing thereby the head-race much closer to the mill-site.

"3rd.—To convey, from this basin, the water through large pipes, laid along the west bank, to the mill-site aforesaid, a distance of some 2,500 feet."

Mr. Gauvin concludes his report with the following words:—

"Situated as they are, in the finest timber region of this Province, a region also remarkable for its minerals—the Ottawa country abounds in iron ore of the richest description, says Mr. Walter Shanly in his report already cited on the Ottawa and French River navigation project—these beautiful water-powers of the Grand Calumet falls cannot but attract the attention of capitalists and large manufacturers."

Mountain Rapid.

Mountain rapid, a very remarkable spot on the Calumet channel, is situated about two and a half miles below the foot of the Grand Calumet falls, and some 63 miles above the city of Ottawa. It is five and three-quarters miles distant, in a straight line, from the nearest railway station, and lies between lot No. 21, range iii, of the township of Litchfield, patented to John Egan, September 23, 1845, and lot No. 7, of the south range of the township of Grand Calumet (Calumet island) patented to Walter Thomson, December 15, 1865.

An abstract of the report of Mr. C. E. Gauvin, C.E., who examined these falls, on behalf of the Quebec government, is given in the following:—

"At the head of the rapid, the Calumet channel is only about 200 feet wide, from the small island measuring about 100 feet × 150 feet, near the south or left bank, to Calumet island.

"Between said small island and the south bank, and right along the latter, from the head to the foot of the rapid, lies the government timber slide, which is some 700 feet long. On the same bank, and at a short distance from the timber slide, there is a good, and very easy portage road.

"The total fall of the rapid, as established by actual levelling, is 15 to 18 feet, or say 15 feet, in round figures; and this may be taken as the difference of elevation between the upper and the lower levels, at ordinary low water. This total elevation is composed of a perpendicular drop of about 5 feet at the very head of the rapid, where the latter forms a regular cascade, and of an incline, whose height is 10 feet and base 500 feet at most.

"As stated in a former report, respecting the Grand Calumet falls, the discharge of the Calumet channel of the Ottawa river, at the latter falls, and at low water, may be assumed at 8,000 cubic feet per second. The discharge of said channel, at Mountain rapid, is practically the same as what it is at the Grand Calumet falls. But as provision ought to be made for the floating, at any time, of logs, and of rafts of squared timber, through the timber slide, I will reduce the above figure, the same as I have done with regard to the Grand Calumet falls, to 7,500 cubic feet per second, and take this last quantity as the disposable minimum volume of water at Mountain rapid.

"With such head (15 feet), and discharge (7,500 cubic feet per second), the minimum power of Mountain rapid is equal to thirteen thousand (13,000) horse-power, in round figures, whilst the average power would no doubt be equal to about 18,000 to 20,000 horse-power.

"But by damming the river above the rapid, which could be done I believe at reasonable expense, the head of the Dargis rapid, hereafter described —this head is about 6 feet—could be added to that of the Mountain rapid. This would give, at the latter spot, a total head of 21 feet, and a power, at low water, of very nearly 19,000 horse-power.

"A dam causing the level to rise 7 feet above the present low water mark, at the head of the Mountain rapid, would back up the water in the river as far as the foot of the Grand Calumet falls, according to the profile of the river, by the Ottawa ship canal survey.

"This profile, by the Ottawa ship canal survey, shows a difference of level between high and low water marks, above Mountain rapid, of nearly 12′-6″. Therefore the construction of a dam, at the head of this rapid, causing here the low water level to rise some 6 or 7 feet, would not bring the level of the river even to the present high water mark, and consequently would not cause much damage to property.

"To increase the size of the water-way at the head of the rapid, in the event of the construction of such a dam, so that the then high water mark would not be at a greater elevation than the present one, a channel could be opened across the peninsula, formed by a sharp bend in the river, a short distance below the rapid. The total length of such a channel would be 1,330 feet, and about half of it would present heavy cutting, averaging 9 feet deep.

"Mountain and Dargis rapids together would constitute quite a fine water-power, and one which could be most easily developed.

"There is a very fine site for a mill, on the left, or south bank of the river, right at the foot of the rapid, on the aforesaid lot No. 21, of range iii, of Litchfield. The distance from this mill-site to the head of the rapid is only about 500 feet, in a straight line, and, to utilize the power of said rapid, the water can be brought from the upper level to the mill-site, through flumes or large pipes, without it being necessary to overcome any serious difficulty. Pipes could be laid either close to the bank of the river, along the timber slide, or along the Portage road, about 300 feet from said bank.

"There is no ground for development on the right or north bank of the river, that is to say, on Calumet island (township of Grand Calumet).

Dargis Rapid.

"The Dargis rapid is situated about one mile above Mountain rapid, and almost half-way between the latter and the Grand Calumet falls. It lies between lot No. 20, range ii, of the township of Litchfield, and the following lots, in the township of Grand Calumet: Nos. 1 and 2 of the south range, and Nos. 8 and 9 of range ii, of the government reserve.

"There is nothing very remarkable about this rapid, as a water-power, and I do not see how, alone, it could be utilized as such, to advantage.

"I found, from a point (which I had first considered as the head of the Dargis rapid) opposite the centre of said lot No. 9, range ii, of the government reserve, or thereabout, to the foot of the rapid, almost opposite the middle of lot No. 2, of the south range, a total difference of level of only 4·88 feet, and the distance between these points is some 2,300 feet, measured along the main channel of the river.

"But there is, at low water, a small rapid opposite lot No. 8, range i, of the government reserve, which may be regarded as forming part of the Dargis.

"The latter is perhaps not exactly on a continuous grade or incline. The grade is more or less broken by level reaches here and there, but the profile would represent the average inclination of the surface of the river between the two extremities of that portion of the same which is known as the Dargis rapid.

"With regard to the height and length of both the Grand Calumet falls and the Mountain rapid, my figures agree pretty closely with those of the Ottawa ship canal survey, but they do not agree very well with the latter when it comes to the Dargis rapid. On the profile of the Calumet channel, drawn by the Ottawa ship canal survey, the Dargis rapid is represented as having a length of 1,600 feet only, and a fall, at low water mark, of 6′-6″. I found hardly 5 feet, in a total distance of about 2,300 feet.

"The minimum power of the Dargis rapid would be, with 5 feet of head, 4,500 horse-power, and with 6′-6″ of head, 5,900 horse-power.

"But, after all, I think it matters little whether there is a fall of 5 feet or one of 6′-6″, and whether the rapid is 1,600 feet long or 2,300 feet long, as even with the best of these conditions, that is to say, with the greatest head and the shortest length, I do not see that this water-power can be developed with advantage, especially when there are so close to it many finer ones.

"It must not be inferred from this, however, that the Dargis rapid is absolutely of no value as a water-power, and when I say I do not see that it can be developed with advantage, it is when I consider this water-power alone, and its utilization irrespective of that of the neighbouring water-power.

"But if the Dargis rapid is regarded as a portion of the Mountain rapid, its importance and value then becomes totally different."

Portage Du Fort Water-Power.

The following is an abstract of the report of Mr. C. E. Gauvin, who made a survey of these falls, in the year 1901, on behalf of the Quebec government:—

"The village of Portage du Fort, on the east side of the Ottawa river, lies in the township of Litchfield, on lots Nos. 29, 30, 31, and 32, range i, and is about 63 miles above the city of Ottawa.

On descending the Ottawa river, some four miles below that stretch of the river known as the Roche Fendu lake, that is to say, 4 miles below the southern extremity of Calumet island, we come to the head of the Portage du Fort rapids, which head, though within the limits of the municipality of the incorporated village of Portage du Fort, is about half a mile above the village proper. The river, from this spot down as far as the head of the comparatively large island of Portage du Fort, presents a most complicated aspect; it is nothing but a confusing assemblage of rapids, which appear to flow from all directions, between a considerable number of islands large and small.

"The total fall of these rapids is not very great; it is, according to the plans of the Ottawa canal survey, only between 8 and 9 feet, from the head above mentioned, a short distance above Bentley bay, on the Quebec side, to the foot of Devil's Elbow, on the Ontario side, a distance of some 3,600 feet. The Portage du Fort rapids are situated, as is known, partly in Quebec, and partly in Ontario. It is most probable that the greatest portion of the volume of water flowing at that spot of the Ottawa, passes on the Ontario side. There is a timber slide in Ontario, just one mile above the village of Portage du Fort.

"I arrived at Portage du Fort September 13, 1900, and landed with my party at the head of Crooked rapid, one of the Portage du Fort rapids. At that date, the small channel, separating the main shore from the island lying between the Crooked rapid and Bentley bay, was perfectly dry, the water in the river being then probably only about 2 feet above its lowest level. I made a special examination of that channel, to ascertain if advantage could be taken of it to utilize part of the Crooked rapid, but I do not see any inducement to do so; the head there is too small, 4 or 5 feet only. Below the Crooked rapid a dam has been built across from one of the islands, on the south side of the Devil's Elbow, to Shea island, raising the level of the river, east of the latter island, and increasing the flow in the Portage channel, east of the island of Portage du Fort. A dam also exists between the latter and Shea island. The above dam, from Devil's Elbow to Shea island, and another very strong permanent one which exists between the main shore, village of Portage du Fort, and Shea island, and which had evidently been built there a great many years ago, form, of that part the channel of the Ottawa river lying between said shore and Shea island, a regular basin, from whence the gristmill and the sawmill now built immediately below the big dam and near the highway bridge, between the village and the island of Portage du Fort, derive their water.

"From information obtained on the spot, the water in the basin above referred to, was, on September 14, 1900, about 2 feet above its lowest pitch. The difference of level then found by actual measurement, between the head race and the tail race, was 9·63, say 9′-8″. A gauging was made of the Portage channel under the highway bridge, and the discharge was found to be equal to 492 cubic feet per second. Assuming the discharge to be 400 cubic feet per second, and the head 9 feet, at extreme low water, the minimum power of the fall, in its present condition, would be equal to 409 horse-power. This power might be increased, but I do not see that it could be to any considerable extent, without heavy expenses, or without, probably, diverting part of the waters which naturally flow on the Ontario side.

"The present owner of the two mills above referred to, Mr. Joseph Brown, informed me that he had a title for the water-powers and islands from Usborne street, below the small bridge, between the village and the island of Portage du Fort, up to, and including, Devil's Elbow, on the Ontario side. Mr. Brown also told me that the original grant of these water-powers, with adjacent lands, was made many years ago to the large firm of Ackinson & Usborne, who formerly carried on a very extensive lumber trade in the Ottawa region, and who had their headquarters at Portage du Fort.

"Mr. Brown runs his grist-mill with two Leffel wheels, 4 feet in diameter, reputed to give together 70 horse-power, under a 9 ft. head, which is practically the head there; and his sawmill with two Tyler wheels, claimed to give each 20 horse-power under the same head. This would represent a total power of 110 horse-power.

"Portage du Fort is about 10 miles from either Shawville station, in range vi, of Clarendon, or Clarke station, both on the Pontiac and Pacific Junction railway, and is almost at the same distance from the nearest station (Renfrew), on the Canadian Pacific railway, in Ontario."

The Chats Falls.

These constitute some of the most beautiful water falls on the Ottawa river. They are situated about 26 miles west of Ottawa, between the township of Fitzroy on the Ontario side, and Onslow on the Quebec side, and extend for a mile, affording a series of beautiful cascades.

Through the courtesy of the Hon. Minister of Lands, Mines and Fisheries for the Province of Quebec, the writer is able to give the following abstract of the documents referring to the survey of these falls, by Mr. C. E. Gauvin, in 1899:—

"The gauging was made as near the site of the falls as practicable, on a comparatively narrow spot of the stream, about 3½ miles below the Chats, opposite lot number 13, of range iii of the township of Onslow, Que. The water at the time of this survey was at its ordinary low level.

"The Ottawa, at that place, is about 920 feet wide, and its greatest depth, at low water, is 66′-4″, which greatest depth is found at some 600 feet from the Quebec shore. The average depth of the stream there is 44′-9″, at low water.

"The total area of the cross-section of the river at the place above mentioned, is 41,110 square feet; but as, where I took the cross-section, there happened to be no appreciable velocity of flow from the Ontario shore, to a distance towards the middle of the channel of some 240 feet, it follows that the useful area of this cross-section is only equal to about 35,000 square feet.

"The greatest and smallest velocities observed with the current-meter in that cross-section, are respectively equal to about 0·67 and 0·28 feet per second, and the average mean velocity is very nearly equal to 0·48 feet per second.

"The velocity of flow was measured at 43 different points of said cross-section, but unfortunately could not be ascertained at a depth greater than about 17 feet from the surface of the water, as the instrument used (the current-meter) did not permit of reaching a greater depth.

"The total discharge of the river at that place, calculated from the above data, is equal to 16,748 cubic feet per second.

"As my intention in gauging the river at that place was to determine, as near as could be done under the circumstances, the volume of water, flowing, at the Chats falls, between the mainland on the Quebec side and Morris island on the Ontario side, I had to gauge the Mississippi channel, in Ontario, between Morris island and the mainland, and also the Quio river, in Quebec, as both these streams empty into the Ottawa, between the Chats falls and the place where the former had been gauged; in order to deduct their collective discharge from that of the Ottawa opposite lot No. 13, range iii, of Onslow.

"The discharge of each of these two streams is as follows:—

Mississippi channel	75 cubic feet per second
Quio river	122 cubic feet per second
Total	197 cubic feet per second

"By deducting this amount from the discharge above referred to (16,748) of the Ottawa, we get 16,551 cubic feet as the discharge at the Chats. Inasmuch as the velocity of the stream (the Ottawa), could not be measured at depths greater than 17 feet, and it is expected that the mean of the measured velocities, in the two or three central sections of the cross-section above referred to, is somewhat less than the true average velocity in those central sections, I think it safe to increase about 7 per cent the discharge corresponding to the latter. By doing so, the total discharge of the Ottawa, at the Chats, at ordinary low water, would be equal to about 17,200 cubic feet per second.

"As there is a total difference of level of 36 feet, in round figures, between the head and the foot of the falls, it follows that the total theoretic power of these falls, from the Quebec shore to the Ontario shore, is equal, at low water, to very nearly 70,000 horse-power. But as this total head of 36 feet is not available, or cannot be utilized at each of the falls composing the total power, it follows that the total maximum power that can be practically derived from the Chats falls, at low water, is less than that amount, and probably not much more than 50,000 horse-power.

"After completing the gauging of the Ottawa, I proceeded to the examination of the falls, on the Quebec territory. These are eight in number:—

Old Mill chute.
Fall No. 1.
Egan chute.
Conroy chute.
Sturgeon chute.
Black chute.
Moore chute west.
Moore chute east.

"In order to get thoroughly acquainted with the place, and to be able to locate exactly the position of every point of interest in connexion with the investigation entrusted to me, I decided to make a regular survey of the ground from the old mill—Egan mill—on the west shore of the Ottawa, along with the upper shores of the islands, and the heads of the chutes, to the southwest point of Moore island, and thence in a southwesterly direction to the upper end or head of the long dam, built by the Upper Ottawa Improvement Co., to divert part of the water in the main channel of the Ottawa, and cause it to flow through the Long channel, and Sturgeon canal. I also made, in compliance with the instructions I had received, a survey of the channel, at high water, across Moore island, in its widest part, and finally, a survey of the whole of the east shore of the latter island, and one of the Old Indian portage road, on Indian island.

"The accompanying general plan of the Chats falls and islands has been partly drawn from actual survey, and partly from the map of the Chats islands, by the Ottawa ship canal survey, and from a plan drawn by G. G. Rainboth, Esq., P.L.S., and furnished to the Department by the Upper Ottawa Improvement Company.

"Old Mill chute is that which is situated between the mainland, at the site of the old Egan mill, and the lower end of Egan island. The head there at low water is about 13 feet, from the level above the old dam of the mill to the level in Big bay below the islands. The portion of this old dam still in existence produces, of course, the effect of increasing the natural head of the fall. Taking, however, the head as it is, 13 feet, and the discharge as being equal to about 320 cubic feet per second, at low water, the power of this chute is equal to about 470 horse-power, in round figures.

"The only suitable place that I can see, for the erection of buildings, etc., in connexion with the development of the power of this fall, is on the main shore, at the very site of the old mill.

"Fall No. 1 is, after the close inspection I have made of the ground, and from the comparison between my own plan of survey and that of the Ottawa ship canal survey, the first fall from the mainland, between the mainland and island No. 57, and is one which Mr. Matte has designated as Fall No. 0, on his plan.

"The discharge at Fall No. 1 is equal to 221 cubic feet per second, at low water, and the total available head—the difference at level between the Chats rapids, at the head of the chutes, and the basin immediately above the old mill, being 23 feet, its power—Fall No. 1—is equal to about 580 horse-power.

"Egan chute is situated between Egan island, No. 4, and island No. 58. The total discharge there, at low water, is 116 cubic feet per second, and the total head being 23 feet, that is from the Chats rapids to the basin immediately above the old mill, the total power that could be developed from this chute would be equal to 300 horse-power, in round figures.

"Conroy chute is situated between Egan island and Indian island. The volume of water flowing through it, at low water, is equal to about 54 cubic feet per second only, and as nearly the entire head of 36 feet is available there, the total power of the fall at low water is equal to about 220 horse-power. But I see no great room in the immediate vicinity of this chute for the erection of a mill, or power house, unless it was partly built on made up ground, on the north side of Egan island. The feasibility of this, however, could only be properly ascertained in the summer time, when the snow and ice are gone.

"Sturgeon chute, and Sturgeon canal, were improved and built by the Upper Ottawa Improvement Co. for the proper floating of the logs, and form part of what is called the Log channel. This canal is provided with three sluice-gates, 28′-6″ wide each. I estimated the discharge over the sills of these three gates to be about 1,134 cubic feet per second. The total head that can be practically utilized there, at low water, may be taken to be about 22 or 23 feet. The power of this fall, consequently, is equal to 2,900 horse-power, or thereabout.

"There is no great room for the individual development of this power, the only place I can see where buildings could be erected in connexion with this development, is on island No. 2, which seems to me to be rather an awkward place for such purpose.

"Black chute, next to Sturgeon chute, and quite close to it, the distance between them being only about 100 feet, is separated from the latter by Merrill island, (No. 34.)

"Before the existence of Sturgeon canal, the logs used to pass through this chute.

"The discharge over Black chute being about 1,084 cubic feet per second, at low water, and the head being practically the same as that at Sturgeon chute, say 22 feet and a half, the power there is very nearly equal to 2,800 horse-power, in round figures.

"Black chute lying between two small islands, there is no sufficient space for individual development of its power.

"Moore chute west is situated at the westernmost extremity of Moore island, No. 1. The discharge, at low water, is 248 cubic feet per second, and the available head about 23 feet. The total power of the fall, at low water, is 650 horse-power, in round figures. This power can be easily developed from Moore island, the latter offering ample, and in every way suitable ground for that purpose.

"Moore chute east is the largest of the falls on the Quebec side, and has a perpendicular drop of 25 feet. I could make no precise gauging there; but, taking the total length of the crest at 400 feet, including the narrow stream between Moore island and the small island, No. 73, estimating the vertical height of water above the crest to average about 1′-6″, and considering the flow over said crest as that which takes place over an ordinary weir, I calculate the total discharge, at low water, to be about 2,500 cubic feet per second, in round figures. With this discharge, and the head of 25 feet, the power is equal to about 7,000 horse-power."

Summing up the above figures we have—

For the discharge:—

Old mill	320	cubic feet
Fall No. 1	221	"
Egan chute	116	"
Conroy chute	54	"
Sturgeon chute	1,134	"
Black chute	1,084	"
Moore chute west	248	"
Moore chute east	2,500	"
Total discharge (Quebec side)	5,677	

For the power:—

O d mill chute	470	h.p.
Fall No. 1	580	"
Egan chute	300	"
Conroy chute	220	"
Sturgeon chute	2,900	"
Black chute	2,800	"
Moore chute west	650	"
Moore chute east	7,000	"
Total power (Quebec side)	14,920	"

Say 15,000 horse-power, in round figures, which is not quite one-third of the whole power of the Chats falls, Quebec and Ontario together, at low water.

Mr. Matte, in his report, gives the collective power of the three falls—0, 1, 2—west of Egan island, as being equal to 2,000 horse-power, when my estimation of the same is only 1,350 horse-power. He adds: "With regard to the power that may be derived from the other falls, on the Quebec side, it will vary in proportion to the works that may be executed for their development. In any case," he says, "it is certain that with the comparatively small outlay, they could be made to produce 9,000 to 10,000 horse-power each."

Therefore, according to Mr. Matte, the total power on the Quebec side. at low water, would be 2,000, say 9,600 × 5, 50,000 horse-power; this being equal to what he gives as the total available power, at low water, of the whole of the Chats falls, in Quebec and in Ontario.

GATINEAU RIVER

The Six Portages Falls.

These falls are a series of rapids and falls, which have an aggregate length of about 5 miles. They extend from lot No. 14, range i, of Kensington (down stream), to lot No. 51, range iii, of the township of Cameron. An abstract of Mr. C. E. Gauvin's report on these falls, which he made in the year 1903, on behalf of the Quebec government, is given in the following:—

"The Six Portages falls are composed of six minor falls, (see fig. 13,) the total, or difference of level, between the head of Six portages and the foot of the Bonnet rouge, being 50·73 feet. The fall of each rapid, or group of rapids, is laid down in the following table:—

Rapids at the head of the Six portages	8·07	feet
Corbeau rapids	15·79	"
Boom rapids	14·17	"
Cedar rapids	9·20	"
La Passe rapids	1·00	"
Bonnet Rouge rapids	2·50	"
Total	50·73	"

Mr. Gauvin made a gauging of the Gatineau, some 1,500 feet below the Maniwaki bridge, about 3 miles above the head of the Six portages, at a place where the river is divided into two distinct channels, separated by a large sand bank. The level of the river was not then very much above its lowest pitch, it stood at what might be considered at its ordinary summer level.

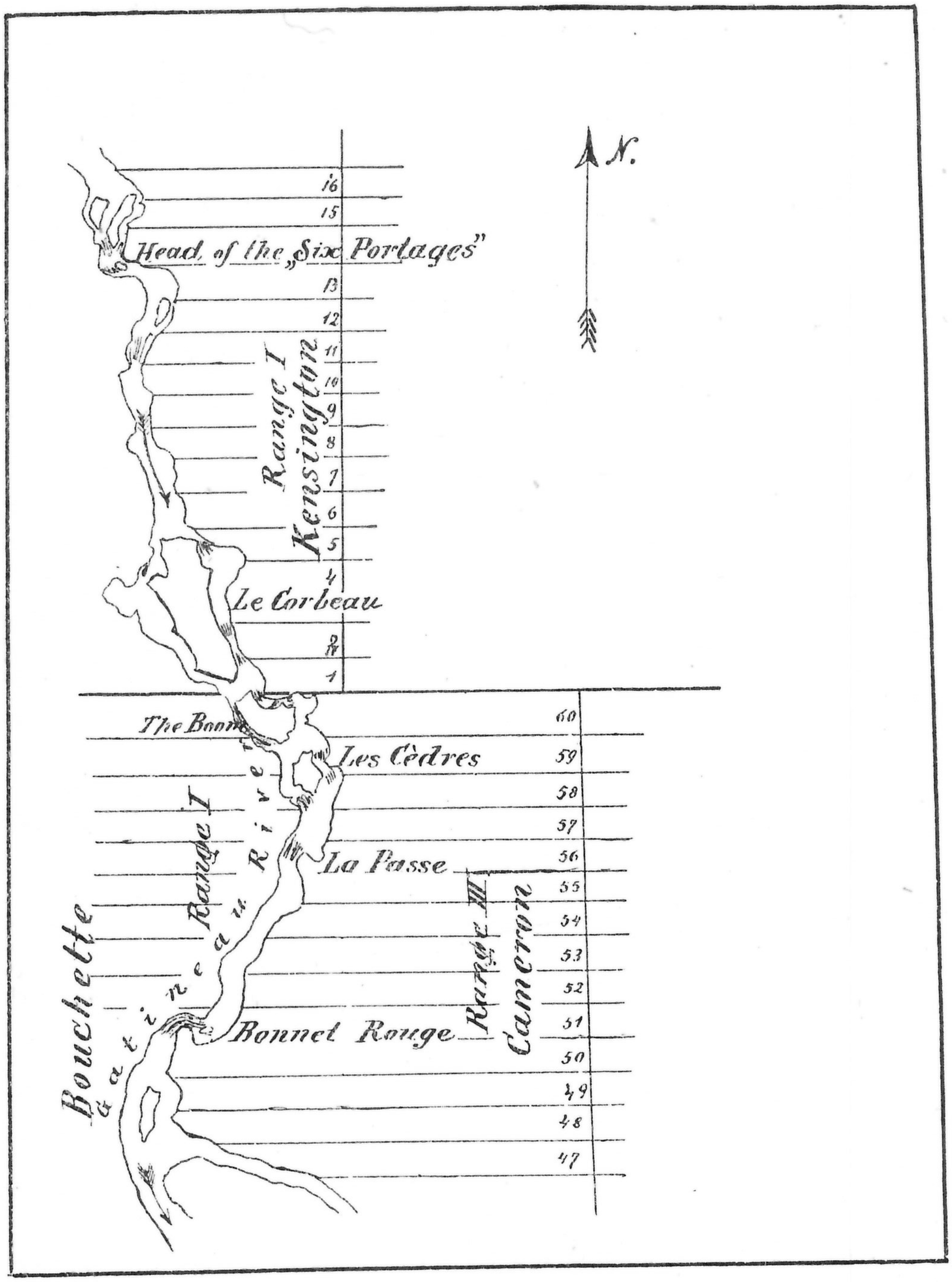

FIG. 13.—Six Portage water power on the Gatineau River. Scale 1 inch to 80 chains.

"Here is a synopsis of the gauging:—

EASTERN CHANNEL.

Useful surface width	217·80 feet
Average depth	8·32 "
Useful area of cross-section	1816 square feet
Mean velocity	1·86 feet per second
Discharge	3375 cubic feet per second

WESTERN CHANNEL.

Useful surface width	325·19 feet
Average depth	2·01 "
Useful area of cross-section	654 square feet
Mean velocity	1·34 feet per second
Discharge	875 cubic feet per second

"The discharge of the Gatineau at that spot was then equal to 4,250 cubic feet per second, corresponding to a yield of fifty-eight hundredths (0·58) of a cubic foot per second and per square mile of the drainage area of the river above that point.

"With such discharge—4,250 cubic feet per second—each foot of head, or of fall, represents a theoretical force of 483 horse-power, equivalent to 360 effective horse-power. But as the river was not at its lowest level, when it was gauged, 350 horse-power can be adopted as the effective power at low water, for every foot of head.

"The minimum effective powers of the various rapids, or groups of rapids comprised in the Six portages, are therefore approximately as follows:—

Head of the Six portages	2,820	h.p.
The Corbeau	5,520	"
The Boom	4,960	"
Cedar	3,220	"
La Passe	350	"
Le Bonnet Rouge	875	"
Total	17,745	"

"Of this power, however, there is, properly speaking, only 16,500 horse-power which can be practically utilized."

Mr. Gauvin then examines successively, each of the water-powers created by said rapids, or groups of rapids.

Rapids of the Head of the Six Portages.

"Total fall	8·07 feet
Effective power, at low water	2,820 h.p.

"The head here is not great, and it is almost impossible to increase it by damming the river so as to raise the level above the Six portages, as from this point to Maniwaki there is hardly any fall, and the inhabitants of this important village question whether it would be possible, or not, by enlarging the channel at the head of the Six portages, that is to say, by removing some of the islets and rocky points which reduce so much the water-way at that spot, to prevent, or at least attenuate the damages and inconveniences which, every year, during the spring freshets, the inundation causes them.

"On the right bank the land belongs to the Indians of Maniwaki, and on the opposite side, township of Kensington, all the lots are sold.

Corbeau Rapids.

"Total fall	15·79 feet
Effective power at low water................	5,520 h.p.

"There are here two channels, separated by a large island, l'Ile du Corbeau, covering an area of about 100 acres. On the left side is the largest channel, called the Grand Corbeau, and on the right side the smallest one, called the Petit Corbeau."

Mr. Gauvin estimates at 4,300 horse-power the power of the first, and at about 1,220 horse-power that of the second.

"There is, near the foot of the rapids of the Petit Corbeau, a fine place to dam the river, and to concentrate there, as it were, the total fall, 15·79 feet of these rapids. At the foot of the latter, on the Maniwaki side, there is a good mill-site.

"The rapids on the Grand Corbeau are much longer than those on the Petit Corbeau. The Grand Corbeau could, however, be quite easily dammed across, near its lower end, so as to bring the upper level close to the foot of the rapids, where a good mill-site can be found, on the southern extremity of the island.

"Probably the best way to develop the water-powers of the Corbeau would be to dam the Grand Corbeau channel at its head, forcing thereby the whole volume of the river to pass through the Petit Corbeau channel, to dam the latter near the foot of the rapids, and to put up the mill, or plant, on the right bank, on the Maniwaki reserve side.

"By giving these dams a sufficient height to drown the rapids at the head of the Six portages, a 24 ft. head could be made available at the foot of the Petit Corbeau rapids, and the power which then might be developed at that spot would be at least equal to 8,000 horse-power, effective power, at low water.

Boom Rapids.

"Fall.................................	14·17 feet.
Effective power at low water...........	4,960 h.p.

"Boom island, containing 37 acres, divides the stream into two channels, the Great Boom, on the left side, and the Small Boom, on the right side.

"Nearly the whole volume of the Gatineau, at low-water at least, flows through the first of these channels. The discharge through the Small Boom, compared to that of the other channel, is insignificant." Mr. Gauvin estimates it at 80 cubic feet per second only.

"The total length of the rapids on the Great Boom is about 2,000 feet, while it is only from 700 to 800 feet on the Small Boom.

"A dam 24 to 25 feet high, which could be quite easily built across the Great Boom, at the head of the small cascade lying opposite the middle of the island, or nearly so, and another dam, of the same height, which could be very easily erected on the Small Boom, would probably cause the drowning of all the rapids above this point, as far as the head of the Six portages. That way, with the difference of level, 14 to 17 feet, between the head and the foot of the Boom rapids, a total head of 38 feet could be obtained at the latter spot. Then by causing the whole volume of the river—the low-water discharge—to flow through the Small Boom, 13,000 effective horse-power could be developed there.

"It is probably at that point of the Six portages that the greatest hydraulic force could be most easily and economically developed.

"A good mill-site could be found on lot No. 60, or on lot No. 59, range i, of the township of Bouchette, which lots are no more the property of the Crown.

Cedar Rapids.

"Fall.	9·20 feet.
Effective power, at low water.	3220 h.p.

"To the right of Cedar island, which has an area of 12 acres, lies the cascade called Great Cedar falls, and to the left of the same is the Little Cedar channel. The latter is very narrow, and is but from 150 to 200 feet long."

The discharge of the Little Cedar channel is very small at low water. Mr. Gauvin estimates it to be about 80 cubic feet per second.

"By erecting on each of these channels a dam 14 to 15 feet high, above the level at the head of the rapids, the head of Boom rapids could be added to that of the Cedar rapids, forming a total head, or fall, of from 23 to 24 feet; and by giving, for instance, to the dam on the Little Cedar channel, an elevation slightly greater than that of the other dam, so as to force, at low-water, the whole volume of the Gatineau to flow through the Great Cedar channel, 8,000 horse-power could be economically developed, at low-water, on the latter channel.

"It is probably on lot No. 57, range i, of the township of Bouchette, that the best mill-site could be found for the exploitation of this water-power. This lot is sold, but the one next to it, No. 58, is still the property of the Crown.

La Passe Rapid.

"Fall.	about 1 foot
Effective power at low water.	350 h.p.

La Passe is situated opposite lot No. 56, range iii, of the township of Cameron.

"On account of its very low head, this water-power could not be profitably utilized.

Bonnet Rouge Rapid.

"Fall.	2·50 feet.
Effective power, at low water.	875 h.p.

"The Bonnet Rouge lies opposite lot No. 51, range iii, of Cameron.

"The length of this rapid is about 500 feet, and its smallest width about 100 feet.

"The river could be dammed at this place with a view of increasing the head, and creating, therefore, at that point, a greater hydraulic power. Moreover, and without flooding a great deal of valuable land, a dam could be built there, that would take up, if not the whole, at least a great portion of the total fall of the Six portages." But Mr. Gauvin does not think there would be any great advantage in doing this, and he thinks that the best hydraulic power of the Six portages is that of the Boom, as this spot appears to be the point on the Six portages where the greatest power can be developed, for the least expense.

The Cascades.

Cascades is a station of the Canadian Pacific railway, Gatineau branch, in range xiv, Hull, and some 16 miles from Ottawa. It derives its name from the five cascades which exist there, on the Gatineau river, over a stretch of a little more than a mile. Going down the river, the first cascade is but a short distance—about 400 feet—below Mohr's hotel, at the railway crossing; the others are respectively met with at distances, from the head of the first one, of 1,200 feet, 2,300 feet, 3,100 feet, and 5,650 feet.

The relative positions of these cascades, their heights, etc., may be seen from the accompanying plan and profile, (fig. 14) drawn from actual measurement, by Mr. C. E. Gauvin, C.E., in 1902.

These heights are as follows:—

First cascade.	2·85
Second "	3·33
Third "	2·25
Fourth "	8·72
Fifth "	4·85
Total head.	22·00

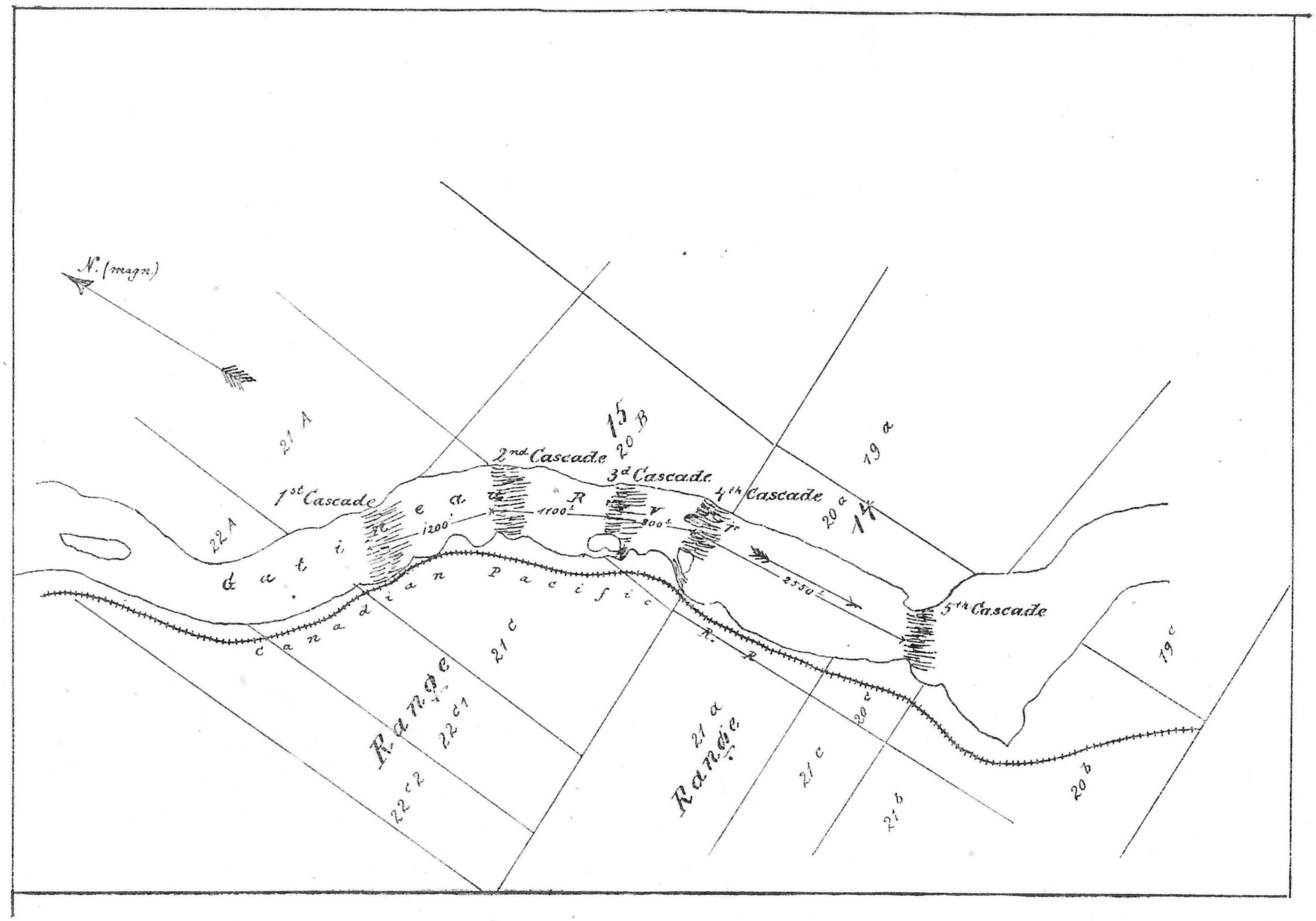

FIG. 14.—Cascades on the Gatineau River. Scale 1 inch to 20 chains.

An abstract of Mr. Gauvin's report for the Quebec Government is given in the following:—

"A gauging of the Gatineau was made at its mouth, at the bridge between Hull and Gatineau Point, on October 14, 1902, and another one had been made a few days before, at Maniwaki, below the mouth of the Desert. The discharge at the mouth, at Hull, was found equal to 5,240 cubic feet per second, and the discharge at Maniwaki equal to 4,250 cubic feet per second.

"But it is expected that the minimum discharge will be considerably less, and from the careful computation which I have made, it would probably go down, at low water, to 4,000 cubic feet per second. When the gaugings above referred to were made, the level of the river stood, at the mouth of the Gatineau, some 2 feet above low water mark. As the Cascades are not very remote from the mouth of the river, and as the discharge there is practically the same as at Gatineau Point, I shall assume the above figure, 4,000 cubic feet per second, as the probable minimum discharge at the place now under consideration.

"The power of the different cascades, at extreme low water, would therefore probably be as follows:—

First cascade	1,300 h.p.
Second "	1,500 "
Third "	1,000 "
Fourth "	4,000 "
Fifth "	2,200 "
Total.....................	10,000

"Of course, the above, it must be remarked, is the minimum power only, of the Cascades. Their average power would be, I should say, about four times as much, or 40,000 horse-power. The best place offered for development is at the fourth cascade, on the right bank, on the railway side, where a mill existed some years ago. Hardly anything now remains of this old mill. There is a very good mill-site there, and by damming the river across, at the head of this cascade, the total fall—8·43 feet—of the three other cascades above, could be added to that of the fourth one, so as to obtain there a total head of some 17 or 18 feet, in round figures, with which, at extreme low water, 7,800 nominal horse-power—about 6,000 effective—could be obtained. The mill could be placed on top of a dam built near the lower end of the narrow channel, between the mainland and the small island, this channel serving as a flume. The island, and the rocks which lie along the head, or crest, of this cascade, would render the construction of a dam there comparatively easy. The river, along this crest, is about 700 feet wide. This mill-site is only a few hundred feet from the line of the Ottawa and Gatineau Valley railway.

"I do not believe that the other cascades, first, second, third, and fifth, considered separately, could be advantageously developed. I think the total head of the first three should be thrown on that of the fourth cascade as mentioned above. Of course, if an 18 foot dam could be easily built at the head of the lower or fifth cascade, the full development of the Cascades could there be obtained, but I doubt very much that this site, from the rapid examination I have made of it, will be found advantageous. The water, raised by an 8 foot dam, at the head of the fourth cascade, would not flood any valuable ground, and would not expand very far beyond the present shore lines, principally on the left or east bank, which is quite abrupt and rocky all along the Cascades.

Chelsea Rapids.

These falls were examined and surveyed by Mr. C. Keefer, C.E., in 1899, for Messrs. Gilmour & Hughson, Limited, the owners, and through the courtesy of the latter the writer is able to furnish an abstract of the document referring to these surveys.

"The falls lie between Ironsides and Kirk Ferry, and were surveyed with a view of showing extent and capabilities of the water powers. The accompanying figure, which is a condensed copy of the original plan, shows the results of surveys, as regards the littoral and topographical features of the river. The survey was made in September, 1899, at a time when the water was at a stage that may fairly be termed extreme low water. Measurements to determine the flow of the river were made at the points shown in the plan, above Eaton chute. The river here is broad, with fairly uniform cross-section. Two measurements were made, one on September 15, at the lowest stage of water, and the other on October 19.

"The areas of waterway at the three points cross-sectioned were:—12626·11; 11997·66; 12435·50.

Velocity. . . . . .0·8 feet per second
Flow. . . . . .9,882 cubic feet per second
Nominal horse-power for every foot 1,119
Effective horse-power for every foot 840

"For the ordinary, or normal water level of October 19, 1899, the areas of water-way were 14216·10; 13600·50; 14055·50.

Velocity. . . . . .1·4 feet per second
Flow. . . . . .19540·70 cubic feet per second
Nominal horse-power for every foot of fall 2,213
Effective horse-power for every foot of fall 1,660

"These measurements, therefore, show that the effective horse-power, at the extreme low water, is 840, while for the ordinary, or normal water level, the effective horse-power is 1,660.

"I am of the opinion that the power which can be developed at ordinary low water might safely be taken at 1,000 horse-power, for every foot of fall. The high water flow, which may be taken for purposes of comparison, though its duration is probably short, would be, assuming the same velocity as observed for the nominal flow of October 19, 24,907 cubic feet per second, with nominal horse-power of 2,821, and effective 2,116 horse-power, for every foot of fall.

"From the lower end of your property on the west side of the river, near the old iron mines shipping dock, opposite Ironsides village, to the level of the river above Eaton chute, near Kirk Ferry, the rise is 160·87 feet. The river is navigable above the iron mines dock to your lumber shipping yard; farther up at Wright Bridge the rapid rise in the river commences. From the old iron mines dock to Eaton chute, a distance of 6·63 miles, the rise per mile is 24·26 feet. From Wright Bridge to Eaton chute, a distance of 5·49 miles, the total rise is 154·46 feet, and the rise per mile, 28·13 feet. This very rapid rate of fall of 28·13 feet per mile, indicates the possibilities in the river for power development.

Eaton Chute.

"This power, near Kirk Ferry, is 9 miles from the junction of the Gatineau with the Ottawa river. The height of falls at this point, at extreme low water, is 21·14 feet; the effective horse-power, with this head, would be, for extreme low water, 17,757 horse-power. The river below the falls forms a broad basin, which discharges, a little lower down, through channels contracted by islands. This contraction has an influence on the river at high water.

"As to the development of the power at Eaton chute, it must be said that a dam, as shown on the plan of the river, could be constructed from the west to the east shores of the river, at the lower end of the island below the falls. For the utilization of the power on the west side of the river, a power canal, or raceway, may be constructed across the flat at the west end of the dam. For the utilizations of the power, to its greatest extent, and where ample space for buildings and raceways could be obtained, the east side, on Patterson flat, is well adapted, and a power canal could be constructed across Patterson flat. The fall, or head, at the lower end of this canal, would be, at extreme low water, 22·88 feet, and during high water, at flood stage, 18·1 feet.

Chelsea Falls.

"This is the next power down the river, and is located 5½ miles from the junction with the Ottawa. As the banks of the river, on both sides, between this point and Eaton chute, are high, and as there are no other falls to be interfered with, this power can be increased by the construction of dams at Chelsea island, as shown on plan, so as to raise the water to the level of the river below; and Eaton chute would thus become a most valuable power. This would make the head or fall in the river at Chelsea island, for extreme low water, 60 feet, and the effective horse-power 50,400.

Fall, and Rapids Below Shingle Mill.

"The river, from the level below Chelsea falls to the point where the boundary line of the property is, on the west side, has a fall of only 56 feet.

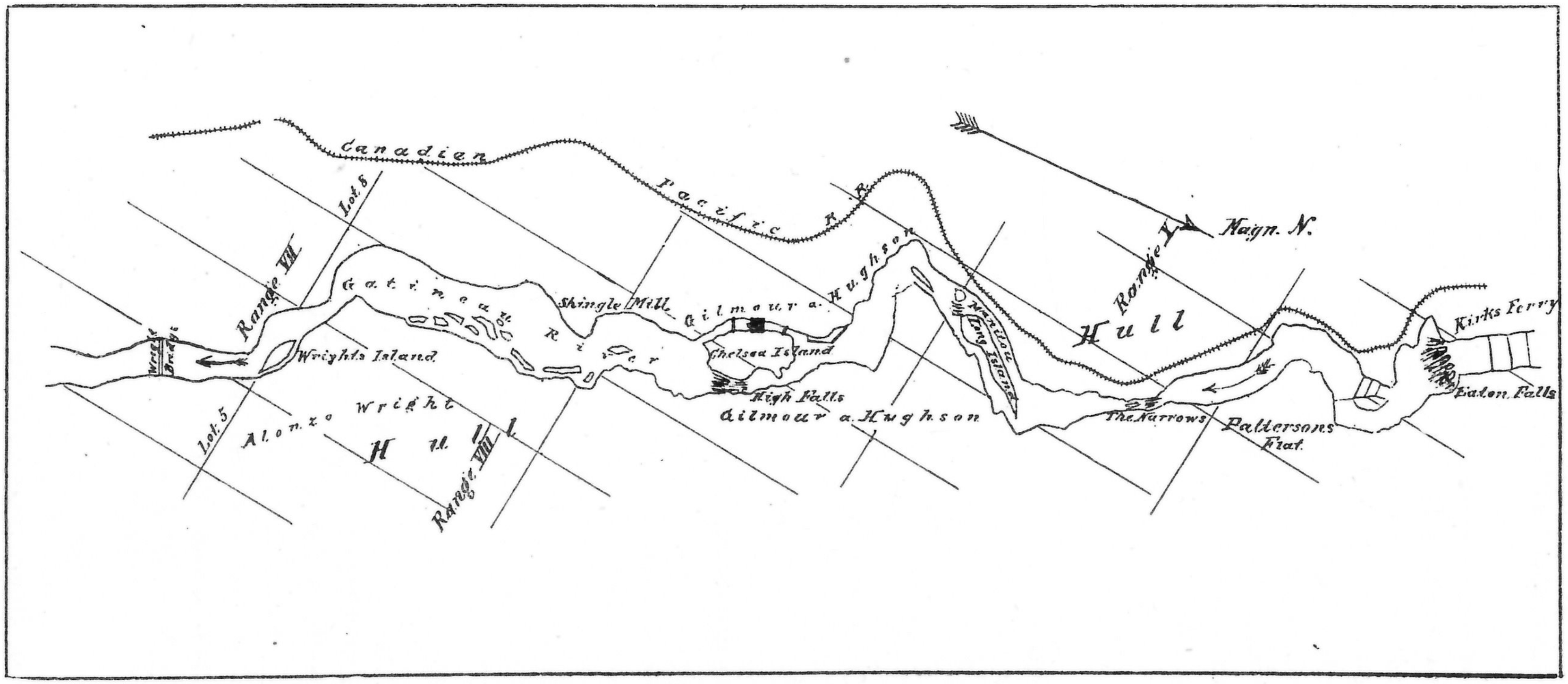

FIG. 15.—Water powers from Kirks Ferry to Wright Bridge, on the Gatineau River. Scale 1 inch to 3,000 feet.

This would represent an effective horse-power, at extreme low water, of 47,040. The development of these rapids would consist in the construction of a dam across the river, at the head of the fall, and to continue the same from the island opposite the east shore. The series of short dams between the islands would form a natural channel between the islands and the east shore, which would be closed by a dam at the lower end. The water power formed by these dams, on the east side of the river, would have a head of 26 feet at its lower end, at extreme low water. On the west side of the river, the present channel or flume could be enlarged, and a head of 22 feet at its lower end obtained. Below this power, two powers could be formed by dams, each with a head of 15 feet.

"These powers are all at a distance of 5 to 6 miles from Ottawa.

"Below these powers, to a point a short distance above Wright Bridge, there is a further fall of 16 feet, which might form another power, on the east side, if required. This power, however, more likely would have to be developed in the event of a high dam being built, and a large amount of power concentrated.

"As I have stated, in view of the extremely low water when measurements were made, on which an effective horse-power for every foot of fall in the river of 840 horse-power was based, I am of the opinion that for ordinary low water this might be increased to 1,000 horse-power.

Summary Results.

"Between Ironsides and Kirk Ferry is a rise of almost 161 feet. The rate of rise from Wright Bridge, about 1¼ miles above Ironsides, is a little over 28 feet per mile.

"This total fall would represent in effective horse-power:—

For extreme low water.	135,240
For ordinary low water.	161,000
Level of October 17, 1899.	237,260

"All this water power would be capable of development, if it were desired. The plans I have outlined for the development of power above Wright Bridge, would represent a total effective horse-power for the river, at different points, as follows:—

Below shingle mill, for extremely low water.	47,040	h.p.
Ordinary low water.	60,000	"
Level of October 19, 1899.	99,000	"

For Chelsea Falls, 60 *feet head.*

For extreme low water.	50,400	"
For ordinary low water.	60,000	"
Level of October 19, 1899.	99,000	"

For Eaton Chute, 21 feet head.

For extreme low water	17,640 h.p.
For ordinary low water	21,000 "
Level of October 19, 1899	34,860 "

"In connexion with the very large amount of power on the Gatineau river, at the above points, it is interesting to notice the available powers on the Merrimac and Connecticut rivers, at the principal manufacturing cities where they are utilized. In order to make a proper comparison I have deducted 25 per cent from the theoretical horse-power, in order to get the effective horse-power. The results are as follows:—

	Available power		Total power (effective) Gatineau river
	Merrimac river	Connecticut river	
Holyoke, Mass.	....	18,000	
Chelsea falls	....	....	50,400
Turner falls, Mass.	....	12,750	
Shingle mill	....	....	47,040
Manchester, Mass.	9,000	....	
Eaton chute	....	....	17,640
Lowell, Mass.	8,884	....	
	17,884	30,750	115,080 h.p.
	48,634 h.p.		

"This comparison of the water powers of the Gatineau river with the available power which has been in use in some cases for over 50 years in the principal American water power cities, will be of interest, in giving some idea of the magnitude of the Gatineau powers.

"The topography and geology of the Gatineau river, the favourable climatic conditions, the low temperature, causing a large rainfall and small evaporation, the great facilities for storage, the extensive forests, and the absence of destructive freshets, all combine to place this river in the front rank as a water power stream. On the section of the river in which these water powers are situated, the rapid declivity, broken by falls over edges of hard rock, and the favourable character of the bed and banks as regards foundation and freedom from overflows, with their proximity and accessibility to competing lines of transportation, and the very large amount of power capable of development, renders these water powers very valuable."

Summary of Water Powers.

In the following tables a summary of the total minimum horse-powers are given, which, according to the foregoing reports, can be developed within the limits of the accompanying map sheet:—

OTTAWA RIVER.

Name of Falls	Head	Minimum power h.p.	Authority
L'Islet rapid on the Culbute channel	14'-0"	2,000	C. E. Gauvin, C.E., Que.
Roche Fendu channel	....	....	" "
Sable rapids	4'-3"	3,800 (estimated)	" "
Timber slide	12'-3"	1,400 "	" "
Garvin chute	10'-5"	5,000 "	" "
Crawford rapids	20'-0"	7,000 "	" "
Black rapids	10'-0"	5,700 "	" "
Muskrat rapid	7'-0"	7,000 "	" "
Rocher Fendu chute	5'-6"	5,600 "	" "
Grand Calumet falls	57'-0"	25,000 "	" "
Mountain rapid	15'-0"	13,000 "	" "
Dargis rapid	5'-0"	4,500 "	" "
Portage du Fort	9'-0"	400 "	" "
Chats falls	36'-0"	50,000 "	" "
Deschenes rapids, near Ottawa	10'-0"	35,000 "	J. P. Brophy, Ottawa.
Skeads mills, near Ottawa	8'-0"	25,000 "	" "
Chaudiere falls, Ottawa	20'-0"	70,500 "	" "
Black River falls, near Weston	120'-0"	21,000 "	" "
Coulonge River falls, near Fort Coulonge	138'-0"	24,120 "	" "
Total		306,020 h.p.	

GATINEAU RIVER.

Name of Falls	Head	Minimum h.p.	Authority
Six portages, below Maniwaki, total head .... 50·73 feet.			
Head of Six portages	8·07 feet.	2,820	C. E. Gauvin, C.E., Que.
The Corbeau	15·79 "	5,520	" "
The Boom	14·17 "	4,960	" "
Les Cedres	9·20 "	3,220	" "
La Passe	1·00 "	350	" "
Le Bonnet Rouge	2·50 "	875	" "
The Paugan falls	60·00 "	73,500	J. P. Brophy, C. E., Ottawa.
The Cascades, total head... 22·00 feet.			
First cascade	2·85 "	1,300	C. E. Gauvin, C.E., Que.
Second cascade	3·33 "	1,500	" "
Third cascade	2·25 "	1,000	" "
Fourth cascade	8·72 "	4,000	" "
Fifth cascade	4·85 "	2,200	" "
Chelsea rapids, total head.. 136 feet.			
Eaton chute	20 "	17,640	C. Keefer, C.E., Ottawa.
Shingle mill	56 "	47,040	" "
Chelsea falls	60 "	50,400	" "
Total h.p.		216,325	

The total number of minimum horse-power which can be developed in the district under consideration, thus is:—

Ottawa river .... 306,020 h.p.
Gatineau river .... 216,325 "

Grand total .... 522,345 h.p.

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